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ABSTRACT

AN EMPIRICAL EXAMINATION OF SEVERAL THEORIES
OF THE COMMODITY COMPOSITION OF TRADE

By

Robert A. Brusca

Since Leontief produced his famous paradox, international trade theorists have reexamined the assumptions underlying the Heckscher-Ohlin (H-O) model. Their efforts have produced new theories and caveats. Currently, several models provide explanations for the commodity composition of trade. This study empirically evaluates the H-O and several post-H-O models: human skills, scale economies, the technological gap, and preference similarity.

The total factor requirements, calculated from the U. S. 1970 input-output (I-O) table, are used to examine the 1975 trade patterns of nineteen developed and developing countries. U. S. coefficients are applied to other countries' trade flows. The study focuses on trade in manufactures, but shows the effect of adding natural resource intensive products to the trade flows.

The human skills and scale economy theories are evaluated using I-O and multiple regression analysis. In both cases the I-O classifications (121 sectors) constrain the level of industrial detail. The input-output tests find support for each theory, while

regression analysis rejects the scale theory based on economies internal to the plant. Although the regression results generally support the conventional human skills theory, a three factor approach including unskilled labor, skilled labor, and capital better explains the trade patterns of the developed countries not at the extremes of the endowment rankings. The three factor model is buttressed by the relative factor intensities revealed by a three factor I-O model.

The technological gap model is not itself tested, but the human skills tests provide some insights by identifying workers who supply services required in high technology industries. Multiple regression analysis reveals the United States as the only country in the world which derives an advantage from workers providing highly technical services. The "revealed comparative advantage" (RCA) approach developed by Balassa reinforces this finding by identifying commodities in which the most highly developed countries have an advantage. The RCA rankings are related to the skill intensities of the products. Current trends toward protectionism are better understood by assessing changes in the RCA pattern over time and due to different standards of comparison in the same time period. These methods also produce casual empirical support for Linder's trade model.

In a separate test, Linder's preference similarity hypothesis is supported by the trade patterns of the most developed countries in a sample of twenty-six. The test involves a dependent variable with a truncated distribution and uses a quadratic specification. The difficulty in testing Linder's hypothesis is discussed thoroughly.

The test reveals some favorable statistical evidence, while other supportive but insignificant evidence gains credibility due to the unconstrained nature of the quadratic form.

The study also addresses several general issues. The total and immediate factor requirements are shown to be highly similar across industries. When each is used to explain the export performance of nineteen countries' trade, similar regression results are produced. Thus the immediate coefficients (which correspond to the value added produced in an industry) may be used to test trade theories without loss of correspondence to the correct total factor requirements. If this finding is not sensitive to aggregation, it implies that greater industrial detail and, therefore, more refined tests are possible.

To my wife, Candice

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CHAPTER I

INTRODUCTION

The fundamental purpose of the pure theory of international trade is to explain the commodity composition of trade. Currently, several hypotheses offer complementary or competing views. In this study we test these theories in isolation, in direct opposition, and simultaneously where appropriate. The Heckscher-Ohlin, human skills, and scale economy theories comprise the group of supply models which are tested. Linder's demand driven model is also tested. Although the technological gap theory is not tested, examination of the human skills model provides some insights by focusing on technically oriented laborers.

We address these issues by first considering the supply models. In Chapters II through V the models are presented, the literature is reviewed, and new evidence is offered. The following two chapters concern the opposing predictions of Linder and the supply models. In Chapter VIII we take a policy approach, centering on issues ignored in the previous chapters. Chapter IX provides a simultaneous test of the relevant theories.

The Heckscher-Ohlin theory centers on two factors of production: labor and capital. Countries which are relatively abundant in capital are predicted to have a comparative advantage in

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commodities whose production requires a relatively intensive use of capital. When labor is relatively abundant, countries derive an advantage in commodities which are relatively labor intensive. A related three-factor model is tested empirically in Chapter III; the two-factor H-O model is examined in Chapter IX.

The human skills theory of international trade is set in the same "factor proportions" framework as the H-O theory. There are three factors of production: skilled labor, unskilled labor, and capital. But, the relative availability of skilled and unskilled labor is the sole determinant of trade flows. Capital, it is argued, does not influence trade patterns due to its relative international mobility. Multinational corporations play a primary role, since a corporate empire transcends international boundaries allowing capital to move freely. A large and growing proportion of international trade involves transactions within the multinational corporation (7). Thus the human skills theory concentrates on the relative availability of labor of differing qualities. Countries which are relatively abundant in skilled labor derive an advantage in products which use skilled labor relatively intensively. Chapter III tests this theory in isolation, using input-output analysis. The chapter also explores the possibility that the relative availability of all three factors, skilled labor, unskilled labor, and capital, determines trade patterns.

The scale economy theory is tested in Chapter V. It asserts that comparative advantage is determined by relative plant size when economies of scale are internal to the plant. The hypothesis is examined under the assumption that (1) scale economy benefits are passed on from sector to sector to the export market, and (2) only final stage scale economy benefits confer an advantage to exporters.

The Heckscher-Ohlin (H-O) and post H-O supply models identify the pertinent production characteristics of commodities. By relating these to countries' national endowments, the theories single out commodities in which nations will have a comparative advantage. Thus, supply theories of international trade assert that greater differences in national endowments create greater opportunities for gains from trade. In this sense, the preference similarity model of Burenstam Linder is different. Focusing on international variations in consumer preferences, Linder sets out to show that the greatest opportunities to reap gains from trade lie between nations with highly similar demand structures. This prediction is in direct conflict with the supply driven models. The opposing viewpoints are tested in Chapter VII.

In Chapter VIII a different approach is pursued. Among a selected sample of commodities, the products are identified in which the eleven most highly industrialized countries in the world have their greatest advantage. The comparative advantage ranking of commodities is given for five countries plus the EEC (original six) as a unit. Labor force characteristics and technological aspects of high and low ranking products are related to each country's "revealed comparative advantage." Changes in the commodity rankings over time and under differing assumptions are used to help explain the current trend toward protectionism and the increased reliance on orderly marketing agreements. Additional insights into Linder's preference similarity hypothesis are obtained.

The various themes explored in the earlier Chapters are brought together in Chapter IX, where the relevant theories are tested simultaneously using multiple regression techniques. The trade patterns of nineteen developed and developing countries are examined. As most tests of international trade theories are conducted using immediate factor requirements (those factors employed in the final stage of fabrication), we conduct an investigation as to the similarity between these and the theoretically correct total factor requirements (which include the factor requirements of the inputs and inputs into the inputs, and so forth).

The purpose of this empirical analysis is to test certain logical implications of competing and complementary theories; therefore, we must have confidence that the empirical results are objective and meaningful. In several previous empirical studies (1,3,4,10) the critical test results[1] have been found to be sensitive to the choice of a dependent variable. If two dependent variables are reasonably good measures of comparative advantage, but produce widely different critical test results, it is very difficult to judge exactly what we learn from the divergent findings. To see whether this problem plagues this study, the regression analysis in

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[1]The signs and significance of the independent variables in regression equations.

Chapter IX is conducted using two different, but reasonable, dependent variables to measure comparative advantage.

The following chapters are intended to illuminate a variety of issues in international trade theory. The analysis, basically, is cross-sectional, although the revealed comparative advantage approach uses comparative statistics. The year 1975 was chosen for two reasons: first, it is the most recent year for which an international data set is available; second, by 1975, fluctuating exchange rates had been in existence long enough to have settled at their equilibrium level, thereby allowing commodity trade flows to adjust. The supporting data on commodity characteristics also are very recent. The human skills occupational classes are from the *1970 Census of Population*, the scale elasticity parameters are estimated from data in the *1972 Census of Manufactures*, and the input-output table is of 1970 vintage. Therefore, this study embodies the most current information generally available. This is important because most previous studies were conducted in the early to mid-1960s. Since then, tariff barriers have declined, exchange rates have begun to float, Japan's development has increased enormously, and multinational corporations have exerted considerable influence on international trade flows. New tests with more recent data are warranted.

REFERENCES

1. Baldwin, R. E. "Determinants of the Commodity Structure of U. S. Trade." The American Economic Review (March 1971): 126-46.

2. Bhagwati, L. "The Pure Theory of International Trade: A Survey." Surveys of Economic Theory, Growth and Development 2 (New York: 1965): 173-5.

3. Branson, William H., and Junz, Helen B. "Trends in U. S. Trade and Comparative Advantage." Brookings Papers on Economic Activity 2 (1971): 285-346.

4. ________. "U. S. Comparative Advantage: Some Further Results." Brooking Papers on Economic Activity 3 (1971): 754-9.

5. Hufbauer, G. C. "Factor Endowments, National Size, and Changing Technology: Their Impact on the Commodity Composition of Trade in Manufactured Goods." In The Technology Factor in International Trade. Edited by R. Vernon. New York: Columbia University Press, 1970.

6. Katrak, H. "Human Skills R and D and Scale Economies in the Exports of the United Kingdom and the United States." Oxford Economic Papers (November 1973): 337-60.

7. Kreinin, M. E. International Economics: A Policy Approach. New York: Harcourt Brace Jovanovich, Inc., 1975.

8. Leamer, E. E. "The Commodity Composition of International Trade in Manufacturers: An Empirical Analysis." Oxford Economic Papers (1972): 350-74.

9. Leontief, W. "Domestic Production and Foreign Trade, The American Capital Position Re-examined." Economia Internazionale (February 1954): 9-45.

10. Weiser, L., and Jay, Keith. "Determinants of the Commodity Structure of U. S. Trade: Comment." American Economic Review (June 1972): 459-66.

CHAPTER II

THE HUMAN SKILLS THEORY OF INTERNATIONAL TRADE

2.1 Introduction

The human skills theory is based on the proposition that the relative availability of skilled and unskilled labor is the fundamental determinant of international trade patterns. Although capital is a factor of production, it is relatively more mobile internationally than labor, and therefore, less likely to determine trade patterns. Skilled workers are relatively more difficult for a nation to acquire than capital. Labor migration does not occur in sufficient magnitude to alter initial endowments importantly. An existing stock of unskilled labor may be transformed into skilled labor, but this requires an intensive national training program. Physical capital, on the other hand, can be purchased directly at prevailing market prices; the profit motive will attract financial capital. These considerations are relevant, especially to a world economy whose nation's have engaged in trade for a considerable period of time. The dynamic environment has provided each country with the opportunity to supplement an initial endowment of a relatively mobile factor of production, such as capital. But, since labor is immobile, if the skill intensity rankings of commodities across countries are similar, relative skill endowments will determine trade flows.

The preceding discussion conveys the essence of the skills approach. In this chapter the theory is formalized. Empirical evidence establishing the validity of the necessary assumptions is presented. Then, the contrasting assumptions of the human skills and human capital theories are set out, and it is shown that the former approach is more consistent with existing empirical evidence. The chapter concludes with a survey of the human skills literature.

Most tests of the skills theory are conducted using immediate or direct skill coefficients. Since it is the main point of this chapter that the theory is not properly tested by these coefficients, let us establish the terminology which will be employed in this and in all subsequent chapters. Input-output tables distinguish between three types of factor input requirements: immediate, direct, and total. Immediate characteristics are qualities of the product itself; direct characteristics are qualities of the product plus its first stage inputs; total characteristics include the direct characteristics plus those embodied in the inputs of all other stages of production (the inputs into the inputs etc.). The importance of these distinctions is established in the following section.[1]

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[1]Those who are familiar with Keesing's work (10,11,12,13) are aware that he claims to use direct coefficients. Immediate coefficients seem to be more consistent with his arguments (10, p. 288). I will interpret Keesing's statements to mean that the direct factor requirements were used. Although this may be incorrect, it will serve to make a point. If this is a misinterpretation, it is not important, since both direct and immediate coefficients are inappropriate.

2.2 The Theory and Its Assumptions

According to the human skills approach, production functions are linear and homogeneous in the first degree. Labor services from workers of specified skill classes comprise the factor inputs; all factors are perfectly divisible. Define the amount of labor services of each type, t, necessary to produce one dollar's worth of output in industry j as S_{tj}. Let the structural relationship of industries in the economy be defined by the matrix A, where $a_{ij} \varepsilon A$ (i = 1, 2, . . . m; j = 1, 2, . . . n). Each a_{ij} represents the amount of industry i's output required to produce one dollar's worth of output in industry j. The total factor requirements of industry j are obtained by combining the skill vectors s_t for each industry j with the Leontief inverse of the matrix, A. Thus, the total requirements[2] for each type of labor t in industry j are:

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[2]Keesing has proposed that the direct factor requirements (obtained by replacing r_{ij} in equation 2-1 with a_{ij}) can be used, as in an open economy inputs can be obtained through trade (10, p. 288). However, the theory which takes for granted that which it purports to explain is not logically sound. Furthermore, direct factor requirements include only the factor requirements which are specific to the final stage of fabrication and the first stage material inputs. Ignoring the inputs into the inputs, etc., implies that the total factor content of a product is not adequately measured regardless of the location of the supplier of that input. In any event, use of direct coefficients in no way implies that the inputs actually were produced domestically. Therefore, the use of direct coefficients is not defensible. By comparison, the total factor requirements measure the factor service content of all inputs and inputs into the inputs etc. Thus they measure the total factor content of a given product.

$$\bar{S}_{tj} = \sum_{i=1}^{m} S_{ti} r_{ij} \qquad (2\text{-}1)$$

where: $(t = 1, 2, \ldots n; i = 1, 2, \ldots m)$

$r_{ij} \in [I-A]^{-1}$, the Leontief inverse matrix.

The total labor content of a nation's exports may be obtained by computing,[3]

$$(S_t)_x = \sum_{i=1}^{m} [\sum_{i=1}^{m} S_{ti} r_{ij}] X_j \qquad (2\text{-}2)$$

for $t = 1, 2, \ldots n; j = 1, 2, \ldots m$,

where X_j is the value of a nation's exports of commodity j.

U. S. technical coefficients (r_{ij}'s) and skill vectors (S_{ij}'s) are used throughout. The theory explains trade in manufactures, ignoring products which are highly dependent on natural resources. The immobility of natural resource inputs prevents the product which intensively uses them from being produced where factor prices would be most advantageous, except by chance.

The application of U. S. skill coefficients to foreign countries is a procedure which must be justified. Two general questions are pertinent: (1) What are the theoretical implications? (2) Is the procedure empirically valid?

Taking up the theoretical issue first, it is possible, although unlikely, that every country produces each commodity with

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[3]The factor content of imports is obtained by replacing X_j with M_j in equation 2-2, where M_j is the value of a nation's imports of commodity j.

exactly the same skill mix as the United States. In this case, the U. S. coefficients measure the skill content of exports and imports perfectly, causing no distortions. However, if capital and unskilled labor can be substituted for one another, but not for skilled labor, U. S. coefficients mismeasure the unskilled labor content of trade.[4] The amount of skilled labor embodied in a given trade flow is accurately measured, but the amount of unskilled labor may be mismeasured. (In fact, it will be too low if the United States substitutes its relatively abundant capital for its relatively scarce unskilled labor.) If high and low skilled labor are easily substituted for one another, "skill intensity reversals" can occur. These are a response to divergent factor price ratios which cause a relatively skill-intensive product in one country to be unskilled intensive in another. These reversals disturb the skill-intensity orderings of commodities between countries. When this happens, it is no longer possible to assert that a relatively skilled labor abundant country will export skill-intensive commodities. Since those same commodities may be produced by a relatively labor-intensive process, a country which is relatively abundant in unskilled labor may enjoy a conflicting advantage. Thus, the admission of substitution possibilities destroys the theoretically deterministic nature of the theory.

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[4]Berndt and Christensen recently have estimated an aggregate production function for the U. S. and found that capital and skilled labor are complements while capital and unskilled labor are substitutes. Skilled and unskilled labor also are substitutes, but capital and unskilled labor are more easily substituted for each other (3).

Nonetheless, the model is useful so long as substitution does not alter the essential relationships across industries. If, for example, substitution between capital and unskilled labor occurs to the same extent across all industries, their relative skill-intensity rankings are not affected, and the model accurately measures the relative skill intensity of a given trade flow. Whether or not reversals constitute a serious problem is an empirical question. The existing evidence to be discussed in the next paragraph, supports the nonreversability assumption.

Rank correlations between the 1958 average wages paid in thirteen industry groups across twenty-three nations produced 182 out of 253 positive and significant (1% level) Spearman's correlation coefficients (8, p. 174). If wage rates are a good proxy for skill intensity across industries, these results imply that the international skill intensity ordering of commodities is rather uniform. Similarly constructed rank correlations on an average earnings basis between the United States and seven other countries produced even larger positive rank correlation coefficients, all of which were significant at the 1% level (8, p. 174). However, more direct evidence is available. Keesing (13) has used analysis of variance to compare directly the immediate industrial requirements[5] of scientists, engineers, and technicians (R & D) and also white-collar workers

[5]The relevance of these findings based upon the immediate requirements is established following a presentation of the empirical results.

across the manufacturing industries of seventeen countries.[6] Considering a subset of nine developed countries, 83% of the total variance of the R & D coefficients is attributable to differences between industries. Less than 3% is associated with differences between countries. The industry effect is very significant, while the country effect is not statistically significant. A second test, involving the white-collar labor coefficients, revealed that 79% of the total variance of the coefficients is explained by industry effects; 11% is explained by country effects. Once again the industry effects are highly significant, while the country effects are significant only at the 10% level. When eight smaller and poorer countries are included in the sample, the country effect for white-collar workers is not quite significant at the 5% level.[7]

These results are based on immediate coefficients, and it has been argued here that only the total coefficients are theoretically correct. Yet, Keesing's results are both relevant and important. The total coefficients are derived from the immediate coefficients [$\bar{S}_{tj} = f(S_{ti})$, equation 2-1]. Since the relationship is an aggregation of a series of linear combinations, the test results presented above apply rather straightforwardly to the total requirements coefficients.

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[6]Based on data from a 1966 study by Horowitz, Zymelman, and Herrnstadt (7).

[7]Keesing fails to report the importance of this effect and the industry effect. The smaller and poorer countries which were added to the sample are Finland, Norway, Ireland, Israel, New Zealand, Yugoslavia, Argentina, and Chile.

These findings make an additional contribution. International trade studies attempt to explain a flow of commodities by using industry characteristics. However, the industry product mix varies across countries. Close correspondence between countries' industry level skill characteristics implies that differences in the product mix of industries do not affect empirical results importantly. Alternatively, this finding may be evidence that the actual industry product mix does not vary importantly between countries. If this is the reason for the international similarity skill coefficients, we have confidence that the U. S. technical coefficients (r_{ij}'s) are accurately measuring industrial interrelationships.

2.3 Previous Empirical Tests of the Theory

Attempts to measure the relative importance of labor heterogeneity in determining trade flows can be classified into two divisions: human capital and human skills. The former approach begins from the proposition that labor essentially is homogeneous. From that beginning, empirical studies set out to measure the extent to which an industry's labor force embodies human capital over and above a specified base level. Generally, this is measured as the excess of the industry wage over a selected base wage (4,5,14,15). Alternative approaches estimate the amount of embodied capital directly from the cost of education (2,6), or from the income flows accruing to laborers (25). These empirical studies generally are confined to an analysis of U. S. trade patterns, although several have inspected other individual countries (4,25). One common application is to try to resolve the Leontief paradox (or its equivalent for other countries) under the assumption that physical and human capital can be aggregated.

Using input-out (I-O) analysis, Bharadwaj and Bhagwati found that when human capital estimates were added to India's tangible capital stock, the relative capital-labor ratio of India's exports increased (4, p. 139). A re-examination of U. S. 1947 trade patterns reveals that the Leontief paradox can be reversed by using wage differentials capitalized at 9.0 percent in combination with the physical capital stock (15, p. 457).

Baldwin's I-O study (2) showed that a one million dollar bundle of 1962 U. S. exports embodied the services of more highly educated laborers than a comparable import bundle. However, the aggregation of net physical plus human capital did not resolve the Leontief paradox until natural resource intensive industries were excluded from the trade flow. By considering human capital as a third factor of production, West German exports were found to embody that input most intensively and simple labor services least intensively. Thus it was concluded that West Germany is most abundant in human capital, then physical capital, and least abundant in simple labor (25, p. 160).

The classification of human as distinct from physical capital is fundamental to the skills approach. Various occupational categorizations designate laborers with different skills. By identifying skilled and unskilled classes, industries can be ranked by their relative skill intensity. Obviously, this is not completely unrelated to the human capital approach. Wage rates across industries are influenced certainly by the occupational mix of the industry. Thus, a paper by Waehrer provides an empirical bridge between the two approaches (27). She finds that an occupational skill index[7] explains a great deal of the variation in wages across industries (R^2 = .74). Furthermore, the skill index explains each industry's trade balance as a percentage of industry shipments better than its yearly wage (16, p. 196).

The occupational index is a fundamental tool of the human skills approach which measures the skill intensity of an industry. Although several specific indexes have been employed (10,12), the common objective is to devise a measure of the ratio of skilled to unskilled workers. The index is used either as an independent variable in a regression equation across industries (9, 27) or to reveal the factor intensity of an aggregate trade flow (10,12).

Existing evidence seems to favor the skills approach. In a recent study, blue-collar and white-collar workers were found to be distinct inputs which cannot be aggregated (3). Separately, human capital and the physical capital/labor ratio have been found to influence U. S. export performance in different directions. Branson and Junz found the United States derived an advantage from human capital intensity and a disadvantage from physical capital intensity across industries (5). This result undermines studies which combine

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[7]Waehrer's skill index and occupational groupings may be found in (27, p. 29).

physical and human capital (2,4,15). We shall, therefore, confine our attention to the empirical studies of the human skills theory.

Most tests of the theory are based upon the use of direct or immediate skill coefficients, but there is one exception. Using total factor requirements, Baldwin (2) found that in 1962 the United States was a net exporter of the services of professional and technical workers, craftsmen and foremen, clerical workers, and all types of farm labor. His regression analysis revealed the United States derived a significant advantage in industries which used scientists and engineers, craftsmen and foremen, and farmers and farm laborers relatively intensively. U.S.-Japan bilateral trade showed the U. S. advantage to be associated with the intensive use of scientists and engineers, and farm workers in an industry. The U. S. disadvantage was found to lie in industries which intensively used laborers and service workers. In trade with the Western European countries, the U. S. enjoyed a significant advantage in industries which required large proportions of scientists and engineers and farm laborers.

Typically, skill indexes are used to test the theory. Their most common application is in conjunction with input-output analysis. Keesing has performed this type of test based on direct factor requirements. The method, described at the beginning of this chapter, requires the computation of the amount of services from laborers of each class embodied in a given export and import flow. Indexes are constructed to measure the relative skill intensity of each country's exports and imports using U. S. labor coefficients. The following skill classes have been used:

I. Scientists and engineers
II. Other professional and technical workers
III. Managers
IV. Machinists, electricians, and tool and diemakers
V. Other skilled manual workers
VI. Clerical, sales, and service workers
VII. Semiskilled and unskilled workers

From these classifications, several index are formulated:

$$A = (I + II + III + IV + V)/VII$$

$$B = (I + II + III)/VII$$

$$C = (IV + V)/VII$$

$$D = [2(I + II) + IV]/VII$$

The index chosen does not seem to be important. The rankings of nine countries according to indexes A, B, and C computed from 1951 export flows of manufactured goods are very similar, as are the import rankings by thos indexes (10). For these nine leading industrialized countries, Keesing has found that the export rankings are approximately the inverse of the import rankings. Using index A, 20 out of 36 possible pairings revealed a rank ordering of countries such that a country which ranks above another always has the greater skill content in the bilateral exchange of exports. From this Keesing concludes that labor skill availabilities influence trade patterns. However, he has made no attempt to measure actual factor endowments. In a second study the commodity coverage and the set of sample countries was expanded (to include developing countries), and index D was applied to 1962 manufactured trade flows; similar test results were obtained. Although no "perfect" export and import ordering emerged, the Spearman's correlation coefficient between the export and import rankings of thirteen countries was .87[8] (12). Using all fourteen countries, a rank correlation between their export indexes and the corresponding country per capita income ranking was .93. However, this still does not connect skill-intensity rankings to relative skill endowments. The results are interesting, but do not consitute tests of any theory, particularly not of the factor proportions framework which Keesing claims underlies the results (10, p. 5). Separately, this same skill index, computed from the immediate requirements, has been used successfully as an independent variable in an equation explaining U. S./U. K. exports. The United States was assumed to be skill abundant relative to the United Kingdom (9).

2.4 Conclusions

There is ample evidence that various measures of heterogeneous labor inputs explain trade patterns. The skills approach has produced evidence that labor skills influence international trade patterns, but the underlying causal factor has not been inspected. It is entirely possible that Keesing means for us to infer from the skill intensity rankings the factor endowment rankings which "must" underlie his test results. But this is not a test. Unless these two rankings are found to be highly similar across countries, there is no support for a factor proportions theory based upon labor skill availability. Furthermore, we have no idea as to the distortion of

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[8]Hong Kong was omitted from this calculation without explanation. Hong Kong's export index is the lowest in the sample, but its import index is not reported.

the skill indexes computed from the direct compared to the total requirements. Use of direct requirements is not defensible. They are no easier nor harder to use than total requirements, and they are theoretically inferior; thus, there appears to be no rationale for their use. The case for immediate requirements is different. These are free of the effects of imported inputs, they are theoretically incorrect, but they are easier to use and are capable of achieving far greater industrial detail than an input-output table allows. Therefore, the relationship between the immediate and total requirements is of interest. Nonetheless, a proper test of the human skills theory must use the total factor requirements and relate the resulting evidence to cross-national skill endowment rankings.

REFERENCES

1. Arrow, K.; Chenery, H.; Minhas, B.; and Solow, R. "Capital-Labor Substitution and Economic Efficiency." Review of Economics and Statistics (August 1961): 225-50.

2. Baldwin, R. "Determinants of the Commodity Structure of U. S. Trade." American Economic Review (March 1971): 126-46.

3. Berndt, E., and Christensen, L. "Testing for the Existence of a Consistent Aggregate Index of Labor Inputs." American Economic Review (June 1974): 391-404.

4. Bharadwaj, R., and Bhagwati, J. "Human Capital and the Pattern of Foreigh Trade: The Indian Case." Indian Economic Review (October 1967): 117-42.

5. Branson, W., and Junz, H. "Trends in U. S. Trade and Comparative Advantage." Brooking's Papers on Economic Activity 2 (1971): 285-346.

6. Fareed, A. "Formal Schooling and the Human-Capital Intensity of American Foreign Trade: A Cost Appraoch." The Economic Journal (June 1972): 629-40.

7. Horowitz, M.; Zymelman, M.; and Herrnstadt, I. Manpower Requirements for Planning: An International Comparison Approach Vol. II, Statistical Tables. Boston: Northeastern University, Department of Economics, 1967.

8. Hufbauer, G. "The Commodity Composition of Trade in Manufactured Goods." In The Technology Factor in International Trade. Edited by R. Vernon. New York: NBER, Columbia University Press, 1970.

9. Katrak, H. "Human Skills, R. and D. and Scale Economies in the Exports of the United Kinguom and the United States." Oxford Economic Papers (November 1973): 337-60.

10. Keesing, D. "Labor Skills and International Trade: Evaluating Many Trade Flows with a Single Measuring Device." Review of Economics and Statistics (August 1965): 287-94.

11. Keesing, D. "Labor Skills and Comparative Advantage." American Economic Review (May 1966): 249-58.

12. ________. "Labor Skills and the Structure of Trade in Manufactures." In The Open Economy. Edited by Kenen and Lawrence. New York: Columbia University Press, 1968.

13. ________. "Different Countries' Labor Skill Coefficients and the Skill Intensity of International Trade." Journal of International Economics (January 1971): 443-52.

14. Kenen, P. and Yudin, E. "Skills Human Capital and U. S. Foreign Trade." International Economics Workshop, Columbia University, New York, 1965.

15. ________. "Nature, Capital, and Trade." Journal of Political Economy (October 1965): 437-60.

16. ________. "Skills, Human Capitol, and Comparative Advantage." Conference on Human Resources (NBER 1968).

17. Kravis, I. "Wages and Foreign Trade." Review of Economics and Statistics (February 1956): 14-30.

18. Kreinin, M. "Comparative Labor Effectiveness and the Leontief Scarce Factor Paradox." American Economic Review (March 1965): 131-40.

19. Leontief, W. "Domestic Production and Foreign Trade, The American Capital Position Re-examined." Economia Internazionale (February 1954): 9-45.

20. ________. "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis." Review of Economics and Statistics (November 1956): 387-407.

21. ________. "International Factor Cost and Factor Use." American Economic Review (June 1964): 335-45.

22. Minhas, B. An International Comparison of Factor Cost and Factor Use. Amsterdam: North-Holland Publishing, 1963.

23. Philpot, G. "Labor Quality, Returns to Scale and the Elasticity of Factor Substitution." Review of Economics and Statistics (May 1970): 194-9.

24. Robinson, R. "Factor Proportions and Comparative Advantage, Part I." In Readings in International Economics. Edited by R. Caves and H. Johnson. Irwin, 1968.

25. Roskamp, K., and McMeekin G. "Factor Proportions, Human Capital and Foreign Trade: The Case of West Germany Reconsidered." Quarterly Journal of Economics (February 1968): 152-60.

26. Valavanis-Vail, S. "Leontief's Scarce Factor Paradox." Journal of Political Economy. (December 1954): 523-28.

27. Waehrer, H. "Wage Rates, Labor Skills, and United States Foreign Trade." In The Open Economy. Edited by P. Kenen and K. Lawrence. New York: 1968.

28. Weiser, L., and Jay, K. "Determinants of the Commodity Structure of U. S. Trade: Comment." American Economic Review (June 1972): 459-66.

29. Yeung, P., and Tsang, H. "Generalized Production Function and Factor Intensity Crossovers: An Empirical Analysis." Economic Record (September 1972): 387-99.

CHAPTER III

THE HUMAN SKILLS THEORY OF INTERNATIONAL TRADE: EMPIRICAL EVIDENCE

3.1. Introduction

In this chapter we assess empirically the human skills theory for a group of nineteen countries. They represent a cross section of both developed and developing nations. We address two major questions concerning the theory:

1. Do human skills influence the commodity composition of international trade?
2. Can the influence of human skills be related directly to a nation's relative skill endowment?

Input-output analysis[1] is utilized to provide answers to these questions and to reveal the relative factor intensity of ten countries' trade when physical capital is introduced to the analysis.

The structure of the input-output table imposes the fundamental limit to disaggregation. A more detailed input-output (I-O) table would be of little value as the present level of disaggregation

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[1]The input-output table was compiled by the Bureau of Economic Analysis, U. S. Department of Commerce. It represents the input-output relations of 121 sectors of the U. S. economy for 1970. The compositional skills data are from U. S. Census of Population 1970, Occupation by Industry. The Annual Survey of Manufacturing 1971 provides the labor-output ratios necessary to perform the analysis. This data set represents the most current available statistics to assess the theory.

nearly exhausts the most detailed census classification by occupation and industry (12) at least for traded commodities.[2]

Throughout, this analysis assumes U. S. skill requirements to characterize the production processes in all countries. The assumption is supported by statistical evidence offered by Keesing (8); its implications have been addressed in the previous chapter.

3.2 Methodology

A neo-factor proportions test of the human skills theory requires computation of the total skill requirements of each industry. The following procedure describes how to transform the immediate skill requirements into total requirements on an industry level basis. Define the direct requirement input-output table of the economy as A.

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[2]For several industries the census classifications are not detailed enough. The primary and secondary ferrous and non-ferrous metal industries (I-0 sectors 49-57) suffer most from this deficiency. For these sectors some averaging of the compositional skills data occur. No skill data for the sector "space vehicles and guided missles" were available so the aircraft industry's coefficients were used as proxies for the immediate coefficients. Nonetheless, overlapping data are not very common and census to I-0 concordances are considered quite acceptable.

$$A = \begin{bmatrix} a_{11}, & a_{12}, & \cdot & \cdot & \cdot, & a_{1n} \\ \cdot & \cdot & & & \cdot & \cdot \\ \cdot & \cdot & & & \cdot & \cdot \\ \cdot & \cdot & & & \cdot & \cdot \\ a_{n1}, & a_{n2}, & \cdot & \cdot & \cdot, & a_{nn} \end{bmatrix}$$

Here each a_{ij} represents

$$\frac{X_{ij}}{X_j}$$

where: X_j is the total gross output of industry j

X_{ij} is the output of industry i absorbed by industry j, each expressed in value terms using producer's prices.[3]

The total requirement input-output table of the economy is the Leontief inverse,

$$[I-A]^{-1} = \begin{bmatrix} r_{11}, & r_{12}, & \cdot & \cdot & \cdot, & r_{in} \\ \cdot & \cdot & & & \cdot & \cdot \\ \cdot & \cdot & & & \cdot & \cdot \\ \cdot & \cdot & & & \cdot & \cdot \\ r_{n1}, & r_{n2}, & \cdot & \cdot & \cdot, & r_{nn} \end{bmatrix},$$

where: r_{ij} is the total requirement of industry i's output needed to produce one dollar's worth of industry j's output.

The vectors, S_j, representing the immediate skill requirements of each industry j per one million dollars of value of shipments are defined by,

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[3]Prices reveived by producers.

$$S_j = [s_1, s_2, s_3, s_4, s_5, s_6, s_7]_j, \quad S_j = [s_t]_j \qquad (3\text{-}1)$$

The occupational groupings[4] of this chapter which correspond to the subscripts, t, are

I. Engineers and Scientists
II. Other professional, technical, and managerial
III. Clerical and sales
IV. Craftsmen and foremen
V. Operatives
VI. Nonfarm laborers and service workers
VII. Farm Laborers

Each s_{tj} represents the number of man years from the t^{th} skill category required to produce one million dollars of output of industry j. For example, s_{11} is the number of man years of service from scientists and engineers required in industry one to produce one million dollars' worth of industry one's output. ΣS_j is the number of man years of all types of labor service required by industry j to produce one million dollars' worth of output.

The immediate skill coefficients are combined with the total requirement matrix to yield the total skill requirements for each industry. Define the total skill requirements of industry j for labor of type t as $\bar{s}_{tj}$, then

$$\bar{s}_{tj} = \sum_{i=1}^{n} s_{ti} r_{ij} \qquad (3\text{-}2)$$

where: $t = 1, 2, \ldots 7$, $j = 1, 2, \ldots 121$.

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[4]A detailed description of the occupational groupings may be found in (12).

The $\bar{s}_{tj}$'s are interpreted similarly to the s_{tj}'s except that the $\bar{s}_{tj}$'s incorporate the labor services from all stages of production required to produce one million dollars worth of output. For example, $\bar{s}_{11}$ is the total number of man years of service from scientists and engineers required to produce one million dollars' worth of industry one's output.

The representative one million dollar export and import bundles are obtained by computing the percentage weight of each commodity in the actual export or import bundle. Define X_j as the proportional weight of commodity j in the export bundle. We also may interpret X_j as the value of exports of commodity j expressed in millions of dollars. The import bundle M_j is computed and defined similarly.[5]

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[5] In order to calculate the amount of labor services embodied in each nation's exports and imports, we must first adjust the 1975 trade data to the 1970 price level in which the a_{ij}'s and r_{ij}'s of the input-output table are expressed. Then an adjustment is made to transform the value of the import and export vectors into producer's prices (14). This adjustment removes the transportation and wholesale trade mark-ups which are included in the valuation of the international trade flows. This is done because wholesale and retail trade are treated as separate sectors in the I-O table. Transportation is also a separate I-O sector, therefore, transport costs incurred in "moving" a product from one sector to the next must also be excluded. These adjustments avoid double counting.

The total labor services of each type, t, required to produce the one million dollar export bundle is estimated by,[6,7]

$$(s_t)_x = \sum_{j=1}^{n} [(\sum_{i=1}^{n} s_{ti} r_{ij}) X_j] \qquad (3\text{-}3)$$

similarly for imports,

$$(s_t)_m = \sum_{j=1}^{n} [(\sum_{i=1}^{n} s_{ti} r_{ij}) M_j] \qquad (3\text{-}4)$$

Using the total skill requirements from equation (3-3) and (3-4) five measures of skill intensity are computed. As these indexes test the human skills theory, the following empirical results must not be interpreted as a search for a skill index which performs best. Instead, we should view each as testing a different aspect of the theory. The indexes are defined below. Generally, we do not expect the results of the tests to vary greatly as the measure of skill

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[6]For the computations of the total skill requirements by type i = 1, 2, . . ., 121. Therefore, the contribution of all sectors--excluding government--is accounted for. Since our main concern is with manufactures, natural resource intensive products were excluded from the first stage of the analysis. Manufactures are then defined as I-O sectors 18, 19, 22-92, excluding 42. These sector numbers refer to the values taken by j in the computation of the skill indexes in equation 3-5' - 3-9' for manufactures. In a separate calculation each nation's skill indexes were computed for all tradeables, except oil. For these calculations j = 1, 2, . . ., 8, 10, . . ., 41, 43, . . . 92. Finally, oil was added, then j = 1, 2, . . ., 92.

[7]Due to the sharp increase of the price of oil and oil's increased prominence in the import vector of most of the countries studied here, it has been omitted from the analysis. Here "oil" refers to crude petroleum and natural gas (I-O sector 9) and refined petroleum (I-O sector 42).

intensity is changed. However, γ_3 represents less of a skilled to unskilled disparity than the other measures and may be expected to not perform as well.

The greatest disparity between skilled and unskilled labor is represented by index γ_1. However, this neglects a large portion of each industry's labor force. Therefore, expect index γ_2 to give the most objective test of the skills hypothesis. It combines a relatively large skill disparity with consideration to the bulk of the labor force in each industry.

The seventh skill category, farm labor, although clearly unskilled, was omitted from the general indexes because it is the only class which is specific to an industry. Therefore, the size of $\bar{s}_7$ is an industry's skill vector is totally determined by that industry's requirement of agricultural goods. To isolate this effect, γ_5 alone includes $\bar{s}_7$ in the denominator.

Skill index γ_4 focuses attention on scientists and engineers. Keesing found this occupational classification to be the major determinant of trade flows when the direct requirements coefficients are used (6). The index represents the percentage of the total labor services consumed by an industry which are supplied by workers of type 1. This measure is the total requirements counterpart of Keesing's variable.

The skill indexes are calculated for exports and imports. The ratio of a given index for imports versus exports (M/X) is the usual factor proportions test statistic. The export indexes are:

$$\gamma_{1x} = (s_1)_x/(s_6)_x \tag{3-5}$$

$$\gamma_{2x} = \frac{(s_1)_x + (s_2)_x}{(s_5)_x + (s_6)_x} \tag{3-6}$$

$$\gamma_{3x} = \frac{(\sum_{x=1}^{4} s_t)_x}{(s_5)_x + (s_6)_x} \tag{3-7}$$

$$\gamma_4 x = \frac{(s_1)_x}{(\sum_{t=1}^{6} s_t)_x} \tag{3-8}$$

$$\gamma_{5x} = \frac{(s_1)_x + (s_2)_x}{(\sum_{t=5}^{7} s_t)_x} \tag{3-9}$$

The formulas representing the indexes for imports are obtained by replacing the subscripts, x_1 in equations (3-5)-(3-9) with m. The usual factor proportions test statistic for the ratio of skill embodied in imports versus exports is defined by,

$$\gamma_{1r} = \gamma_{1m}/\gamma_{1x} \tag{3-10}$$

$$\gamma_{2r} = \gamma_{2m}/\gamma_{2x} \tag{3-11}$$

$$\gamma_{3r} = \gamma_{3m}/\gamma_{3x} \tag{3-12}$$

$$\gamma_{4r} = \gamma_{4m}/\gamma_{4x} \tag{3-13}$$

$$\gamma_{5r} = \gamma_{5m}/\gamma_{5x} \tag{3-14}$$

The formulas by which the export indexes [equations (3-5)-(3-9)] are estimated are derived by substituting for (s_t) from equation (3-3) into equations (3-5)-(3-9) for the appropriate values of t. The resulting estimators are:

$$\hat{\gamma}_{1x} = \frac{\sum_{j=1}^{n} [(\sum_{i=1}^{n} s_{1i} r_{ij}) X_j]}{\sum_{j=1}^{n} [(\sum_{i=1}^{n} s_{6i} r_{ij}) X_j]} \tag{3-5'}$$

$$\hat{\gamma}_{2x} = \frac{\sum_{j=1}^{n} [(\sum_{t=1}^{2} \sum_{i=1}^{n} s_{ti} r_{ij}) X_j]}{\sum_{j=1}^{n} [(\sum_{t=5}^{6} \sum_{i=1}^{n} s_{ti} r_{ij}) X_j]} \tag{3-6'}$$

$$\hat{\gamma}_{3x} = \frac{\sum_{j=1}^{n} [(\sum_{t=1}^{4} \sum_{i=1}^{n} s_{ti} r_{ij}) X_j]}{\sum_{j=1}^{n} [(\sum_{t=5}^{6} \sum_{i=1}^{n} s_{ti} r_{ij}) X_j]} \tag{3-7'}$$

$$\hat{\gamma}_{4x} = \frac{\sum_{j=1}^{n} [(\sum_{i=1}^{n} s_{1i} r_{ij}) X_j]}{\sum_{j=1}^{n} [(\sum_{t=1}^{6} \sum_{i=1}^{n} s_{ti} r_{ij}) X_j]} \tag{3-8'}$$

$$\hat{\gamma}_{5x} = \frac{\sum_{j=1}^{n} [(\sum_{t=1}^{2} \sum_{i=1}^{n} s_{tj} r_{ij}) X_j]}{\sum_{j=1}^{n} [\sum_{t=5}^{7} \sum_{i=1}^{n} s_{tj} r_{ij}) X_j]} \tag{3-9'}$$

Similarly, the estimators of the skill index for imports are derived by substituting for $(s_t)_m$ from equation (3-4) into the import equations analogous to equations (3-5)-(3-9). The resulting estimators defined as $\hat{\gamma}_{1m}$, $\hat{\gamma}_{2m}$, $\hat{\gamma}_{3m}$, $\hat{\gamma}_{4m}$, $\hat{\gamma}_{5m}$, are identical to equations (3-5')-(3-9') except the X_j is replaced with M_j.

The ratio of the factor (service) content of a country's imports versus its exports is estimated by equations (3-10')-(3-14').

$$\hat{\gamma}_{1r} = \hat{\gamma}_{1m}/\hat{\gamma}_{1x} \tag{3-10'}$$

$$\hat{\gamma}_{2r} = \hat{\gamma}_{2m}/\hat{\gamma}_{2x} \tag{3-11'}$$

$$\hat{\gamma}_{3r} = \hat{\gamma}_{3m}/\hat{\gamma}_{3x} \tag{3-12'}$$

$$\hat{\gamma}_{4r} = \hat{\gamma}_{4m}/\hat{\gamma}_{4x} \tag{3-13'}$$

$$\hat{\gamma}_{5r} = \hat{\gamma}_{5m}/\hat{\gamma}_{5x} \tag{3-14'}$$

This concludes the technical description of the formulation of the skill indexes. Although they are computed deterministically, the indexes derived from the computational form have been written with "hats" to stress that the underlying data from the Census

Bureau is estimated. However, for expositional convenience the "hats" and the terminology "estimate" will no longer be used.

3.3 Application of the Skill Indexes

The human skills theory suggests two empirical tests. The first requires knowledge of a country's relative skill endowment. Once the endowment ranking is known, the theory predicts the relative skill intensity of imports compared to exports (the value of γ_{ir}). For countries with the greatest relative skill endowment, we expect $\gamma_{ir} < 1$, which implies that the skill intensity of exports exceeds the skill intensity of imports. For those countries in which skilled labor is relatively scarce, $\gamma_{ir} > 1$ is predicted. Although it is difficult to formulate expectations for countries whose relative skill endowments are at neither extreme, we can expect the skill endowment rankings to agree roughly with the inverse of the country rankings obtained by first ranking each country according to the value of γ_{ir}. This test statistic divides out the effect of imported inputs which become embodied in a nation's exports. The double counting of the factor services embodied in imports which are re-exported changes the value of γ_{ir} (compared to the case in which this effect is absent), but does not cause it to be greater or less than unity. Since this is our main interest, the critical nature of the text statistic is not affected. However, when γ_{ix} and γ_{im} are considered separately, the double counting may be of concern as it is not divided out.[8]

The second test requires separate consideration of the skill intensity of a country's exports and imports. These intensities are measured by γ_{ix} and γ_{im}, respectively. Countries are ranked separately, according to the skill intensity of their exports and imports. If skills (or lack of them) are the motivating force behind these trade patterns, we expect to find a negative and significant rank correlation between countries ranked by γ_{im} versus γ_{ix}. Corroboration of the theory by this test implies that labor skills influence trade patterns. This, of course, is one of the theoretical predictions. But unless the skill intensity rankings of aggregate trade flows can be related to endowment rankings, the theory does not receive support. Correlations between the endowment rankings and either γ_{ix} or γ_{im} establish this link. However, both of these measures contain the bias imparted by imported inputs. The bias of γ_{im} will grow larger as the proportion of national imports demanded as inputs for subsequent exports increases. The export skill intensity index becomes more biased as exports contain a larger proportion of imported inputs. However, if the total and immediate skill coefficients are highly similar across industries, γ_{ix} is relatively less biased than γ_{im}.[9]

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[8]This problem is addressed below; an empirical perspective is provided in section 3.5.

[9]The similarity between the total and immediate factor requirements is established in Chapter IX.

To clarify this point, let us assume that the human skills theory is correct. We would expect a relatively skill abundant country to export relatively skill intensive products. The imported inputs for these exports also would be relatively skill intensive. However, if skill availabilities influence trade patterns, imported inputs would be relatively less skill intensive than the value added by the final stage of fabrication (measured by the immediate coefficients) of the export product. Since these imports are pulled by input demand, their skill intensity may exceed that of imports demanded for final consumption or investment purposes. This would cause γ_{ix} to be smaller than its "true" value (with imported inputs excluded), while γ_{im} would be "too large." (When a country has a relative abundance of unskilled labor, the direction of these biases would be reversed.) Similarity between the total and immediate skill coefficients would imply that γ_{ix} is not biased much while γ_{im} would become more biased as input demand pulls a larger proportion of total imports. Thus, γ_{ix} would measure skill intensity across countries better than γ_{im}, if the human skills theory is correct.

Differing domestic tariff structures and national demand patterns imply that export skill indexes are superior to import skill indexes. National import composition is affected greatly by these differences. Export composition, on the other hand, is influenced more uniformly across countries as these distortions are faced by all exporters. Therefore, skill indexes measured from export patterns will be used to relate skill intensity to relative national skill abundance.

The skill endowment rankings which provide the standard of comparison are compiled from international data on the occupational mix of each country's labor force. The ILO (10) provides this information. The relative skill endowment of each country is measured by calculating the ratio of skilled to unskilled workers in each country. Skilled laborers are assumed to be professional, technical, administrative, and clerical workers. Service, farm, and production workers comprise the unskilled portion of the labor force.

3.4 Empirical Evidence for the United States

Tables 3.1 and 3.2 provide detailed summaries of the labor content of U. S. exports and imports in 1975 by occupational groupings. Table 3.1 clearly shows that the United States is a net exporter of each type of skilled labor service while it net imports each type of unskilled labor service, for a balanced one million dollar bundle of manufacturing exports and imports. Since the United States is the most skill abundant country in the world (Table 3.7), these findings represent strong support for the human skills theory.

Table 3.1 refers to manufactures trade alone. When oil and other natural resource intensive products are entered in the export and import vectors, the United States no longer is revealed to net export each type of skilled labor services; nor does it net import each type of unskilled labor services. Yet it is precisely because of their natural resource intensiveness that these products were excluded. This point may be clarified by using oil as an example. "Crude petroleum and natural gas" products and "petroleum products"

TABLE 3.1.--U. S. Labor Requirements by Skill Classes, Per Million Dollars of Exports and Competitive Import Replacements (Total Requirements in man years, 1975 Manufactures Trade with the World)

Manufactures		Exports	Imports	Exports Minus Imports
I.	Scientists and engineers	2.80	2.08	.72
II.	Other professional, technical and managerial	9.13	8.45	.68
III.	Clerical and sales	12.33	12.01	.32
IV.	Craftsmen and foremen	12.07	11.64	.43
V.	Operatives	21.64	24.36	-2.72
VI.	Laborers (non-farm) and service	5.29	5.54	- .25
VII.	Farmers and farm laborers	.91	1.00	- .09
	TOTAL	64.17	65.08	- .91

SOURCE: Commodity Trade Statistics (Magnetic Tapes) and (12).

are skilled intensive relative to most other products. The United States and other countries, purchase oil from the countries which product it; but, is this because oil is a relatively skill intensive product? In fact, if the oil producing countries are at all skill abundant, it is largely due to the cooperation of multinational oil companies who have provided the skilled labor required by oil production. But we are trying to test a theory which implies that the direction of causation is the reverse of this. It is the relative immobility of the natural resource that makes the flow of factor services required to produce it irrelevant with respect to the theory. Nonetheless, the effect of adding oil and other natural resource products is revealed in Tables 3.2 and 3.3.

With oil included in the million dollar bundle, the United States imports relatively more skilled labor services than when we consider only manufactures trade. This occurs because the United States is a net importer of oil, which shows up as a skill intensive commodity. However, γ_3 alone reveals imports as skill intensive relative to exports. This index incorporates the smallest skill to unskilled dispersion. When other natural resources are added, U. S. imports are measured as relatively skilled intensive by γ_5 also.

The only index which includes farm labor (unskilled) is γ_5. However, 1975 U. S. trade is affected by large shipments of wheat to the U.S.S.R. In addition, U. S. imports of agricultural goods were down by 10% in 1975 compared to 1974. These factors tend to make U. S. net agricultural exports larger than "normal." Since agriculture is very unskilled intensive, these factors depress the skill

TABLE 3.2.--Distribution of U. S. Labor Requirements by Skill Classes per Million Dollars of Exports and Competitive Import Replacements (Total Requirements in percentages 1975 Trade with the World)

Skill Classes	Exports	Imports	Import/Export Ratio
I. Scientists and engineers			
All industries	3.38	3.31	.980
Excluding oil	3.37	2.79	.828
Manufactures	4.36	3.20	.733
II. Other professional, technical and managerial			
All industries	12.31	13.74	1.116
Excluding oil	12.28	12.50	1.018
Manufactures	14.22	12.99	.913
III. Clerical and Sales			
All industries	17.21	19.60	1.139
Excluding oil	17.15	17.57	1.025
Manufactures	19.22	18.46	.961
IV. Craftsmen and foremen			
All industries	15.42	15.93	1.033
Excluding oil	15.42	16.13	1.046
Manufactures	18.81	17.89	.951
V. Operatives			
All industries	27.04	31.00	1.147
Excluding oil	27.07	33.11	1.223
Manufactures	33.73	37.43	1.110
VI. Laborers (nonfarm) and service			
All industries	7.82	8.91	1.139
Excluding oil	7.81	8.73	1.118
Manufactures	8.25	8.51	1.031
VII. Farmers and farm laborers			
All industries	16.81	7.51	.447
Excluding oil	16.90	9.17	.543
Manufactures	1.42	1.53	1.080

SOURCE: See Table 3.1.

NOTE: The tabled values give the percentage distribution of the labor force, embodied in exports and imports, by occuaptional class for each of three balanced bundles of exports and imports, i.e., all industries, all industries-excluding oil, and manufactures.

TABLE 3.3.--Skill Ratio of U. S. Imports, Exports, and Imports/Exports for Various Skilled/Unskilled Ratios and for Selected Groupings of Industries. (Total requirements 1975 Trade with the World)

Exports	γ_1	γ_2	γ_3	γ_4	γ_5
All Industries	.4320	.4502	.4517	.0338	.3037
Excluding oil	.4315	.4485	.4507	.0337	.3022
Manufacturing	.5289	.4427	.5973	.0436	.4282
Imports	γ_1	γ_2	γ_3	γ_4	γ_5
All Industries	.3717	.4272	.4920	.0331	.3595
Excluding oil	.3196	.3653	.4581	.0279	.2997
Manufacturing	.3761	.3523	.5168	.0320	.3410
Imports/Exports	γ_1	γ_2	γ_3	γ_4	γ_5
All Industries	.8604	.9489	1.0892	.9800	1.1838
Excluding oil	.7406	.8145	1.016	.8279	.9868
Manufacturing	.7111	.7958	.8652	.7334	.7964

SOURCE: Table 3.2

Skill Ratios: γ_1 = I/VI, γ_2 = (I + II)/(V + VI)

γ_3 = (I + II + III + IV)/(V + VI)

γ_4 = I/(II + III + IV + V + VI + VII)

γ_5 = (I + II)/(V + VI + VII)

NOTE: For skill class definitions, see Table 3.2.

ratio of U. S. exports. Despite the anomalies created by large oil imports and large agricultural exports, the U. S. is shown to export skill intensive commodities by three of the five import/export test statistics when all industries are included. Still, the results for manufactures alone are considered the best test of the theory.

3.5 Revealed Factor Intensity: The Export and Import Patterns of Nineteen Countries

In this section we assess the proposition that the skill content of goods influences international trade. The approach used here is based on the method which Keesing first employed (4). The procedure does not require knowledge of the relative skill endowment of each country. In the next section we shall relate these findings to national skill endowments. As U. S. skill coefficients are used throughout, we assume that skill intensity reversals do not occur. The assumption becomes less reasonable as the country to which it is applied becomes less developed. Since we are considering export and import indexes separately, we have the problem of bias discussed in the previous section.[10]

Table 3.4 presents the skill indexes for the manufacturing exports and imports of the nineteen countries which comprise the sample. The correlations between the exports and import skill intensity rankings of nineteen countries are listed in Table 3.5. This table presents correlation coefficients for manufactures trade along

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[10]This bias should be relatively large for Hong Kong, Taiwan and Singapore. Hong Kong's import skill intensity ranking has been perverse in two previous studies (5,4).

TABLE 3.4.--Skill Indexes for Exports and Imports of Nineteen Countries' Trade in Manufactures (Total Requirements, 1975 Trade with the World)

Country	γ_{1x}	γ_{1m}	γ_{2x}	γ_{2m}	γ_{4x}	γ_{4m}	γ_{3x}	γ_{3m}	γ_{5x}	γ_{5m}
Ungrouped										
United States	.529	.376	.443	.352	.044	.032	.597	.517	.428	.341
Canada	.328	.425	.381	.386	.033	.035	.557	.556	.367	.374
Japan	.438	.275	.400	.358	.037	.030	.615	.480	.386	.327
EEC										
United Kingdom	.469	.378	.410	.370	.038	.033	.568	.519	.396	.353
West Germany	.424	.360	.394	.330	.035	.030	.576	.480	.381	.314
Netherlands	.457	.392	.408	.355	.038	.033	.565	.511	.391	.341
France	.401	.394	.371	.378	.034	.034	.543	.540	.357	.361
Italy	.364	.404	.324	.395	.029	.036	.493	.546	.312	.374
Belgium-Luxembourg	.338	.375	.351	.357	.030	.032	.517	.514	.335	.341
Denmark	.408	.392	.379	.379	.034	.034	.577	.554	.336	.363
Ireland	.386	.365	.358	.362	.030	.031	.483	.508	.210	.305
Other Europe										
Spain	.319	.451	.326	.431	.027	.039	.522	.583	.315	.413
Yugoslavia	.304	.401	.319	.393	.027	.035	.514	.573	.304	.376
Oceana										
Australia	.310	.439	.343	.395	.027	.036	.486	.544	.310	.379
New Zealand	.234	.439	.412	.292	.021	.037	.407	.573	.256	.394
Asia										
Hong Kong	.303	.391	.219	.337	.020	.031	.341	.462	.208	.311
Korea	.282	.419	.239	.403	.022	.038	.380	.564	.225	.377
India	.240	.421	.239	.443	.019	.038	.378	.607	.220	.428
Pakistan	.202	.389	.217	.403	.016	.035	.330	.581	.189	.376

TABLE 3.5.--Correlations Between Skill Indexes for Exports and Imports for Nineteen Countries (Total Requirements, 1975 Trade with the World)

Type of Correlation Coefficient	γ_1	γ_2	γ_3	γ_4
		Manufactures		
Spearman	-.556 (.007)	-.607 (.003)	-.391 (.049)	-.574 (.006)
Kendall	-.404 (.008)	-.462 (.003)	-.298 (.038)	-.439 (.005)
		Excluding Oil Intensive Industries		
Spearman	-.463 (.023)	-.498 (.015)	-.054 (.413)	-.193 (.215)
Kendall	-.322 (.028)	-.404 (.008)	-.088 (.300)	-.146 (.191)
		All Industries		
Spearman	-.361 (.065)	-.244 (.158)	+.056 (.410)	+.009 (.486)
Kendall	-.263 (.058)	-.170 (.156)	-.006 (.487)	-.0526 (.377)

NOTE: The correlations are between the skill intensity rankings of the exports versus the imports of the nineteen sample countries in Table 3.4. The export and import bundles were balanced with respect to each of the commodity groupings named above.

with, total trade, and total trade excluding oil. Since the indexes underlying the correlations are ordered high to low, we expect negative and significant correlations. Considering trade in manufactures alone, we find that both the Kendall and Spearman's coefficients are negative and significant, indicating that countries which export relatively skill intensive products import unskilled intensive products. Therefore, the skill content of goods influences trade patterns. If Hong Kong is omitted from the nineteen country sample, we find the relevant Spearman's correlations are: $\rho\gamma_1 = -.821$, $\rho_2 = -.891$, $\rho\gamma_3 = -.637$, $\rho\gamma_4 = -.851$. All are easily significant at the 1% level and all are substantially greater (in absolute value) than when Hong Kong is included.[11]

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[11]For Hong Kong, the export and import data concorded to the input-output sectors confirm the hypothesis that Hong Kong's imports are strongly related to its input demand for the products in which Hong Kong has an export advantage. Hong Kong is a large net exporter of apparel and hosiery and knit goods. It substantially net imports textile products of a more primary nature which are also rather unskilled intensive, but are important inputs for Hong Kong's textile exports. Although synthetic fibres are not relatively unskilled intensive, this product group is another example of Hong Kong's export advantage determining its import demand. In order to see if these results could be generalized, and to assess the magnitude of the bias of the γ_{im}'s, a crude index of the bias was constructed for the nineteen sample countries. Imports as a percentage of GDP provides the crude measure of bias. Although this does not directly relate the export demand for imported inputs to imports, the rankings by this measure, across countries, ought to be more or less correct. When this is done, we find γ_{im} is most biased for: (1) Hong Kong, (2) Ireland, (3) Belgium-Luxembourg, (4) the Netherlands, (5) Korea. For Hong Kong, the bias is exceptionally large as the value of its imports is nearly identical to its GDP. The least bias was found for: (1) U. S., (2) India, (3) Japan, (4) Australia, (5) West Germany. The association of bias with geographic country size is not surprising. The lack of association of bias with stage of development is notable.

When to our million dollar bundle we add natural resource intensive products--excepting oil--the proposition that the skill intensity of goods influences trade receives less support. Although the direction of the correlation is as we expect for all skill indexes, γ_3 does not meet the usual standards for significance. The lack of importance of scientists and engineers, in determining the trade flows of natural resource intensive products (excluding oil), is indicated by the decline in significance of $\rho\gamma_4$ when these products are included in the million dollar bundles.

When oil intensive products are included, the significance of all the correlation coefficients declines. Several Spearman's coefficients (for γ_3 and γ_4) appear with perverse positive signs although they are not significant. Obviously, the is due to the relative importance of oil in the import bundles of the developed and relatively skill abundant countries which are predicted to export, not import, skill intensive commodities such as oil. We have explained how the inclusion of natural resource intensive products can subvert the analysis, and shown that their admission has that effect. We shall, therefore, proceed to focus on manufactures and ignore all natural resource intensive products, including oil.

Considering trade in manufactures again, Table 3.6 presents the usual factor proportions test statistic ($\gamma_{ir} = \gamma_{im}/\gamma_{ix}$) for our sample of nineteen countries. In view of our previous discussion, it is satisfying to note that Hong Kong is a net importer of unskilled labor services. It is worth repeating that the values in Table 3.6 are biased in terms of their value, but are accurate with respect to

TABLE 3.6.--Skill Index Ratios of γ_{im}/γ_{ix} Derived from Nineteen Countries' Trade in Manufactures (Total Requirements. 1975 Trade with the World)

Country	γ_{1r}	γ_{2r}	γ_{3r}	γ_{4r}	γ_{5r}
Ungrouped					
United States	.711	.796	.865	.733	.796
Canada	1.299	1.014	.998	1.079	1.020
Japan	.629	.896	.780	.799	.849
EEC					
United Kingdom	.805	.901	.913	.868	.891
West Germany	.850	.839	.833	.843	.824
Netherlands	.859	.871	.905	.874	.871
France	.983	1.109	.994	1.001	1.011
Italy	1.109	1.220	1.107	1.227	1.201
Belguim-Luxembourg	1.108	1.015	.994	1.062	1.019
Denmark	.962	.999[1]	.960	1.020	.993
Ireland	.946	1.010	1.052	1.025	1.454
Other Europe					
Spain	1.413	1.323	1.118	1.444	1.313
Yugoslavia	1.317	1.234	1.114	1.281	1.237
Oceana					
Australia	1.419	1.154	1.119	1.304	1.221
New Zealand	1.876	1.410	1.407	1.751	1.537
Asia					
Hong Kong	1.289	1.535	1.357	1.564	1.492
Korea	1.487	1.681	1.482	1.743	1.673
India	1.756	1.856	1.605	2.041	1.941
Pakistan	1.924	1.856	1.759	2.270	1.987

[1]This ratio, if rounded to three decimal places, is equal to unity.

whether they are greater or less than one. In Table 3.6 $\gamma_{ir} < 1$ designates countries with relatively skill intensive exports, while $\gamma_{ir} > 1$ implies relative unskilled labor intensity. The United States, Japan, West Germany, the Netherlands, and the United Kingdom are shown to export skill intensive commodities by every ratio. This corresponds to our casual intuitive knowledge of their relative skill abundance. Denmark, Canada, France, and Belgium-Luxembourg exhibit a skill intensive pattern according to at least one ratio. The problem of bias notwithstanding, it is encouraging to find that Pakistan, India, and Korea are indicated as having the least skill intensive exports of all nineteen countries in our sample by nearly every ratio of skill indexes.

3.6 Skill Endowments and Revealed Skill Intensity

In this section we will perform the most critical skills test. Although we already possess ample evidence that skills influence international trade patterns, unless these findings can be linked to countries' skill endowment rankings, the previous evidence is little more than an interesting statistical finding.

The skill endowment index is constructed from national occupational groupings provided by the ILO (10). These data are highly inclusive of service professionals (such as ministers) in the most skilled occupational class. Thus, inferring endowment rankings from the percentage of workers in this class alone is a tenuous procedure, although it has been done (4). Instead, Table 3.7 employs a more inclusive index which ought not be as sensitive to ILO classification

TABLE 3.7.--Skill Endowment Rankings and Skill Intensity Rankings (γ_{ix}) of the Exports Seventeen Countries 1975

Endowment Rank	Country[1]	Endowment Index	γ_{1x}	γ_{2x}	γ_{3x}	γ_{4x}	γ_{5x}
1	United States	.814	1	1	7	1	1
2	Canada	.804	11	6	2	8	6
3	Netherlands	.617	3	3	6	2	3
4	United Kingdom	.598	2	2	5	3	2
5	Germany	.555	5	5	4	5	5
6	Japan	.522	4	4	1	4	4
7	Belgium-Luxembourg	.505	10	10	10	10	9
8	Denmark	.444	6	7	3	7	7
9	France	.443	7	8	8	6	8
10	Ireland	.342	8	9	13	9	15
11	Italy	.274	9	12	12	11	11
12	Hong Kong	.216	15	16	16	15	16
13	Spain	.209	12	11	9	13	10
14	Yugoslavia	.200	13	13	11	12	12
15	Korea	.128	14	14	14	14	13
16	India	.075	16	15	15	16	14
17	Pakistan	.059	17	17	17	17	17
Spearman's correlation between endowment and revealed rank			+.846 (.01)	+.919 (.01)	+.804 (.01)	+.907 (.01)	+.887 (.01)

SOURCE: ILO (10), and Table 3.4.

[1]New Zealand and Australia are omitted. If included, Australia would rank fourth and New Zealand seventh in the expanded sample. Australia's γ_{ix} rank is consistently about 12 while New Zealand's is about 16. When inlcuded in the rank correlations, all are positive and significant at the 1% level, but range in value from around .65 to 75.

[2]SKILL ENDOWMENT INDEX--(Professional, technical, administrative and clerical)/(service, farm, and production workers)

problems. Others may be calculated, but due to the classification problem, they are less reliable in their correspondence to the actual (but unknown) skill endowment ranking of countries. The endowment index used in Table 3.7 considers professional, technical, administrative and clerical workers as skilled. Service, farm, and production workers are treated as unskilled. With the shortcomings of the data in mind, the resulting rankings are considered to be as accurate as the data allow.

The theory predicts that we will find a positive correlation between the endowment and skill intensity rankings.[12] The appropriate rankings and corresponding correlation coefficients appear in Table 3.7. The correlations are very high, positive, and significant. These results, which strongly favor the theory, are somewhat less striking when the two omitted countries, Australia and New Zealand, are included. These countries, although clearly developed, are not highly industrialized. However, the ILO data are suspect for several reasons. First, Australia has, over the least decade, made a concerted effort to attract skilled labor by offering to skilled professionals, free round trip transportation if they remained in the country for a specified number of years. Yet, Hufbauer (4) estimated Australia's skill endowment ranking as third among these same countries in the early 1960's. (New Zealand ranked sixth at that time.) The relatively high ranking does not appear consistent with Australian policy for the ensuring period. For this reason, the Australian

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[12]The γ_{ix} measures of skill intensity are used as they are less biased than the γ_{im} indexes.

ranking is suspected of being incorrect. Lacking an alternative ranking criterion, both countries are omitted from the test.

In terms of individual countries, the skill indexes for Canadian exports alone are persistently out of line with the endowment ranking. No country falling lower than 10th in the endowment ranking is ever revealed to be a net exporter of skilled labor services (Table 3.6). Also, every country in the top ten is shown to export relatively skilled labor intensive commodities according to at least one skill ratio. Although the endowment rankings roughly approximate the ranking of countries according to the size of γ_{ir} (Table 3.6), Canada's trade patterns are generally more akin to those of a less skill endowed country. Japan trades as if it were more highly endowed with skill.

3.7 A Three Factor Revealed Approach to the Assessment of Trade Patterns: Evidence For Ten Countries

Thus far, we have conducted out tests as if only two factors of production exist: skilled and unskilled labor. However, it has been suggested that a three factor, factor proportions model best explains trade patterns. Recently Branson and Junz (2) have offered this hypothesis after finding a significantly negative coefficient for the capital/labor ratio in their multiple regression analysis of

U. S. trade. Since a similar finding is made in Chapter IX, we shall construct a three factor model.[13]

The total requirements for capital were computed by using the gross book value of capital augmented by working capital in the form of materials and work in progress. Finished goods inventories are treated as if held for the industry about to consume them and distributed to the consuming industry using the input-output table (direct requirements). This yields the immediate capital stock for all industries. The capital stock is converted to a flow by dividing it by the value of shipments for industry j, call this k_j. Using the same input-output notation as earlier,

$$\sum_{j=1}^{n} \left(\sum_{j=1}^{n} k_j \cdot r_{ij} \right) X_j = K_{tx} \qquad (3\text{-}15)$$

where, K_t is the total requirement of capital (measured in thousands of dollars) to produce one million dollars worth of exports.

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[13]Although both the multiple regression and input-output tests begin with some underlying data set, there is little statistical evidence which would lead us to believe that each test--of the same theory--would produce the same results. The multiple regression analysis is based solely on capital/labor ratios. The input-output analysis, although employing these same ratios sums the flow of capital services by means of the capital/output ratio weighted by the percent of exports (or imports), and divides it by a similarly derived measure for labor services (of each type). Since the multiple regression analysis completely ignores capital/output and labor/output ratios, corresponding results between the two tests is by no means assurred. We will compare the results of this chapter to those of Chapter IX in the latter chapter. The choice of countries for this test was determined by the findings in Chapter IX. Countries for which the capital/labor ratio was significant in the multiple regressions are included here, as are those countries for which the skills variables did not "work" as well as expected.

Replacing X with M in equation (3-15) yields the comparable import requirement of capital, K_{tm}. To obtain capital/skilled labor and capital/unskilled labor ratios the K_{tx} and K_{tm} values are divided by the respective $\Sigma(S_t)_x$ and $\Sigma(S_t)_m$ values [equations (3-3) and (3-4)] which are summed over the relevant t's. For this analysis occupational classes I, II, III, and IV are designated at skilled V, VI, and VII are unskilled. U. S. capital and labor coefficients are used to measure the relative skill intensity of manufactures trade.

The results of the three factor calculations are presented in Table 3.8. The U. S. is revealed to have relatively more skill embodied in its exports than its imports. Relative to imports, U. S. exports are also more skilled than capital intensive, but more capital intensive then unskilled. Thus, the factor intensity ordering revealed by the U. S. trade flow is, skilled labor > physical capital > unskilled labor. Canada is shown to derive its greatest advantage from capital intensive industries; its greatest disadvantage is in labor intensive industries. It is well known that Canada trades most intensively with the U. S. Transportation costs are certainly one reason for this. However, if we accept the three factor model and the relative factor abundance which these calculations imply for both the U. S. and Canada, we find another, if somewhat unconventional, explanation for U. S.-Canadaian trade. The U. S. derives its greatest advantage from the same factor in which Canada is most scarce, skilled labor. Therefore, relatively skill intensive exports from the U. S. are readily absorbed by Canada, since Canada needs to import the services of relatively scarce skilled

TABLE 3.8.--Revealed Relative Factor Intensity with Three Factors: Capital, Skilled Labor, and Unskilled Labor--Manufactures Trade (Total Requirements, 1975 Trade with the World)

	x	m	m/x	x	m	m/x
	United States			Netherlands		
sk/un	1.31	1.11	.848	1.22	1.09	.886
k/sk	19.74	21.13	1.070	23.10	21.30	.921
k/un	25.76	23.38	.908	28.27	23.11	.818
k/l	11.18	11.108	.994	12.71	11.08	.872
	United States: sk > k > un			Netherlands: k > sk > un		
	New Zealand			Japan		
sk/un	.86	1.25	1.452	1.29	1.00	.780
k/sk	26.02	21.58	.829	21.90	21.48	.981
k/un	22.44	27.02	1.204	28.21	21.56	.761
k/l	12.05	12.00	.996	12.33	10.76	.823
	New Zealand: un > k > sk			Japan: k > sk > un		
	Australia			Korea		
sk/un	1.04	1.18	1.137	.77	1.18	1.54
k/sk	25.27	19.75	.781	19.95	22.83	1.15
k/un	26.32	23.33	.888	15.30	27.02	1.77
k/l	12.89	10.72	.832	8.66	12.37	1.43
	Australia: k > un > sk			Korea: un > sk > k		

TABLE 3.8.--Continued

	x	m	m/x	x	m	m/x
	Yugoslavia			Canada		
sk/un	1.053	1.23	1.167	1.19	1.20	1.011
k/sk	22.32	23.52	1.053	22.78	18.94	.831
k/un	23.51	28.91	1.230	27.04	22.73	.840
k/l	11.45	12.97	1.133	12.37	10.33	.836
	Yugoslavia: un > sk > k			Canada: k > un > sk		
	Denmark			Belgium-Luxembourg		
sk/un	1.22	1.17	.961	1.11	1.11	.992
k/sk	18.96	21.66	1.413	23.39	20.92	.894
k/un	23.11	25.38	1.098	26.05	23.12	.887
k/l	10.41	11.69	1.122	12.32	10.98	.891
	Denmark: sk > un > k			Belgium-Lux.: k > sk > un		

NOTE: sk = skilled laborers, classes I, II, III, and IV (man years)

un = unskilled laborers, classes V, VI, VII (man years)

k = physical capital (thousands of dollars)

l = total labor (man years)

laborers. The relative abundance of capital provides Canada with an advantage in a factor which is neither most abundant nor scarce in the U. S. The U. S. may be said to be indifferent to the absorbtion of this factor. Given that neither country is relatively abundant in unskilled labor, it is most likely that their bilateral trade patterns will be governed by the factors in which each has the greatest relative advantage. The relative unimportance of transport costs will tend to make small advantages relatively more important in determining their bilateral trade.

The Netherlands exhibits a strong skill pattern in its trade as well as its endowment ranking (Table 3.7), but its trade flows are found to be even more intensive in capital than skilled labor. The trade patterns of Australia, Japan, and Belgium-Luxembourg are capital intensive relative to both skilled and unskilled labor. Denmark, Korea, and Yugoslavia exhibit a factor content of trade which implies that they lack capital relative to the other factors of production.

3.8 Conclusion

The two factor skills theory is very consistent in its correspondence to several theoretical predictions; the skill content of exports with respect to imports, the skill index for exports with respect to the relative endowment rankings of nations, and the national endowment rankings with respect to the ratio of the skill-import/skill-export indexes. With the exception of Canada, all of the anomalies can be accounted for. As predicted, when natural resources are included, the skills theory does not explain the commodity composition of trade as well.

The relative endowment rankings which are revealed by the three factor model and accepting the three factor version of the theory, produces some interesting results. The relative factor endowment rankings for the U. S. are exactly as expected. When coupled with the revealed Canadian endowment position, we find a very unconventional explanation for U. S.-Canadian trade. The three factor approach is useful in explaining the Leontief paradox. We infer that physical capital is neither relatively scarce nor relatively abundant from U. S. manufacturing trade. In a two factor sense, the relative capital content of U. S. trade is stable. A 1962 study of U. S. manufacturing trade, showed the capital/labor ratio for imports divided by that for exports to equal .99 (1). For 1975, that ratio is unchanged (Table 3.8).

The form of this three factor model is different from any other that has been used in the past. Usually human capital is estimated, and combined with the physical capital stock. The approach used here is considered superior for several reasons. First, it has greater value in use. Occupational groupings can be made very detailed. Since they are rather objective and uniform, we can link comparative advantage to specific and identifiable characteristics in the economy. Second, the human capital tests could be performed from the occupational data by assigning to each class its average wage rate.

REFERENCES

1. Baldwin, R. "Determinants of the Commodity Structure of U. S. Trade." American Economic Review (June 1974): 122-46.

2. Branson, W. and Jung, H. "Trends in U. S. Trade and Comparative Advantage." Brookings Papers on Economic Activity 2 (1971): 285-346.

3. Carter, A. Structural Change in the American Economy. Cambridge, Massachusetts: Harvard University Press, 1970.

4. Hufbauer, G. "The Commodity Composition of Trade in Manufactured Goods." In The Technology Factor in International Trade. Edited by R. Vernon. New York: NBER, Columbia University Press, 1970.

5. Keesing, D. "Labor Skills and International Trade: Evaluating Many Trade Flows with a Single Measuring Device." Review of Economics and Statistics (August 1965): 287-94.

6. ________. "Labor Skills and Comparative Advantage." American Economic Review (May 1966): 249-58.

7. ________. "Labor Skills and the Structure of Trade in Manufacturers." In The Open Economy. Edited by Keven and Lawrence. New York: Columbia University Press, 1968.

8. ________. "Different Countries Labor Skill Coefficients and the Skill Intensity of International Trade." Journal of International Economics (January 1971): 443-52.

9. Miernyke, W. The Elements of Input-Output Analysis. New York: Random House, 1965.

10. International Labor Office, Yearbook of Labor Statistics. Geneva, 1975.

11. Internal Revenue Service. Corporate Income Tax Returns, 1970.

12. U. S., Bureau of the Census. Census of the Population by Industry by Occupation, 1970.

13. U. S., Bureau of the Census. Annual Survey of Manufacturing, 1970.

14. U. S., Department of Commerce. Survey of Current Business. November, 1974.

15. U. S., Department of Commerce. Wholesale Prices and Price Indexes, 1975.

CHAPTER IV

THE SCALE ECONOMY THEORY

4.1 The Theory

Of the several possible versions of the scale economy hypothesis, we are concerned with scale economies internal to the plant. When scale economies are present, large plant size confers a comparative cost advantage to producers.

In the pre-trade stage, home market size is a factor if plants as large as the most efficient size elsewhere cannot be supported. If scale economies do not persist across all sizes of plants, domestic producers in small countries may not be able to satisfy a given level of domestic demand with plants of optimum scale. As home demand grows, firms are faced with the choice of building new establishments or adding capactiy to existing optimally sized plants. Thus, the size of the home market may be important in the pre-trade stage. But when the economy is opened and trade is allowed, the potential market is expanded. However, except for products that are highly standardized, it is unlikely that producers in small countries will be able to depend on the foreign market (6).

Several recent studies provide empirical support that home market size is important when internal economies exist. The average employment size of manufacturing establishments across industries is strongly correlated with indicators of market size (15,16). This highlights the obstacles small nations face in achieving industrial efficiency when scale economies are important. Suppose, for a given industry, the distribution of plant takes the same shape across countries. Figure 4.1 illustrates the effect of market size on these distributions. Country B, having a relatively larger market, also has a larger average plant size. Exporters gain their advantage due to their size, given the level of scale economies in this industry. Thus Country B, having a larger proportion of its firms reaping scale benefits, has an advantage compared to A. Suppose we denote S_0 as the minimum scale necessary for a firm to absorb transport costs, penetrate tariff barriers and compete in the foreign market. Then, being larger than Country A, Country B has absolutely more plants in a given size class, even when the relative frequency of plants is the same in each country, thus B has relatively more plants which reap the advantage. This effect also operates for B's less efficient firms; however, they are partially protected by existing tariff and quota barriers.

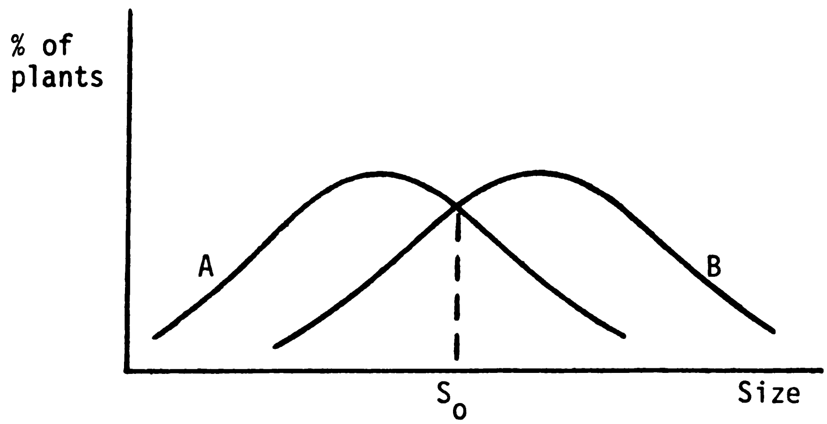

Figure 4.1.--Hypothetical Distribution of Firms in Two Countries.

When scale economies are internal, the assumption of perfect competition must be dropped in order to explain the survival of sub-optimal plants (4, p. 134). Caves, Khalilzadeh-Shirazi and Porter have proposed that a price umbrella is maintained by dominant sellers. If this assumption is correct, we expect to find producers, who export and service the home market, earn relatively larger profits. Empirical evidence consistent with this hypothesis has been found. United Kingdom exports as a percentage of industry output are both positively and significantly associated with the profit rate in the industry (4, p. 137).

4.2 Internal Economies: Previous Empirical Tests

The scale economy theory has been tested by measuring "scale" as the proportion of an industry's employees working in establishments with 250 or more employees (1). Using net exports as the dependent variable in regressions estimated across industries, this variable failed to emerge as a significant determinant of the commodity composition of U. S. trade. The coefficient of the scale variable was negative for U. S. trade with the world, "others," Western Europe and Japan; significantly negative for the last two. The scale hypothesis was weakly confirmed by U. S. trade patterns with Canada and the LDC's; neither coefficient was significant. Input-output analysis was employed to calculate the relative plant size embodied in U. S. exports and import replacements. This technique revealed U. S. exports as relatively more scale intensive then imports. Excluding agricultural commodities decreased the relative importance of scale embodied in exports compared to imports.

These test results indicate either, that scale economies are not determinants of U. S. trade patterns, or that size alone is not a sufficient proxy for scale economies. A simple measure of internal scale economies in an industry has been proposed by Hufbauer (6). The extent of scale economies internal to the plant are measured by alpha in the following equation:

$$V_i = kn_i^{\alpha} \tag{4-1}$$

where, V_i represents the ratio between value added per man for the employment size class i and the average value added per man for all establishments in the four digit industry.

n represents the average number of workers employed per establishment in size class i;

k is a constant

α represents the scale elasticity parameter.[1]

Therefore, $\alpha = .05$ implies that a doubling of plant size increases output per worker by 5 percent. The scale elasticity parameters estimated by Hufbauer (6) have been employed frequently to test the scale economy theory (2,3,6,8,17).

Using scale elasticity parameters, the scale account has been tested in isolation by relating the scale embodied in a nation's manufactured exports to the size of national manufacturing output (6).

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[1]The potential biases inherent in this measure are fully discussed in Chapter V.

The scale content of exports is estimated by $\sum_j \alpha_j X_j$ where X_j is the proportional weight of commodity j in a nation's manufactured export bundle; α_j is the scale elasticity parameter for industry j. These calculations were performed at the three digit SITC commodity level for 102 SITC's (classifications 5, 6, 7, and 8). For a sample of 24 nations, the rankings between the scale intensity of exports and national manufacturing output were positively, but insignificantly correlated.[2] However, rank correlations between the scale intensity of exports and per capita gross domestic product produced a positive and significant rank correlation. This indicates that scale economy benefits are associated with industrial sophistication, but provides no support for the scale economy account.

Branson and Junz used the scale elasticity parameter in regressions estimated across 101 three digit SITC manufacturing industries (2). Human capital, physical capital, and a measure of technological intensity were also employed as independent variables. The coefficient of the scale elasticity parameter was positive and significant thereby explaining 1964 and 1967 U. S. net exports. In a subsequent study, Branson scaled the dependent variable, using X/(X + M) across industries. When this is done the coefficient of the scale elasticity parameter is no longer significant although it is always positive (3).

This scale economy measure achieved better results when the U. S. share of developed countries' exports was used as the dependent

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[2]Viewing national market size as a proxy for average national plant size, this serves as a test of the scale economy account.

variable and regressions were estimated across industries (17). The positive and significant (1 percent level) coefficient of the scale measure indicates that scale economies were a determinant the commodity composition of U. S. trade in 1960 and 1967.

Using the scale elasticity parameter in a different context, Katrak has argued that whenever

$$(N_i^a/N_i^b)^{\alpha i} > (N_j^a/N_j^b)^{\alpha j} \qquad (4\text{-}2)$$

country a's exports of commodity i will be relatively greater than country b's (8, p. 342). In the equation, N_i is the number of employees in the ith industry; α_i is the scale elasticity parameter of the ith industry; the superscripts represent the country. Rank correlations between 1962 U. S./U. K. exports to the world and the relative scale effect produced correlation coefficients of .59 and .76 for seventeen and fourteen manufacturing industries respectively. Both results are significant at the 5 percent level.

The relative scale variable, $(N_j^a/N_j^b)^{\alpha_j}$, was also employed in multiple regression analysis. It significantly explained U. S./U. K. exports. The relative scale variable performed significantly irrespective of the industry groupings, the functional form of the equation, and the year of observation (1962, 1964, 1966). The scale elasticity parameter, and relative industry size were entered separately in the regressions in conjunction with the same other independent variables. The relative scale effect, embodying both relative size and scale was found to perform better than either size or scale alone.

This is strong empirical evidence, however, the theoretical basis (that the entire output of a nation's industry is produced in a single plant) is questionable. Yet, the finding that industry size and the average employment size of the industry's plants are highly correlated alows N_j^a/N_j^b to be interpreted as a proxy for relative average plant size, thus imparting stronger economic significance to Katrak's findings.

4.3 Conclusion

The most general conclusion based upon empirical evidence is that size or relative size (industry or plant) is not a sufficient criterion by which to measure scale economies. A measure of the scale intensity of industries is essential. If the scale elasticity parameter is to be used, it ought to be in conjunction with a measurement of relative plant size. For tests performed in the aggregate, (such as Hufbauer's) market size may serve as a proxy for plant size due to the empirical relationship between the two measures (6). Nonetheless, it seems desirable to explicitly incorporate relative plant size by following the procedure established by Katrak. This test form creates the best direct linkage between the theory and the empirical test.

REFERENCES

1. Baldwin, R. "Determinants of the Commodity Structure of U. S. Trade." American Economic Review (March 1971): 126-46.

2. Branson, W., and Junz, Helen. "Trends in U. S. Trade and Comparative Advantage." Brookings Papers on Economic Activity (1971): 285-346.

3. ________. "U. S. Comparative Advantage: Some Further Results." Brookings Papers on Economic Activity (1971): 754-9.

4. Caves, R.; Khalilzadeh-Shirazi, J.; and Porter, M. "Scale Economics in Statistical Analysis of Market Power." Review of Economics and Statistics (May 1975): 133-140.

5. Hufbauer, G. C. Synthetic Materials and the Theory of International Trade. Cambridge, Mass.: Howard Printing Press, 1966.

6. ________. "Factor Endowments, National Size, and Changing Technology: Their Impact on the Commodity Composition of Trade in Manufactured Goods." In The Technology Factor in International Trade. Edited by R. Vernon. New York: Columbia University Press, 1970.

7. Jones, R. "Variable Returns to Scale in General Equilibrium Theory." International Economic Review (October 1968): 261-72.

8. Katrak, H. "Human Skills R and D and Scale Economies in the Exports of the United Kingdom and the United States." Oxford Economic Papers (November 1973): 337-60.

9. Keesing, S. B. "Population and Industrial Development: Some Evidence from Trade Patterns." American Economic Review (June 1968): 448-455.

10. Kemp, M. C. The Pure Theory of International Trade and Investment. New Jersey: Prentice Hall, 1969.

11. Matthews, R. C. O. "Reciprocal Demand and Increasing Returns." Review of Economic Studies (February 1950): 149-58.

12. Meade, J. E. A Geometry of International Trade. London: George Allen & Unwin Ltd, 1952. Chapter V.

13. Ohlin, B. Interregional and International Trade. Rev. Edition. Cambridge, 1967.

14. Owen, N. "Scale Economics in the EEC." European Economic Review (July 1976): 144-63.

15. Pryor, F. L. "The Size of Production Establishments in Manufacturing." Economic Journal (June 1972): 657-66.

16. Scherer, F. M. "The Determinants of Industrial Plant Sizes in six Nations." Review of Economics and Statistics (May 1973): 135-45.

17. Weiser, L., and Jay, Keith. "Determinants of the Commodity Structure of U. S. Trade: Comment." American Economic Review (June 1972): 459-66.

CHAPTER V

AN EMPIRICAL TEST OF THE SCALE ECONOMY THEORY

5.1 Introduction

In this chapter two tests of the scale economy theory are performed. The first test uses the concept of scale elasticity parameters introduced by Hufbauer (3) in conjunction with input-putput analysis to assess the trade patterns of nineteen countries. The second employs multiple regression analysis to inspect the scale economy hypothesis for U. S. trade. The analysis is limited to trade in manufactures.

5.2 Methodology

Scale elasticity parameters are utilized to measure the extent of scale economies in each industry. The data are from the recently completed 1972 Census of Manufactures. This census reports the relevant data by the employment size class of establishments. The value added and employment statistics are arranged in employment size classes for establishments ranging in size from one to four employees up to 2,500 (plus) employees. The four digit Standard Industrial Classification (SIC) constitutes the level of disaggregation generally available. Over 300 manufacturing industries were utilized in the analysis. The scale elasticity parameter, α is defined by the following equation:

$$v_i = kn_i^{\alpha} \tag{5-1}$$

where: v_i is the value added per worker in the i^{th} class size,

n_i is the average employment size of establishments in the i^{th} class size,

k is the constant.

The regression equation which was estimated is,

$$\ln v_{ij} = \ln k_j + \alpha_j \ln n_{ij} + e_{ij} \tag{5-2}$$

where: e_{ij} is the error term.

This equation was estimated across establishment class sizes, i, for each SIC industry, j. Use of the scale elasticity parameters implies that increases in value added per worker due to increased plant size are passed on in the form of lower prices. However, other factors, unaccounted for in (5-2), affect output per worker; therefore, the estimates of the scale elasticity parameter may pick up the effects of these omitted variables. Possible sources of bias are:[1]

1. Heterogeneous product mix. Within a given four digit industry different plants may produce different products. If relatively skill intensive or capital intensive products are associated with large plants, $\hat{\alpha}$ is biased upward. If the association is with smaller plants, $\hat{\alpha}$ is biased downward.

2. Varying Factor Proportions. Among plants producing the same product, different qualities of labor or different mixes of

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[1]Presented in Hufbauer (3).

capital to labor may be systematically associated with plant size. If skilled labor intensiveness and capital intensiveness are associated with large plants, $\hat{\alpha}$ is biased upwards. If the association is with smaller plants, the bias is downward.

3. Technology. If larger plants tend to be newer plants, $\hat{\alpha}$ will reflect the effects of improved technology and overstate the measured scale effect.

4. Market Power. To the extent that market power may affect the analysis, it will impart an upward bias to $\hat{\alpha}$, as market power is derived from size.

The estimated values of α_{ij} are concorded to the input-output classification and weighted by the employment size of each industry in the I-O sector in order to get one scale measure (α_w) to represent the sector. However, according to the input-output relations specified by the table, each industry absorbs a portion of the output of other industries to utilize as inputs.[2] To take account of this, it was assumed that any scale economy benefits are passed on to the consuming industry. Therefore, the α_{wj}'s (j = input-output sector) are weighted by the elements of the total requirements matrix, r_{ij}, thus:

$$\alpha_{tj} = \sum_i (\alpha_{wi} \cdot r_{ij}) / \sum_i r_{ij} \qquad (5\text{-}3)$$

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[2]The use of an input-output table to test a scale economy theory implies a basic contradiction. Here, the input-output table is viewed as a tool which measures the interrelationships of industries at a point in time. Curvilinear isoquants are assumed to exist; the input-output table identifies a point on each isoquant for each industry.

measures the total scale economy benefits enjoyed by industry j. Considering a balanced export and import bundle, the tendency of nations to have an advantage or disadvantage in scale intensive products is measured by:

$$R_s = \frac{\sum_j \alpha_{tj} \cdot m_j}{\sum_j \alpha_{tj} \cdot x_j} \qquad (5\text{-}4)$$

where, x_j is the value of exports of commodity j in a million dollar export bundle
m_j is the value of imports of commodity j in a million dollar import bundle

Thus, R_s measures the scale content of imports relative to exports.

5.3 Empirical Test of the Scale Economy Theory: Nineteen Countries

Lacking plant size data across the sample countries, it will be assumed that average plant size is larger and therefore, scale economy benefits are greater, the larger is the domestic market.[3] National manufacturing employment is the best index of market size by which to test the theory. Value added in manufacturing may also be used; however, it provides an inferior test as it contains the scale effect which the theory explains. Table 5.1 presents the scale content index and several relevant national characteristics. The correlation between manufacturing employment and this index is positive

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[3]Pryor (6) has found that the average employment sizes of manufacturing establishments are positively correlated with indicators of market size.

TABLE 5.1.--Scale Economy Relationships to National Characteristics (1975 Manufactures Trade)

Country	R_s	Rank[1]	National Characteristics: Per Capita GDP $ (000)	Rank[2]	Manufacturing Employment (000) man years	Rank[2]	Value Added in Manufacturing $(000,000)	Rank[2]
Ungrouped								
United States	.802	6	6,463	2	18,772	1	402,800	1
Canada	1.230	11	6,597	1	1,715	9	31,151	7
Japan	.479	1	4,152	10	10,998	2	106,885	3
EEC								
United Kingdom	.597	3	3,375	11	7,565	4	62,856	5
West Germany	.489	2	6,198	3	8,021	3	156,930	2
Netherlands	1.214	10	5,109	7	1,090	14	15,407	8
France	.624	4	5,067	8	5,748	5	87,042	4
Italy	.633	5	2,706	12	3,577	7	34,784	6
Belgium-Luxembourg	.908	8	5,480	6	1,133	13	14,168	10
Denmark	1.333	13	6,020	4	426	18	5,273	13
Ireland	1.527	14	2,176	13	917	15	1,265	17
Other Europe								
Spain	.841	7	1,829	14	2,083	8	13,384	11
Yugoslavia	1.608	15	1,162	16	1,533	10	5,692	12
Oceana								
Australia	7.382	19	5,693	5	1,274	11	14,229	9
New Zealand	.996	6	4,417	9	238	19	1,899	16

TABLE 5.1.--Continued

Country	R_s	Rank[1]	National Characteristics					
			Per Capita GDP $ (000)	Rank[2]	Manufacturing Employment (000) man years	Rank[2]	Value Added in Manufacturing $(000,000)	Rank[2]
Asia								
Hong Kong	2.105	16	1,566	15	614	16	549	18
Korea	4.630	17	504	17	1,137	12	2,850	15
India	1.312	12	120	19	4,803	6	4,131	14
Pakistan	4.939	18	134	18	427	17	530	19
Spearman's Rank Correlation Between Characteristics and R_s			+.359		+.688		+.777	
Significance			(.15)		(.01)		(.01)	

SOURCE: U. N. Statistical Yearbook

NOTE: All currency conversions use 1975 midpoint exchange rates

R_s equals ratio of scale embodied in imports to scale embodied in exports.

[1]Ranked low to high

[2]Ranked high to low

and significant, indicating support for the theory. Among those nations whose scale content of exports exceeds that for imports ($R_s < 1$) only Belgium-Luxembourg and New Zealand have relatively small markets. However, among that group of countries whose exports are relatively scale intensive, these two countries have the smallest scale content index. Judging from India's employment size ranking, its performance is perverse.

Also in Table 5.1, the rank correlation between domestic value added in manufacturing and the scale content index is presented. The correlation is positive and significant. Although this does not constitute as sound a test of the theory, it shows that the relative amount of domestic output is highly associated with the extent to which a country reaps scale economy benefits. The last rank correlation in the table, between per capita GDP and R_s, indicates that the level of economic sophistication is positively associated with scale economy benefits. This may be the reason why value added in manufacturing is more closely correlated with scale economy benefits than manufacturing employment. Rankings by national value added differ from national employment rankings due to differences in relative national capital and skilled labor abundance, in addition to any scale effect.

5.4 Empirical Examination of the Scale Economy Theory: The United States

Although the evidence in the previous section supports the scale economy hypothesis, in this section the issue is explored in greater detail. Here, relative plant size is accounted for, then multiple regression analysis is used to test for the significance of the scale effect.

In the previous section an aggregate proxy for national plant size was utilized to provide a test of the scale economy theory. Here average plant size data for five countries[4] is used as a measure of average foreign plant size. If scale economies exist, the nation with the largest average size of plants should have a relative advantage. For the U. S. this hypothesis was tested by calculating,

$$\beta_j = \sum_i [(\frac{n_{usi}}{n_{fi}})^{\alpha_{wi}} \cdot r_{ij}] / \sum_i r_{ij} \qquad (5\text{-}5)$$

and

$$R_\beta = \frac{\Sigma \beta_j \cdot M_j}{\Sigma \beta_j \cdot X_j} \qquad (5\text{-}6)$$

where: n_{usi} is the average plant size in the U. S. in industry i

n_{fi} is the average foreign plant size in industry i

r_{ij} is an element in the total requirement input-output table

α_{wi} is the weighted scale elasticity parameter for the i^{th} industry

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[4]The countries are France, Italy, Belgium, Netherlands, and Canada (5).

Thus, $(\frac{n_{usi}}{n_{fi}})^{\alpha_{wi}}$ is the relative U. S. scale advantage in industry i. Therefore, β_j is total relative scale economy benefit enjoyed by industry j under the assumption that scale economy benefits are passed on to the consuming industry.[5] R_β is the ratio of the total relative scale economy benefits embodied in U. S. imports relative to exports. The test statistic R_β was calculated and found to be .892, indicating that U. S. exports are more scale intensive than imports. However, the U. S. advantage is smaller than when average relative plant size is not accounted for (see Table 5.1).

The final scale economy test employs multiple regression analysis. The specification chosen is comparable to that used by Weiser and Jay (7). The regression equations are reported in Table 5.2; here, only the performance of the scale economy variable is of interest. In each regression regardless of the dependent variable or the form of the scale variable, scale economies are found not to significantly determine U. S. comparative advantage. Nonetheless, Table 5.1 revealed the association between the scale effect and national market size. It is quite possible that the degree of aggregation utilized by the I-O table masks the significance of the scale effect.

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[5]Diseconomies do not pose a problem here as U. S. plants are larger than their foreign counterparts in industries which suffer diseconomies (textiles).

[6]Although the results are not reported, various scale variables were utilized in homogeneous regressions which included all the skill variables. The scale economy variable was never significant. Thus, the results in Table 5.2 capture the essence of those regressions.

TABLE 5.2.--Multiple Regression Test of the Scale Economy Theory (U. S. Manufactures; Trade with the World 1975)

Dependent Variable	Constant	Scientists and Engineers	Operatives	Nonfarm Laborers and Service	Farm Laborers	Ratio of Captial to Labor	Scale Economy Variable[1]	R^2	F
5-7 $(X/\Sigma X)_{\alpha t}$	-2.19	87.99	-1.44	14.47	15.50	-33.91	- .55	.20	2.70*
	(.51)	(3.36)*	(.20)	(.73)	(.68)	(.92)	(.07)		
5-8 $(X\text{-}M)_{\alpha t}$	.061	.230	- .048	- .026	.112	- .143	- .012	.26	3.70*
	(1.17)	(2.70)*	(2.08)*	(.40)	(1.47)	(1.20)	(.47)		
5-9 $(X/\Sigma X)_{\beta}$	.64	87.62	-1.73	15.23	14.51	-36.13	-2.67	.21	2.72*
	(.06)	(3.35)*	(.25)	(.76)	(.62)	(.99)	(.36)		
5-10 $(X/\Sigma X)_{\alpha W}$	- .59	88.17	-1.77	14.89	15.70	-35.22	-1.46	.21	2.61*
	(.08)	(3.37)*	(.25)	(.75)	(.67)	(.98)	(.27)		

NOTE: Several measures of the scale economy variable are tested. The scale variable used in the regression is indicated by the subscript on the dependent variable where α_W is α_{Wt}, the employment weighted scale elasticity parameter; α_t is the I-O weighted scale elasticity parameter; (Equation 5-4). β is the relative scale measure weighted by the I-O table (equation 5-5); $(X/\Sigma X)$ is U. S. exports divided by the exports of the EEC (9) countries plus Canada, Japan, and Australia across industries; (X-M) is U. S. net exports measured in thousands of dollars. The skill variables are entered as proportions of the labor force. The t statistics appear in parentheses.

*Significant at the 5% level.

[1]The notation next to the dependent variable described the actual scale economy variable used in the regression. When entered in the regression, each scale parameter was augmented by one in order to eliminate negative values.

5.5 Conclusion

The evidence uncovered in this chapter is of a mixed nature. There is both support and lack of support for the scale economy hypothesis. Usually when a variable fails to perform significantly in a regression, it is concluded that the theory which that variable represents is not valid. However, due to the level of aggregation involved in this analysis, a more agnostic conclusion is warranted.

Thus, we end where we began. Judging from previous studies, this is not surprising. Branson (1) found that when the dependent variable in his regressions was adjusted for the size of the export balance [X/(X + M)] the scale elasticity parameter was no longer significant. The scale account had received support when X-M served as the dependent variable. Baldwin, who also was constrained by the I-O classification, found that "scale," generally, was not a significant determinant of U. S. trade patterns. Using Baldwin's data and a different measure of scale (the measure used here), Weiser and Jay (7) arrived at the opposite conclusion. Unfortunately, the findings in this chapter are consistent with the existing paradox in the literature.

REFERENCES

1. Branson, W. and Helen Junz. "Trends in U. S. Trade and Comparative Advantage." Brookings Papers on Economic Activity 2 (1971): 285-346.

2. ________. "U. S. Comparative Advantage: Some Further Results." Brookings Papers on Economic Activity 3 (1971): 754-9.

3. Hufbauer, G. C. "Factor Endowments, National Size, and Changing Technology: Their Impact on the Commodity Composition of Trade in Manufactured Goods." In The Technolgoy Factor in International Trade. Edited by R. Vernon. New York: Columbia University Press, 1970.

4. Katrak, H. "Human Skills R & D and Scale Economies in the Exports of the United Kingdom and the United States." Oxford Economic Papers (November, 1973): 337-60.

5. Phlips, L. Effects of Industrial Concentration. North-Holland, 1970.

6. Pryor, F. L. "The Sizes of Production Establishments in Manufacturing." Economic Journal (June 1972): 547-66.

7. Weiser, L. and Keith Jay. "Determinants of the Commodity Structure of U. S. Trade: Comment." American Economic Review (June 1972): 459-66.

8. U. S. Department of Commerce. 1972 Census of Manufactures. Washington, D.C.: U. S. Government Printing Office, 1972.

CHAPTER VI

THE LINDER MODEL

6.1 The Theory

Linder has proposed a two-tiered theory of international trade. For trade in primary products, the factor proportions approach provides the relevant explanation. However, manufactures trade is influenced by a different set of forces which are related to a country's internal demand. Accordingly, it is necessary that a product be consumed (or invested) in the home country before it can be a potential export product (5, p. 87).

As producers are in business to make profits, they offer to consumers products which they perceive consumers to want. The resulting commodity composition of domestic production represents producers' efforts to respond to the preferences of domestic consumers. Therefore, consumer preferences influence production at its most primary stage. Thus, the innovation and research conducted by firms essentially is motivated by consumer preferences. Yet, producers will respond only to profit opportunities of which they are aware. Due to imperfect information they will be most aware of opportunities in the home market, and least aware of opportunities abroad. Furthermore, once an opportunity has been identified and product development has begun, close contact with the market is essential to a successful effort.

Demand, the motivating factor in this analysis, is influenced by a variety of factors, language, culture, religion, climate, prices, income, etc. However, it is assumed that the essential characteristic of demand is described by a country's level of per capita income. Thus, as the distribution of income in a given country is apt to be uneven, each country's comparative advantage is focused in a range of products which is determined by its level of per capita income. The range is referred to as representative demand. As a country's level of per capita income rises, domestic demand becomes relatively more intensive in products which have a higher income elasticity of demand. Therefore, the range of representative demand also shifts. This shift is better understood with respect to characteristics, not specific products. Although as income rises there is a tendency to purchase a different assortment of goods, there is also a tendency to purchase the same type of goods, but ones of higher quality. This aspect of representative demand is very hard to measure. Despite this difficulty, the concept of representative demand is clear. The lesser the difference in per capita income between two countries, the greater is the overlap in their representative demand. The greater the difference in per capita incomes, the lesser is the overlap in representative demand. For countries with very different per capita incomes representative demand can only overlap for products which are qualitatively homogeneous.

Thus far only the potential for trade has been established. However, if we also assume that producers are aware of the demand conditions in other markets, this is sufficient to assure that trade will occur within the range of overlapping representative demand. Producers, seeing the opportunity for profit, will respond by expanding into foreign markets, supplying products which are essentially similar to those already offered by domestic producers. Thus, consumers benefit from a more diversified offering of products. Other factors also may provide impetus to initiate trade. Advantages in the processing of raw materials, technological superiority, managerial skills and economies of scale provide an explanation of why identical prices for the "same" commodity would be a mere coincidence (5, p. 103). These factors operate within the framework established by demand patterns.

It follows that a country's range of potential exports is identical to its range of potential imports (5, p. 91). Also the benefits from trade which is motivated by these considerations are greater for countries whose demand structures are most similar. Two empirical corrolaries follow: The greater the similarity of the demand structures of two countries, the more similar will be the commodity composition of one's exports to the other's imports and, the more intense will be the volume of bilateral trade between the two countries, certeris paribus. Thus, Linder's theory can be tested without a more precise definition of representative demand. As always, empirical examinations will be affected by trade braking forces such as distance, transport costs, and various commercial policies.

6.2 Previous Empirical Tests

The first test of the trade intensity hypothesis was conducted by Linder himself (5). Using graphical analysis he inspected the relationship between the average propensity to import (APM) and per capita gross national product on a bilateral basis for a group of thirty-two countries. The use of the APM as the measure of trade intensity, normalizes for differences in country size. For a given country, the APM between it (the object country) and the other sample countries was calculated. It was found that in many instances, the APM's generally reach their maximum values for countries whose per capita GNP is very similar to that of the object country. As this was Linder's prediction, he concluded that the theory cannot be rejected off-hand (5, p. 117).

Sailors, Qureshi, and Cross (Sailors) have statistically tested Linder's trade intensity hypothesis (7). Letting, $R_{ij} = |I_i - I_j|$, where I_i and I_j represent the per capita incomes of the two countries, and R_{ij} represents a measure of the difference in the demand structure between countries i and j, the hypothesis is confirmed if a negative and significant rank correlation between R_{ij} and the APM is found (each ranked lowest to highest). The authors found support for the theory. Out of a thirty-one country sample, only four positive rank correlations occurred, all of these were small (below .14), and none were significant at the 5 percent level. Of the remaining 28 countries, seven produced rank correlations significant at the 1 percent level, an additional 9 were significant at the

5 percent level. Countries of the European Community displayed strongly significant corroborating results, while the U. S. failed to display any association between R_{ij} and per capita GNP. The authors used Linder's data. Hoftyzer (3) has criticized these findings, claiming that ignoring distance seriously biases the above results. He contends and gives evidence that distance may be the major factor of causation. Hoftyzer's criticism, although valid in theory, is empirically weak as he produces partial evidence for only three countries.

Fortune (2) has tested Linder's trade intensity hypothesis, employing distance and per capita GNP differences as independent variables. The study also finds some support for the hypothesis. Twenty three countries' 1967 imports of finished manufactures (S.I.T.C. commodity categories 7 and 8) are used. The following equation was estimated:

$$M_{ij}/Y_i = a + b \mid Y_j/N_j - Y_i/N_i \mid + cD_{ij} + e_i$$

where: M_{ij} represents finished manufacturing imports received by the ith country from country j

Y_i/N_i is the ith country's per capita GNP

D_{ij} is the great circle distance between the closest large city in each country

e_i is the error term.

Regressions were run across countries i for a fixed country j. Confirmation of the Linder hypothesis requires $b < o$ and significant. Distance is a trade-braking effect, therefore, $c < o$ is expected.

The Linder coefficient (b) took on the expected sign in all but five regressions and was significant at the 5 percent level for five countries; two of which displayed perverse signs. The distance variable performed better having the expected sign on its coefficient in all regressions and being significant (5 percent) in 11 regressions; or 14 regressions (10 percent). The highest R^2 attained was .41; the lowest .07.

Fortune concludes that although Linder's theory is supported, due to the low coefficient of determination, it is hardly the only operative theory. Linder's hypothesis may be a supplement, rather than an alternative, to other trade theories (2, p. 317).

Sailors' and Fortune's studies cover 19 of the same countries. In no case is the Linder hypothesis significantly confirmed for a country in one study and significantly refuted in the other. For France and Austria, Sailors found a significant confirmation, while Fortune found the Linder variable's coefficient to have the "wrong," but insignificant sign. The U. S. and Portugal performed poorly, taking on the "wrong" signs in both studies. The trade intensity hypothesis was significantly affirmed in both studies for the following countries: New Zealand, Switzerland, Sweden, Denmark, West Germany, and the Netherlands.

Hufbauer has inspected Linder's preference similarity hypothesis (4). The proposition tested is that the commodity composition of country i's export (imports) becomes more similar to the commodity composition of country j's imports (exports) as the per capita gross domestic product (G) in countries i and j becomes more similar. Each country's exports and imports of manufactures are ordered in separate vectors according to their S.I.T.C. commodity classification (all three-digit S.I.T.C.'s 5-8 are included) are expressed as percentages. The similarity of country i's exports to country j's imports is measured by $CosX_iM_j$. This measure of similarity is the cosine of the angle between the two vectors,[1] X_i and M_j. When $CosX_iM_j = 1$, country i's export composition is identical to country j's import composition. When $CosX_iM_j = 0$, country i's export composition is completely dissimilar to country j's import composition.

In order to perform the test, Hufbauer divides his twenty-four country sample into two parts and estimates the following equations:

$$CosX_iM_j = c_1 + \overset{(+)}{a_1}\, G_j + \overset{(-)}{b_1}\, G_i + e, \quad \text{when } G_j \leq G_i \qquad (6\text{-}1)$$

$$CosX_iM_j = c_2 + \overset{(-)}{a_2}\, G_j + \overset{(+)}{b_2}\, G_i + e, \quad \text{when } G_j \geq G_i \qquad (6\text{-}2)$$

where: e is the error term.

The variables in the equations have already been identified. The signs above the coefficients are those which are expected if the preference similarity hypothesis is to receive support. Each regression is executed across all countries pooled together over the specified section of the data set.

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[1]The method of computing $CosX_iM_j$ is presented in the following chapter (VII).

Although this is a test of Linder's preference similarity hypothesis, it is at the same time a test of orthodox international trade theory. Orthodox trade theory predicts that differences between countries create the greatest opportunities for mutually beneficial trade. As "rich" countries tend to have the greatest technological advantage, capital endowments, and skill endowments compared to "poor" countries, orthodox theory predicts the exact opposite of Linder. The more dissimilar are the per capita GDP's of two countries, the more similar should one's export composition be to the other's import composition. Therefore, orthodox trade theory predicts that the signs of the coefficients in equations 6-1 and 6-2 will be exactly the opposite of those which are listed. These conflicting predictions are illustrated in Figures 6.1 and 6.2 below.

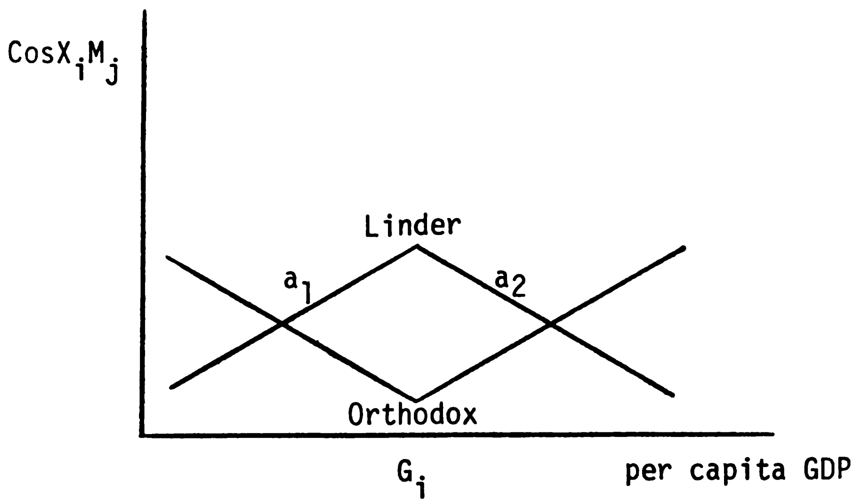

Figure 6.1.--The Tent Shaped Similarity Function for Fixed Country i and Different Countries j.

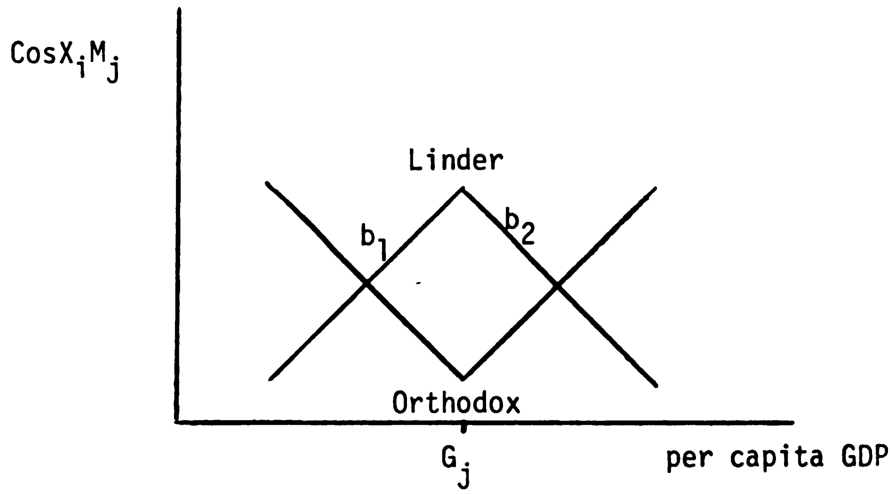

Figure 6.2.--The Tent Shaped Similarity Function for Fixed Country j and Different Countries i.

In the two figures, 6.1 and 6.2, the coefficients a_1, a_2, b_1, and b_2 refer to the coefficients in equations 6-1 and 6-2. Each represents the slope of that side of the "tent" (or inverted tent) which lies below it. Thus, a_1 is the coefficient of G_j in equation 6-1 where $G_j \leq G_i$ and a_2 is the coefficient of G_j in equation 6-2 where $G_j \geq G_i$. The coefficients b_1 and b_2 are interpreted analogously.

Hufbauer estimated the above equations and found a_1, a_2, b_1, and b_2 each to be significant and to exceed zero. Furthermore, $a_1 > a_2$ and $b_1 > b_2$, although a_1 and a_2 are statistically indistinguishable. For equation 6-1 $R^2 = .235$, for equation 6-2 $R^2 = .503$. These results are fully consistent with neither orthodoxy nor Linder although they are partially consistent with both.

Hufbauer concludes that each theory (orthodox and Linder) can be assigned a sphere of influence. He states, "judging solely from the cosine exercise, Linder . . . works best in accounting for trade within the rich country zone. By the same token, orthodoxy . . . does better at explaining the commodity composition of manufactures within the poor country zone. As for trade between zones, the cosine results agree with Linder if the zones are close together, and with orthodoxy when the zones are widely separated" (5, p. 205).

If by "cosine exercise" Hufbauer is referring to the regression analysis he receives no support for these statements. He has estimated only two regressions across the sample countries. The regressions capture the effects of trading "upstream" and "downstream" regardless of the level of per capita GDP in a particular country. Thus, one cannot reach different conclusions for rich versus poor countries based on the regression results. His tests imply that for a given country i (at any level of per capita GDP) the export composition of poorer countries becomes more similar to the import composition of a given country i as their per capita GDP's approach that of country i. This is as Linder predicts. However, as country i's import composition is compared to the export composition of richer countries, the two vectors continue to become more similar, but at a decreasing rate ($b_2 < b_1$). A similar finding is made for any given country's export pattern (compared to other countries' import patterns) except $a_2 < a_1$ is not a statement for which there is statistically significant support.

There is no way to know for certain how Hufbauer reached the conclusions which he did. However, simply viewing the matrix of $CosX_iM_j$ values (4, pp. 224-26) leads one to somewhat similar, although admittedly tentative, conclusions. For example, the values of $CosX_iM_j$ are higher when countries i and j are "rich" than when they are "poor." This would be consistent with the hypothesis that Linder's theory explains trade within the rich country zone. Further speculation is possible but not warranted because no other generalizations seem as clear.

If Hufbauer's conclusions (whatever their basis) are correct, then his test procedure is wrong. As it was pointed out earlier in this chapter, Linder's hypothesis of trade intensity does not receive support across all countries. However, trade intensity does seem to increase with demand similarity for countries which are relatively rich.[2] When Hufbauer reaches a similar conclusion for preference similarity, he effectively destroys his own empirical analysis which inspected the aggregated effect across a pooled set of countries. Yet Hufbauer's conclusions are attractive.

The gains from trade according to Linder's theory would seem to be greatest for relatively rich countries. The potential to increase the menu of choices available to consumers, or to eliminate monopoly returns to technological advances, are relatively more important considerations when there is a greater amount of discretionary income. Furthermore, Linder's theory, as he applies it to poorer countries, is purely static. If the demonstration effect operates or if a relatively poor country is trying to develop, its

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[2]See Sailors (7) and Fortune (2). Both articles are briefly reviewed above.

import pattern would be more similar to that of a richer country. In order to properly address these issues, countries must be tested individually, not collectively.

6.3 Some Empirical Considerations

The basic testing procedure of Linder's hypothesis is similar regardless of whether it is a test of preference similarity or trade intensity. In each case the researcher establishes the object country's level of per capita income (or GDP) as the critical point at which something should occur (maximum trade intensity or peak similarity). Although this is what Linder predicts and therefore it is a reasonable test of the theory, it is entirely possible that no particular change occurs at that specified point. Furthermore, given the very loose definition of representative demand, the choice of a specific point as the center of the range of representative demand is too confining.

The tests performed by Fortune (2) and Sailors (7) have an additional undesirable property. Each of these studies employs the absolute value of the difference in per capita income as an independent variable. This prohibits a separate consideration of upstream and downstream trade patterns. Although Hufbauer used aggregated data, he found Linder's hypothesis of preference similarity to be corroborated for downstream trade, but not for upstream trade. Fortune and Sailors' method does not even allow inspection of this possibility. Furthermore, as countries become richer, there are fewer upstream observations. Similarly, as countries become poorer there are fewer downstream observations. Therefore, splitting the sample at a critical level of per capita income, to separately study the differences of upstream and downstream trade (if there are differences) can only be done for countries in the middle of the sample. Even for these, the number of degrees of freedom, roughly, is cut in half. Thus, if these effects are to be separately considered, a new type of test must be devised.

REFERENCES

1. Bhagwati, J. "The Pure Theory of International Trade: A Survey." In Surveys of Economic Theory, Growth, and Development. New York: 1965, 2, pp. 173-5.

2. Fortune, J. "Some Determinants of Trade in Finished Manufactures." Swedish Journal of Economics (September 1971): 311-317.

3. Hoftyzer, J. "Empirical Verification of Linder's Trade Thesis: Comment." Southern Economic Journal (April 1975): 694-698.

4. Hufbauer, G. C. "Factor Endowments, National Size, and Changing Technology: Their Impact on the Commodity Composition of Trade in Manufactured Goods." In The Technology Factor in International Trade." Edited by R. Vernon. New York: Columbia University Press, 1970.

5. Linder, S. B. An Essay on Trade and Transformation. Stockholm, 1961.

6. Linneman, H. An Econometric Study of International Trade Flows. Amsterdam, 1966.

7. Sailors, J.; Qureshi, U.; and Cross, E. "Empirical Verification of Linder's Trade Thesis." Southern Economic Journal (October 1973): 262-268.

8. ________. "Empirical Verification of Linder's Trade Thesis: Reply." Southern Economic Journal (April 1975): 698-700.

CHAPTER VII

AN EMPIRICAL EXAMINATION OF LINDER'S PREFERENCE SIMILARITY HYPOTHESIS

7.1 Introduction

According to the Linder hypothesis nations which have the smallest per capita income differences will tend to exchange products which are highly similar. Between two countries as per capita income differences increase both the volume of trade and its similarity will diminish. A nation's exports are, therefore, similar to its imports and to the imports of countries with similar per capita incomes. In this chapter we will test the preference similarity aspect of Linder's hypothesis.

7.2 Methodology

The 1975 exports and imports of twenty-six countries and their respective per capita gross domestic products (GDP) constitute the data set. The GDP data are from the U. N. (1) and are almost entirely of 1974 vintage. Where 1974 GDP statistics were not available, the most current year[1] was used by adjusting it to the 1974 dollars by means of U.N. G.D.P. deflators for developing and developed

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[1]This is not a major problem. India's GDP is the least current (1972).

economies (1). The data used are for 102 separate manufacturing industries; SITC's 5, 6, 7, and 8, at the three digit level for trade with the world.

A country's exports and imports may be expressed as vectors in which each element of the vector is the percentage value of the particular SITC in the given vector of manufactures trade. Defining exports and imports in this way, country i's export vector X_i is comprised of elements x_{in}, where n denotes commodity n. Similarly, country i's import composition is represented by M_i where M_{in} is the percentage of that country's total manufacturing imports of commodity n. The cosine of vectors X_i and M_j provide an index of the similarity of two nation's trade.[2]

$$\text{Cos}X_iM_j = \frac{\sum_n X_{in} \cdot M_{jn}}{\sqrt{\sum_n (X_{in}^2) \cdot \sum_n (M_{jn}^2)}} \qquad (7\text{-}1)$$

When $\text{Cos}X_iM_j$ equals one, the two vectors are identical. When the cosine equals zero, they are completely dissimilar.

The similarity functions for which theory suggests estimation are,

$$\text{Cos}X_iM_j = a_o + a_1G_i + a_2G_i^2 + u_i \qquad (7\text{-}2)$$

for j = k; i = 1, 2, . . ., 26, u_i is the error term.

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[2]This measure has been used by Hufbauer (3) and Linneman (5). The following discussion is based on these sources plus R.G.D. Allen (1).

$$\mathrm{Cos}X_iM_j = b_o + b_1G_j + b_2G_j^2 + u_j \qquad (7\text{-}3)$$

for j = 1, 2, . . ., 26; i = k where G_i and G_j are respectively the per capita GDP's of the ith and jth countries, u_j is the error term.

The correspondence between these functions and Hufbauer's tent functions (3) is unmistakable, although there are important differences. First, the similarity functions can be estimated for each individual country; no aggregation is required. Second, the functions are not constrained to reach a critical point at a specific level of per capita GDP. The critical point is estimated where the function best fits the data. Linder predicts that the critical point will be a maximum. Considering equation 7-2, this implies that a nation with the same level of per capita GDP as nation j (G_j) will have an export pattern which is most similar to j's import pattern. Turning to equation 7-3, Linder predicts that country i's export pattern will be most similar to the import pattern of a country experiencing the same level of per capita GDP as i, thus 7-3 should attain a maximum at G_i.

However, equations 7-2 and 7-3 cannot be estimated directly. Since the dependent variable is defined over the range from zero to one, this constraint must be included in the specification. The following logistic model incorporates this restriction,

$$\mathrm{Cos}X_iM_j = \frac{1}{1 + e^{a_o + a_1G_i + a_2G_i^2 + u_i}} \qquad (7\text{-}4)$$

where the variables are defined the same as in equation (7-2). This function can be estimated in the following form,

$$\ln\left(\frac{1}{\mathrm{Cos}X_iM_j} - 1\right) = a_o + a_1G_i + a_2G_i^2 + u_i \qquad (7\text{-}5)$$

This form restricts $\mathrm{Cos}X_iM_j$ to the range between zero and one. Given this restriction the dependent variable in the equation is defined over the interval, $(-\infty, \infty)$. Therefore, the necessary econometric assumptions are satisfied. However, it is no longer clear that this specification lends itself to a test of Linder's hypothesis. In order to constitute a proper test, equation 7-4 must be capable of attaining an interior global maximum over the range of possible values of G. Allowing the exponent of "e" to have a quadriatic term admits the possibility of a maximum, a minimum, or an inflection point. The point at which the critical value occurs is easily located by taking the first derivative of the function, setting it equal to zero and solving for G. This is done below omitting the subscripts i, j.

$$\frac{d\mathrm{Cos}XM}{dG} = \frac{-(a_1 + 2a_2G) \cdot e^{a_o + a_1G + a_2G^2 + u}}{(1 + e^{a_o + a_1G + a_2G^2 + u})^2} \qquad (7\text{-}6)$$

However, the denominator is positive, and since "e" to any power is positive,

$$\frac{dCosXM}{dG} = 0$$

when $-(a_1 + 2a_2G) = 0$

Therefore, the critical value of the function is reached where

$$G = \frac{-a_1}{2a_2} .$$

Next, we must evaluate whether this is a maximum, minimum, or point of inflection. This requires taking the second derivative and substituting $\frac{-a_1}{2a_2}$ for G. In order to simplify this procedure define,

$$f(G) = -(a_1 + 2a_2G)$$

$$h(G) = (1 + e^{a_o + a_1G + a_2G^2 + u})^2$$

$$g(G) = e^{a_o + a_1G + a_2G^2 + u}$$

Using this notation, equation (7-6) can be expressed as,

$$\frac{dCosXM}{dG} = \frac{f(G)g(G)}{h(G)}$$

Then, collecting common terms, the second derivative of equation (7-4) is

$$\frac{d^2 CosX_iM_j}{dG^2} = \frac{f'(G)g(G)}{h(G)} + [f(G)]^2 \cdot$$

$$\left[\frac{-h(G) + 2(1 + e^{a_o + a_1G + a_2G^2 + u})g(G)}{[h(G)]^2}\right] \quad (7\text{-}7)$$

where, $f'(G) = -2a_2$, the other terms are defined above. In equation (7-7) $h(G)$, $[f(G)]^2$ and $(1 + e^{a_o + a_1G + a_2G^2 + u})$ are each greater than zero; $f'(G)$ can be positive or negative. The expression (7-7) must be evaluated by substituting $-a_1/2a_2$ for G in order to determine the nature of the critical point. And, since this is not a simple quadratic function, we must inspect the possibility that an estimated maximum (or minimum) is not global. Therefore, this particular specification (equation 7-4) does not easily lend itself to a test of Linder's hypothesis.

Incorporating the restriction that $o < CosX_iM_j < 1$, does not produce a function with desirable properties; therefore, let us look at the nature of the problem when the restriction is ignored. The entire cosine distribution is "piled up" between zero and one, and $E(CosX_iM_j)$ is not restricted to values within that interval. From an operational point of view, this is not much of a problem unless many observations lie near the extremes of the interval specified above. Table 7.1 presents the values of $CosX_iM_j$. Only 6% of the total observations are found to fall within the two 10% tails [i.e. $P(.1 < CosXM < .9) = .94$]. Although there are relatively few extreme observations, each may be relatively important. Thus, the relative scarcity of extreme observations is a necessary, but not a sufficient condition to allow direct estimation of equations (7-2) and (7-3) using OLS.

Since separate regressions are to be run for each country, we are interested in the concentration of extreme observations on a country level basis. Considering equation (7-2), we find that the following countries have the greatest concentration of data points in the two 10% tails of the cosine distribution; France (39%), West Germany (31%), Pakistan (27%), Hong Kong (23%), the United Kingdom (15%), and Canada (8%). Korea, Italy, and Israel have one observation (4%) in the tails; the remaining countries have none. The cosine values which apply to equation (7-3) are more concentrated in the tails of the distribution for Canada (19%) than any other country. The next highest concentration is for Sweden, Australia, Finland, and New Zealand (12%). For the remaining countries, we find that, ten have two observations in the tails (8%), four countries have one (4%), and seven countries have none.

These casual observations imply that the estimates of equation (7-2) are the least reliable for France, West Germany, Pakistan, Hong Kong, and the United Kingdom. For the remaining countries the problem does not <u>seem</u> serious. The estimates of equation (7-3) are generally less affected as only Canada has a rather large proportion of observations in the tails of the cosine distribution. Although objective skepticism is warranted, there is no evidence that the other regressions will suffer due to the truncated distribution of CosXM. These conclusions allow us to retain the quadratic specification which Linder's theory addresses.

The quadratic form also is suited to test the Linder versus orthodoxy controversy. Linder predicts that each function will attain a maximum where orthodoxy predicts that it will attain a minimum. Yet the test itself does not assure that either theory will receive support even if all the coefficients are significant. The test is "independent" of either theory, but suitable for evaluating both. To clarify this point, refer to Figure 7.1. The figure

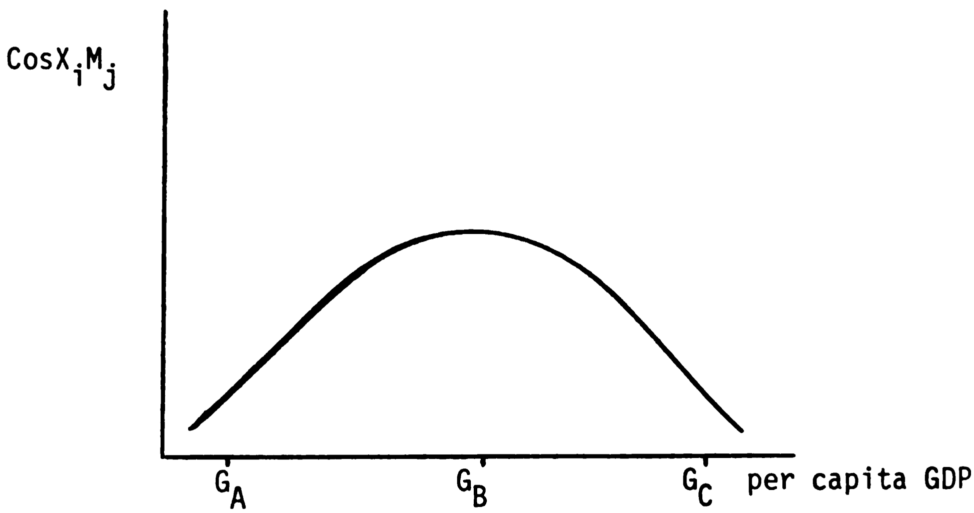

Figure 7.1.--The Similarity Function.

depicts a hypothetical similarity function as it might be estimated by equation 7.2.[3] Thus it describes how the similarity of country j's imports and other countries' exports changes as those other

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[3]The interpretation for equation 7-3 is analagous, except that the object country's export vector is compared to the import vectors of other countries.

countries are richer or poorer than country j. In order to interpret the test results we must know the per capita GDP level in country j and find the level of per capita GDP at which the similarity function peaks (as it does in the example). Suppose the level of per capita GDP for country j (G_j) is equal to G_B. Then the figure represents the case in which Linder is strictly supported. Had the similarity function attained a minimum at G_B (where $G_j = G_B$) the figure would have shown support for orthodoxy. Orthodox trade theory predicts that a country's import vector will be most similar to the export vectors of countries which are most dissimilar in terms of per capita GDP.

However, this test does not restrict the similarity function to attain its critical value at (or near) G_j. But, even when G_j is not close to G_B, the results may be in favor of either orthodoxy or Linder. Suppose, in Figure 7.1, country j is the poorest country in the world, with per capita GDP equal to G_A and further, that for no country in world does per capita GDP exceed G_B. Then the figure depicts an orthodox result. The "downturn" in the quadratic is meaningless as no countries have levels of per capita GDP greater than G_B.

Next, assume that per capita GDP varies across countries from G_A to G_C. The critical value of the function may be attained either within this range or not. When it falls outside of the observable range of per capita GDP, the sample from which the estimate came only provides information on the slope and convexity of the similarity function; the critical value is not meaningful since there are no countries which are that rich (or poor). When the object country's per capita GDP is not close to G_B (and G_B lies within the observable range) neither orthodoxy nor Linder receives strict support.

The specification of equations 7-2 and 7-3 differs substantially from previous tests of the Linder hypothesis. The equations do not impose symmetry with respect to a partciular level of per capita GDP. The test procedures of Fortune and Sailors (see Chapter VI) impose symmetry on upstream and downstream trade patterns. Thus, their tests of Linder's trade intensity hypothesis produce a single estimate of upstream and downstream trade patterns. If Linder (or orthodoxy) is correct their procedure is perfectly valid. However, if for upstream trade, trade intensity reacts differently to per capita GDP differences as compared to downstream trade, the imposition of symmetry aggregates dissimilar effects together. In fact, Hufbauer's regressions which explain preference similarity imply this result, but his data are aggregated across countries. The quadratic form proposed here does not have these shortcomings. The test is considered superior because: it allows separate consideration of upstream and downstream trade; separate consideration of individual countries; and does not require the researcher to split the sample at a specified point (see Chapter XI). Although symmetry is still imposed on the relationship between similarity and per capita GDP, the regression, not the researcher, determines where this occurs.

Next, we must develop a test statistic which can be used to evaluate the theory. As we have established above, we are interested in two results: (1) whether the similarity function attains a maximum or a minimum, and (2) the level of per capita GDP at which the critical value occurs in comparison with a country's own level of per capita GDP. The point at which the critical value occurs is found by taking the first derivative of the similarity function, setting it equal to zero and solving for G. For equation 7-2, the estimated critical value of the function occurs at:

$$\hat{G}_{\bar{m}} = \frac{-\hat{a}_1}{2\hat{a}_2} \qquad (7\text{-}8)$$

For equation 7-2 the estimated critical value occurs at,

$$\hat{G}_{\bar{x}} = \frac{-\hat{b}_1}{2\hat{b}_2} \qquad (7\text{-}9)$$

In equation 7-2 the object country is country j. Therefore, we are intersted in comparing $\hat{G}_{\bar{m}}$ with G_j; define the test statistic as,

$$R_{\bar{m}} = \frac{\hat{G}_{\bar{m}} - G_j}{G_j} \cdot 100 \qquad (7\text{-}10)$$

In equation 7-3 the object country is country i, define the test statistic as,

$$R_{\bar{x}} = \frac{\hat{G}_{\bar{x}} - G_i}{G_i} \cdot 100 \qquad (7\text{-}11)$$

Each of these test statistics measures the percentage difference between the estimated point at which the critical value occurs ($\hat{G}_{\bar{m}}$, $\hat{G}_{\bar{x}}$) and the predicted point (G_j, G_i). If $R\bar{m}$ ($R\bar{x}$) is close to zero and the function attains a maximum, Linder receives support; if the function attains a minimum orthodoxy is supported. If $R\bar{m}$ and $R\bar{x}$ are not close to zero, or within a reasonable range, neither theory is supported. However, in this case a country's placement in the sample of countries ranked by per capita GDP may provide some clues to the proper interpretation.

7.3 Empirical Evidence

Table 7.1 presents the cosine coefficients between each nation's manufacturing export and import vectors. For convenience the countries are ordered by per capita GDP. For each column, the country listed across the top of the table has its export vector held constant while "comparing" it to the import vectors of other countries. For the rows, the import vector of the country listed at the left has been held constant while export vectors of the countries named at the head of the table vary along the row.

The values of per capita GDP were obtained by converting local currency units to dollars, using 1975 mid-point exchange rates. This procedure has been found to undervalue the per capita income levels of less developed countries (2), making per capita income differences between developed and developing countries appear to be greater than they actually are. If Linder's theory is correct, and if upstream and downstream trade patterns are symmetric, this

TABLE 7.1.--$CosX_iM_j$ Values Between National Export and Import Vectors, Three Digit SITC Basis

Importing Countries	Exporting Countries												
	Switzerland	Sweden	Canada	United States	West Germany	Denmark	Norway	Australia	Belgium-Lux	Netherlands	France	Finland	New Zealand
Switzerland	.6084	.7263	.5965	.7851	.8353	.6080	.1997	.4808	.8230	.7877	.8577	.3339	.3126
Sweden	.5608	.8499	.6345	.8330	.9395	.7653	.3789	.5414	.7913	.7770	.9371	.3473	.3124
Canada	.2716	.7600	.9265	.8444	.8613	.3618	.1258	.4060	.7677	.4458	.9877	.1840	.1976
United States	.2806	.7734	.9195	.7871	.8312	.3371	.1568	.4435	.8337	.4940	.9000	.2826	.2585
West Germany	.4986	.7294	.6085	.7240	.7883	.5717	.2480	.4953	.8093	.7732	.8436	.4427	.3368
Denmark	.4969	.8989	.6440	.7795	.8708	.7737	.5540	.5219	.7868	.8432	.8794	.5384	.4167
Norway	.3504	.7332	.4094	.5479	.6643	.8410	.8251	.4414	.5295	.6698	.6638	.4419	.2381
Australia	.5188	.8607	.7637	.8997	.9205	.6228	.2584	.4781	.7825	.7130	.9329	.3527	.3091
Belgium-Lux	.4639	.7875	.8110	.8379	.8941	.5077	.1951	.5120	.8852	.6627	.9313	.3032	.3185
Netherlands	.5318	.8131	.6600	.8209	.8922	.6492	.2556	.4943	.8180	.8023	.9133	.4016	.3709
France	.6041	.8292	.6286	.8513	.9166	.7160	.3324	.5759	.8321	.8451	.9074	.3846	.3848
Finland	.5830	.8644	.6184	.8756	.9559	.8020	.4212	.5206	.7589	.7875	.9309	.3158	.3060
New Zealand	.5599	.8286	.6849	.8745	.9475	.6402	.2723	.5549	.7977	.7339	.9352	.2771	.2776
Austria	.3937	.6932	.7629	.7356	.8081	.4135	.1725	.4630	.8208	.6689	.8723	.2765	.3024
Japan	.6782	.5288	.3296	.6869	.6405	.6195	.2596	.4862	.5676	.7422	.6411	.2815	.3826
Israel	.3908	.5851	.4515	.5135	.5973	.4627	.3490	.4227	.7564	.5309	.5948	.2710	.2505
United Kingdom	.5579	.7573	.6096	.7684	.7862	.5681	.2579	.5253	.7798	.7130	.7924	.4620	.3975
Italy	.6352	.8041	.6636	.8717	.9346	.6506	.2935	.6014	.8093	.8230	.9153	.2885	.3195
Ireland	.5968	.6085	.5992	.7944	.8709	.6951	.2688	.5086	.7750	.8013	.8685	.4354	.4015
Spain	.7477	.7093	.3786	.7802	.8240	.7474	.2670	.5913	.6098	.7916	.7430	.2957	.2744
Hong Kong	.6296	.3967	.2131	.4046	.4495	.4013	.1615	.2816	.5215	.5930	.4491	.2692	.2683
Portugal	.6535	.8152	.6338	.8655	.9384	.6772	.2455	.5454	.8279	.7739	.9110	.2808	.3295
Yugoslavia	.6603	.7831	.4837	.8042	.9025	.7595	.3211	.6044	.7137	.7557	.8359	.2973	.2993
Korea	.6778	.5729	.2642	.6631	.6781	.7126	.4665	.4569	.5387	.8412	.6174	.2619	.2122
Pakistan	.5463	.7216	.5449	.6861	.7780	.5561	.3002	.5523	.7146	.6477	.7668	.3515	.3703
India	.3708	.3915	.2323	.4402	.4465	.3971	.2212	.2875	.4422	.5152	.4138	.1846	.1723

TABLE 7.1.--Continued

Importing Countries	Exporting Countries												
	Austria	Japan	Israel[1]	United Kingdom	Italy	Ireland	Spain	Hong Kong	Portugal	Yugoslavia	Korea	Pakistan	India
Switzer-land	.7570	.6541	.3115	.8530	.8616	.6880	.6805	.4342	.5383	.6108	.4785	.1735	.4783
Sweden	.8390	.7770	.1479	.8836	.9087	.6307	.7381	.3480	.4775	.6965	.4227	.1545	.3695
Canada	.4964	.7479	.0664	.8224	.7733	.3168	.6253	.0963	.1792	.3802	.1239	.0517	.2189
United States	.5608	.7830	.1567	.7960	.8049	.3766	.6791	.2519	.3284	.4617	.2900	.0733	.3058
West Germany	.7948	.6552	.2039	.7773	.8720	.7439	.6980	.5703	.6567	.6718	.6461	.2508	.4918
Denmark	.8301	.8427	.1515	.8203	.8311	.6353	.7726	.2824	.4780	.7439	.3910	.1882	.3326
Norway	.5884	.8170	.1064	.6069	.6072	.4399	.7489	.2333	.3590	.8079	.3492	.0923	.2421
Australia	.7395	.7761	.1476	.9103	.8620	.5991	.6961	.2491	.4127	.5405	.2958	.1852	.3357
Belgium-Lux	.6790	.7318	.3514	.9127	.8656	.5287	.6860	.2673	.4278	.5696	.3218	.1594	.3934
Netherlands	.8189	.7468	.1876	.8511	.9133	.6726	.6977	.4441	.5562	.6538	.5134	.1911	.4158
France	.8564	.7379	.1752	.8939	.8781	.6610	.7187	.2628	.4370	.6477	.3501	.1810	.3716
Finland	.8204	.8106	.1242	.9024	.8763	.5651	.7331	.1705	.3610	.6634	.2687	.1438	.3206
New Zealand	.7871	.7965	.1187	.8886	.8554	.5360	.6777	.0979	.3163	.5572	.1896	.1582	.3205
Austria	.6336	.7303	.1351	.7756	.8286	.6031	.6845	.3659	.4763	.5799	.4385	.2278	.4083
Japan	.6520	.4324	.3409	.7554	.6552	.7341	.4864	.3641	.5288	.5880	.4672	.1915	.4896
Israel	.5220	.6061	.7551	.7337	.5131	.3156	.5366	.0574	.3320	.4426	.1388	.0595	.3569
United Kingdom	.7551	.6246	.5364	.8931	.7758	.6105	.5924	.3135	.5336	.5565	.3833	.1669	.4822
Italy	.7704	.7488	.1333	.8969	.8306	.5971	.6545	.1598	.3466	.5830	.2386	.1547	.3182
Ireland	.8550	.6576	.1635	.8407	.8857	.7156	.6716	.3239	.5224	.6121	.4046	.2260	.3985
Spain	.7917	.5646	.1382	.8078	.7245	.5929	.5141	.1005	.2785	.4871	.1648	.0754	.2262
Hong Kong	.5712	.3935	.4929	.5897	.4881	.5238	.3612	.2882	.6887	.3925	.4140	.4510	.5623
Portugal	.8061	.7321	.2244	.9051	.8564	.5365	.6444	.1393	.3270	.5368	.2011	.1280	.2961
Yuog-slavia	.8389	.6683	.1102	.8296	.7993	.4866	.6266	.0729	.2652	.5434	.1664	.1001	.2426
Korea	.6494	.6158	.1428	.6628	.5829	.4722	.5350	.0898	.2985	.5637	.2302	.0957	.2653
Pakistan	.7508	.6687	.1148	.7204	.6850	.4623	.5581	.0486	.2970	.5007	.1434	.1291	.2088
India	.4635	.3355	.2404	.4291	.3951	.3137	.2817	.0238	.2136	.3080	.0647	.0203	.1115

SOURCE: Commodity Trade Statistics, U.N. (Magnetic Tapes)

NOTE: Countries ordered by per capita GDP (highest to lowest)

[1]1975 Export data for Israel was unavailable from the U.N. However, when Israel's exports in a particular SITC were large enough, they were reported in (7). The remaining export data was estimated from Israel's 1973 experience by assuming that those exports grew as fast as world exports in the same SITC category.

will spoil the fit of the quadratic by stretching out one leg of the function and destroying the symmetry. The calculation of purchasing power parity for 26 countries is not attempted here, so the analysis is affected by this bias.

The multiple regression results, based on estimating equations 7-2 and 7-3, are presented in Tables 7.2 and 7.4. For both of these cases there are problems with multicollinearity, as can be seen by the highly significant "F" statistics compared to the relatively insignificant "t" statistics. The problem arises because of the quadric specification, since any random variable is highly correlated with its squared value. The collinearity does not allow an accurate assessment of the significance of the individual regression coefficients. Thus, we cannot test whether the similarity function acutally attains a critical value or instead indicates increasing similarity as per capita GDP increases. However, multicollinearity does not bias the estimates, nor their ratio. Therefore, we have no reason to believe that the estimated maximums[4] are biased, however, we have no assurance that they are precise. Nonetheless, the tests produce results which can be shown to be significant when taken collectively.

Using the regression results from Table 7.2 we can test Linder's hypothesis that the smaller are differences in per capita GDP the more closely will the import composition of other countries

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[4]All of the estimated equations with significant F statistics were found to attain maximums.

TABLE 7.2.--Regressions for Constant Export Vectors
$CosX_iM_j = b_o + b_1G_j + b_2G_j^2$ 1975 World Manufacturing Trade

Per Capita GDP 1974 Dollars	Country[1]	b_o	b_1	$b_2 \cdot 10^2$	$\bar{R}^2$	F Significance
6930	Switzerland	.575 (.065)*	.028 (.042)	-.748 (.575)	.184	3.82 (.037)
6876	Sweden	.576 (.068)*	.065 (.045)	-.508 (.607)	.194	4.00 (.032)
6597	Canada	.345 (.088)*	.073 (.057)	-.266 (.783)	.342	7.49 (.003)
6463	United States	.619 (.073)*	.067 (.048)	-.610 (.649)	.103	2.44 (.109)
6198	West Germany	.661 (.078)*	.067 (.051)	-.594 (.692)	.103	2.44 (.109)
6020	Denmark	.567 (.084)*	.039 (.055)	-.546 (.753)	-.063	.26 (.771)
5825	Norway	.282 (.085)*	.005 (.056)	-.002 (.760)	-.082	.06 (.944)
5693	Australia	.442 (.046)*	.042 (.030)	-.560 (.409)	-.003	.96 (.397)
5480	Belgium-Lux	.571 (.058)*	.074 (.038)**	-.633 (.518)	.267	5.55 (.011)
5109	Netherlands	.644 (.066)*	.049 (.043)	-.708 (.584)	-.021	.74 (.487)
5067	France	.616 (.075)*	.077 (.049)	-.568 (.667)	.248	5.12 (.014)
4706	Finland	.256 (.047)*	.035 (.031)	-.329 (.418)	.043	1.56 (.231)
4417	New Zealand	.247 (.036)*	.046 (.024)**	-.585 (.324)**	.073	1.99 (.160)
4382	Austria	.654 (.070)*	.049 (.046)	-.650 (.621)	-.035	.58 (.568)
4152	Japan	.524 (.063)*	.054 (.041)	-.287 (.558)	.275	5.75 (.009)
4029	Israel	.143 (.089)	.084 (.058)	-1.243 (.796)	.021	1.27 (.300)

TABLE 7.2.--Continued.

Per Capita GDP 1974 Dollars	Country[1]	b_0	b_1	$b_2 \cdot 10^2$	$\bar{R}^2$	F Significance
3375	United Kingdom	.619 (.058)*	.103 (.038)*	-1.114 (.519)*	.262	5.44 (.012)
2706	Italy	.582 (.070)*	.080 (.046)**	-.654 (.628)	.244	5.03 (.015)
2176	Ireland	.419 (.069)*	.086 (.045)**	-1.017 (.611)**	.085	2.16 (.138)
1829	Spain	.451 (.050)*	.066 (.033)**	-.420 (.446)	.438	10.74 (.001)
1566	Hong Kong	.057 (.067)	.065 (.044)	-.393 (.601)	.289	6.07 (.008)
1524	Portugal	.268 (.067)*	.076 (.044)**	-.796 (.594)	.109	2.53 (.102)
1162	Yugoslavia	.431 (.058)*	.061 (.038)	-.517 (.514)	.185	3.84 (.036)
504	Korea	.141 (.071)**	.070 (.047)	-.534 (.635)	.216	4.44 (.023)
134	Pakistan	.099 (.047)*	.046 (.031)	-.616 (.420)	.009	1.12 (.345)
120	India	.197 (.053)*	.092 (.035)*	-1.060 (.473)*	.216	4.44 (.023)

NOTE: The coefficient b_1 and its standard error are reported as if per capita GDP were measured in thousands of dollars. The coefficient b_2 and its standard error are similarly reported, but are also multiplied by 100. This was done to avoid a cumbersome number of zeros. To compute the critical value of the similarity function for India, one must use $b_1 = .000092$ and $b_2 = -.0000106$.

[1]The figures in parentheses under the coefficients are the standard errors of the coefficients.

**Significant at the 10% level.

*Significant at the 5% level.

TABLE 7.3.--Expected and Estimated Values of Per Capita GDP for the Maximum[1] of the Linder Similarity Function, $CosX_iM_j = b_0 + b_1G_j + b_2G_j^2$. 1975 World Manufactures Trade for 20 Countries.[2]

Country	Expect Maximum at	Maximum Attained at	$R\bar{x}$[3]
Switzerland	6930	1822	- 72.8
Sweden	6876	6443	- 6.3
Canada	6597	13714	+107.9
United States	6463	5456	- 25.6
West Germany	6198	5677	- 8.4
Belgium-Lux.	5480	5823	+ 6.3
France	5067	6794	+ 34.1
Finland*	4706	5352	+ 13.7
New Zealand*	4417	3976	- 10.0
Japan	4152	9386	+126.1
Israel*	4029	3374	- 26.6
United Kingdom	3375	4602	+ 36.4
Italy	2706	6129	+126.5
Ireland*	2176	4227	+ 94.3
Spain	1829	7861	+329.8
Hong Kong	1566	8237	+426.0
Portugal	1524	4763	+212.5
Yugoslavia	1162	5854	+403.8
Korea	504	6600	+1209.5
India	120	4341	+3517.8

SOURCE: Table 7.2.

[1]All similarity functions attained maximums (Table 7.2). The point at which the maximum is attained is estimated by equation 7-5.

[2]All equations which were not significant at the 30 percent level were omitted.

[3]$R\bar{x} = [(\hat{G}\bar{x} - Gi)/Gi] \cdot 100$

*Indicates that the F statistic for the equation was not significant at the 11% confidence level.

resemble the export composition of a given country. For six countries--Denmark, Norway, Australia, the Netherlands, Austria and Pakistan, the F statistics of the regression equations are not signigicant. Therefore, these countries are excluded from further consideration. For a group of 20 countries, we have somewhat greater confidence in the test results. Generally, Linder's hypothesis is supported by the export patterns of the richer countries. Sweden, West Germany, Belgium-Luxembourg, Finland, and New Zealand have similarity functions which attain maximums at a level of per capita GDP which is very similar to their own. For each of these countries, the estimated maximum is at least within 14% ($R\bar{x}$) of where Linder predicts that it will be. Four other countries, the U. S., Israel, France, and the U. K., find their exports to be most similar to countries which are relatively similar, although the difference between the actual and expected location of the maximum is not as small as for the previously named countries. Nonetheless, for the U. S., only two countries do not conform to Linder's prediction. U. S. exports are most similar to the imports of a country with $5456 of per capita GDP. As countries get richer, U. S. exports become less similar to the imports of those countries. But there are only two sample countries with levels of per capita GDP greater than $5456 and less than $6463 (the U. S. level). Thus, only West Germany and Belgium-Luxembourg fail to conform to Linder's expectations of U. S. export patterns. For Israel, only the U. K. violates the predicted pattern. Three sample countries do not conform to the U. K. export pattern predicted by Linder; four fail to conform to the French export pattern.

The poorer countries in the sample exhibit trade patterns which, basically, are orthodox. The similarity functions of Spain and Hong Kong peak at a very high level outside of the range of observable values of per capita GDP. Thus, only the poorer countries, Portugal, Yugoslavia, Korea, and India fail to conform to the orthodox prediction for Spain and Hong Kong. The import patterns of India, Sweden, and Switzerland do not agree with the orthodox prediction in their relationship with Korean exports. The import patterns of each of these countries are less similar to the Korean export pattern than orthodox theory predicts. India's export pattern is most similar to the import pattern of a country about as rich as New Zealand. Thus, India conforms to neither prediction, but since this sample contains the most developed countries in the world, it is not unreasonable to interpret this as support for orthodox theory.

These conclusions are based upon estimates of the maximum of the similarity function which are very imprecise. Therefore, the conclusions are rather tenuous. However, the generalization that Linder's theory best explains the export patterns among relatively rich countries is one which cannot be statistically contradicted. Considering the group of countries in Table 7.3, the correlation between the countries' per capita GDP rankings and the $R\bar{x}$

rankings[5] produces a Spearman's coefficient of +.793. This is easily significant at the 1% level. Thus as countries become richer, the maximums attained by the similarity functions occur closer to the value which Linder predicts. When New Zealand, Finland, Israel, and Ireland are taken out of the sample,[6] the rank correlation rises to +.974 and is highly significant. Therefore, the major conclusion from this exercise cannot be statistically contradicted despite the imprecise measurement of the similarity function's maximum.

Next, we assess Linder's prediction of import patterns. Linder predicts that a given country's import vector will become continuously more similar to the export vectors of countries as the latter become more similar to the former in terms of per capita GDP. Again, orthodoxy predicts the opposite. Table 7.5 presents the test statistic $R\bar{m}$ which was computed from the regression estimates in Table 7.4. These results are more striking than those obtained for export patterns. Nearly every developed country as rich or richer than France conforms to Linder's prediction. Switzerland and Canada perform the worst. However, only Sweden and Switzerland fail to conform to Linder's prediction for Canada's import patterns. The less developed countries of Spain, Portugal, Yugoslavia, Korea, and Pakistan conform rather closely to the orthodox prediction in terms of their upstream trade, but fail in terms of their downstream trade.

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[5]Ranked on the absolute value of $R\bar{x}$, (low to high).

[6]The F statistic of the estimated similarity function for these countries is not significant at the 11% level.

TABLE 7.4.--Regressions for Constant Import Vectors $CosX_iM_j = a_0 + a_1G_i + a_2G_i^2$. 1975 World Manufacturing Trade

Per Capita GDP 1974 Dollars	Country[1]	a_0	a_1	$a_2 \cdot 10^2$	R^2	F Significance
6930	Switzerland	.416 (.116)*	.095 (.080)	-.957 (1.035)	.035	1.45 (.256)
6876	Sweden	.360 (.130)*	.119 (.085)	-1.043 (1.159)	.121	2.72 (.087)
6597	Canada	.149 (.157)	.115 (.103)	-.724 (1.399)	.163	3.44 (.049)
6463	United States	.244 (.144)**	.114 (.094)	-.926 (1.285)	.103	2.44 (.110)
6198	West Germany	.508 (.107)*	.075 (.0710)	-.948 (.968)	.034	.59 (.563)
6020	Denmark	.331 (.115)*	.145 (.075)**	-1.365 (1.028)	.207	4.27 (.027)
5825	Norway	.278 (.120)*	.117 (.079)	-1.120 (1.073)	.104	2.46 (.108)
5693	Australia	.303 (.133)*	.116 (.087)	-.884 (1.187)	.164	3.45 (.049)
5480	Belgium-Lux	.311 (.129)*	.124 (.084)	-1.101 (1.150)	.133	2.92 (.074)
5109	Netherlands	.411 (.123)*	.108 (.083)	-1.080 (1.094)	.058	1.77 (.194)
5067	France	.323 (.125)*	.135 (.082)**	-1.189 (1.113)	.180	3.75 (.039)
4706	Finland	.274 (.137)*	.135 (.090)	-1.049 (1.222)	.205	4.22 (.027)
4417	New Zealand	.237 (.141)**	.133 (.092	-.968 (1.256)	.210	4.33 (.025)
4382	Austria	.394 (.125)*	.080 (.082)	-.794 (1.117)	-.004	.95 (.401)
4152	Japan	.417 (.092)*	.058 (.060)	-.625 (.820)	-.022	.73 (.491)
4029	Israel	.152 (.096)**	.160 (.059)*	-1.670 (.808)*	.293	6.17 (.007)

TABLE 7.4.--Continued

Per Capita GDP 1974 Dollars	Country[1]	a_0	a_1	$a_2 \cdot 10^2$	$\bar{R}^2$	F Significance
3375	United Kingdom	.343 (.093)*	.129 (.061)*	-1.32 (.826)	.198	4.08 (.030)
2706	Italy	.258 (.132)**	.130 (.087)	-.948 (1.180)	.228	4.69 (.020)
2176	Ireland	.373 (.118)*	.112 (.077)	-1.042 (1.050)	.108	2.51 (.104)
1829	Spain	.171 (.122)	.137 (.080)*	-1.007 (1.085)	.291	6.12 (.007)
1566	Hong Kong	.472 (.073)*	-.010 (.048)	-.027 (.657)	-.044	.48 (.628)
1524	Portugal	.218 (.132)	.148 (.086)**	-1.147 (1.174)	.264	5.48 (.011)
1162	Yugoslavia	.178 (.129)	.146 (.084)**	-1.070 (1.149)	.293	6.17 (.007)
504	Korea	.214 (.108)	.104 (.070)	-.769 (.959)	.215	4.41 (.024)
134	Pakistan	.161 (.106)	.144 (.069)*	-1.173 (.941)	.336	7.33 .003
120	India	.062 (.061)	.112 (.040)*	-1.018 (.543)**	.416	9.89 (.001)

NOTE: The coefficient a, and its standard error are reported as if per capita GDP were measured in thousands of dollars. The coefficient a_2 and its standard error are similarly reported, but are also multiplied by 100. This was done to avoid a cumbersome number of zeros. To compute the critical value of the similarity function for India, one must use a_1 = .000112 and a_2 = -.00001018.

[1]The figures in parentheses under the coefficients are the standard errors of the coefficients.

**Significant at the 10% level.

*Significant at the 5% level.

TABLE 7.5.--Expected and Estimated Values of Per Capita GDP for the Maximum[1] of the Linder Similarity Function, $\cos X_i M_j = a_0 + a_1 G_i + a_2 G_i^2$. 1975 World Manufactures Trade for 21 countries.[2]

Country	Expect Maximum at	Maximum Attained at	$R_{\bar{m}}$[3]
Switzerland*	6930	4938	- 28.7
Sweden	6876	5692	- 17.2
Canada	6597	7997	+ 21.2
United States	6463	6145	- 4.9
Denmark	6020	5309	- 11.8
Norway	5825	5231	- 10.2
Australia	5693	6576	+ 15.5
Belgium-Lux.	5480	5630	+ 2.7
Netherlands*	5109	5007	- 2.0
France	5067	5667	+ 11.8
Finland	4706	6449	+ 37.0
New Zealand	4417	6848	+ 55.0
Israel	4029	4786	+ 18.8
United Kingdom	3375	4882	+ 44.7
Italy	2706	6850	+153.1
Ireland	2176	5366	+146.6
Spain	1829	6808	+272.2
Portugal	1524	6451	+323.4
Yugoslavia	1162	6810	+486.1
Korea	504	6748	+646.9
Pakistan	134	6156	+4494.1
India	120	5484	+4470.0

SOURCE: Table 7.4.

[1]All similarity functions, except Hong Kong's (not included) attained maximums (Table 7.3). The point at which the maximum is attained is estimated by equation 7-8.

[2]All equations which were not significant at the 30 percent level were omitted.

[3]$R_{\bar{m}} = [(\hat{G}_{\bar{m}} - G_j)/G_j] \cdot 100$

*Indicates that the F statistic for equation was _not_ significant at the 11% confidence level.

These findings also are based upon rather imprecise estimates of the similarity function. However, the correlations between the per capita GDP and $R\bar{m}$[7] rankings reveal a Spearman's coefficient of +.814. Omitting Switzerland and the Netherlands[8] raises the Spearman's coefficient to +.886. Both Spearman's values are highly significant. These correlations imply that we cannot reject the proposition that Linder's hypothesis best explains the trade patterns of the richer countries, despite the imprecise nature of the underlying estimated coefficients.

7.4 Conclusions

The Linder model has reasonable explanatory power for the group of developed countries. However, judging from the size of the $\bar{R}^2$ values, other forces not accounted for here, also are at work. The dividing line between orthodoxy and Linder appears to lie somewhere between \$4,500 and \$4,000 of per capita GDP. Given the forces which Linder identifies as important, the conclusions which are drawn here are very reasonable. The benefits from differentiated consumption certainly are greater in developed countries than in underdeveloped countries. Therefore, we would expect Linder's theory to best explain the trade patterns of these richer countries.

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[7]Ranked on the absolute value of $R\bar{m}$, (low to high).

[8]The F statistic for the estimated similarity functions of these two countries was not significant at the 11% level.

REFERENCES

1. Allen, R. G. D. Mathematical Economics. New York: St. Martin's Press, 1959.

2. David, P. A. "Just How Misleading are Official Exchange Rate Conversions?" Economic Journal (September 1972): 979-90.

3. Fortune, J. "Some Determinants of Trade in Finished Manufactures." Swedish Journal of Economics (September 1971): 311-317.

4. Hufbauer, G. C. "Factor Endowments, National Size, and Changing Technology: Their Impact on the Commodity Composition of Trade in Manufactured Goods." In The Technology Factor in International Trade. Edited by R. Vernon. New York: Columbia University Press, 1970.

5. Linder, S. B. An Essay on Trade and Transformation. Stockholm, 1961.

6. Linneman, H. An Econometric Study of International Trade Flows. Amsterdam, 1966.

7. United Nations. Commodity Trade Statistics (Magnetic Tapes).

8. United Nations. Statistical Yearbook, 1975.

CHAPTER VIII

REVEALED COMPARATIVE ADVANTAGE: A POLICY PERSPECTIVE

8.1 Introduction

In this chapter the export patterns of five nations plus the EEC-6 are assessed to reveal the comparative advantage rankings of selected commodity groupings for each of these economic units. The rankings for each country are adjusted for the size of the world export flows across particular commodity groups. The concept of revealed comparative advantage (RCA) was introduced by Balassa (1).

We can apply Balassa's concept to policy issues, because policy makers are not concerned with the determinants of trade patterns; they are concerned with the patterns themselves. RCA provides this information by identifying commodities in which nations have their greatest advantage, without reference to cause. Since political pressures generally are associated with industry factions (either producers or unions) identification of comparative advantage by industry is essential. Yet, the determinants of trade patterns are important because, when they are known, the impact of policy decisions on the domestic allocation of resources is better understood.

The trade braking effects of tariffs, transportation costs, orderly market agreements, and quotas are not explicitly taken into account except to the extent that these barriers are common to all countries in each time period considered. Confining the analysis to a study of export patterns, lessens the effect of country specific demand differences and patterns of protection as compared to an analysis of import patterns. It will be shown that the pattern of comparative advantage revealed by this study, provides an explanation for the current trend toward protectionism. Japan and less developed countries have begun to concentrate their advantage in a few product groups which are both important and traditionally strong industries in developed countries. Thus, import penetration and falling world demand, both of which have intensified since 1975, have caused the developed countries to give greater weight to short run, microeconomic solutions, to combat problems which essentially are macroeconomic.

8.2 Methodology

The export performance of industries in individual countries can be evaluated by calculating each industry's relative share of world exports. By comparing these relative industry shares for a given country, rankings, indicating the static comparative advantage of each industry, can be obtained. This procedure takes no account of whether each industry is expanding its relative share or contracting. However, this may be accounted for by calculating a country's relative share of world exports across industries for two periods and normalizing the relative shares in each period by the relative share of the country in total world exports for each respective period. Then a weighted average of the static comparative advantage and the trend (which is calculated from the change in the static comparative advantage between the two periods) provides a more accurate measure of revealed comparative advantage. This procedure gives equal weight to the static comparative advantage and the comparative static effects (1). The following equations describe this procedure:

Static Revealed Comparative Advantage; Period o

$$\frac{X^o_{ij}}{X^o_{nj}} / \frac{X^o_{it}}{X^o_{nt}} = \frac{x^o_{ij}}{x^o_i} \qquad (8\text{-}1)$$

Static Revealed Comparative Advantage; Period 1

$$\frac{X^1_{ij}}{X^1_{nj}} / \frac{X^1_{it}}{X^1_{nt}} = \frac{x^1_{ij}}{x^1_j} \qquad (8\text{-}2)$$

Revealed Comparative Advantage; Trend

$$\frac{x^1_{ij}}{x^1_i} / \frac{x^o_{ij}}{x^o_i} = T \qquad (8\text{-}3)$$

Revealed Comparative Advantage

$$\tfrac{1}{2} \left[\frac{x^1_{ij}}{x^1_i} + \frac{x^1_{ij}}{x^1_j} \cdot T \right] = RCA \qquad (8\text{-}4)$$

where: X = exports to the world
x = relative share of exports
o = base period (1967)
1 = current period (1975)
i = country i
j = product j
t = Σj
n = eleven industrial countries taken together.

This analysis has also been conducted for n = w = world. Thus, X_w implies that total world exports are used to normalize the commodity flows. (X_w and X_n exclude internal EEC exports, as does the EEC vector of exports to the world.)[1]

When X_{in} is used to normalize the RCA indexes, the resultant rankings are demonstrative of each country's comparative advantage relative to the other developed countries in the sample. When X_{iw} is used to achieve normalization, the RCA rankings are relative to the world. The major differences in the ranks produced using X_{in} compared to X_{iw} are caused by the concentration (or absence) of other countries' exports in those commodity groupings where the rankings change. Rankings may change for either "active" or "passive"

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[1]Several data problems were confronted in attempting to use world exports as the base by which to normalize (X_{wj}). First, 1975 data are not available on a world basis at the time of writing; therefore, 1974 exports are used. Second, the U. N. reports all three digit export flows but only selected four digit flows. SITC's 651, 653, and 732 are most affected by this problem. The problem was resolved by assuming that the composition of exports among the sample countries for the four digit SITC's within each relevant three-digit SITC is approximately the same as the unknown world composition. If this is not a correct assumption, the relative RCA ranks of each of these four-digit SITC's may be in error, but the general trend for the group is correct. The remaining four-digit classifications were either reported or obtainable by subtraction. Resulting errors from these data problems ought to be minor as the three digit benchmark is available for each commodity group. The exceptions to this are the non-ferrous metals tin, zinc, and lead. The volume of world trade in these categories is very low, therefore, the index is very sensitive to any estimation error. When the rankings using world data were generated, these products were revealed to have ranks which were unjustifiably low. However, since the relative volume of trade in these categories is very small (tin, zinc, and lead together comprise .052% of total U. K. exports, .047% of external EEC exports, and less for the other sample countries), ignoring them in the world rankings does not constitute a loss of important information.

reasons. When the index base changes from the sample base to the world base, and a commodity's ranking falls,[2] this is due to a concentration of non-sample country exports[3] in that classification. This is an active change. However, when the same change in the base causes an increase in a ranking, the underlying cause is more likely to be passive. That is, the ranking has risen because a product (or products) which formerly ranked higher has fallen in rank. This occurs because products in which the developed countries have the greatest advantage are nearly totally counted in the sample export bundle.

This sample measures most inaccurately the comparative advantage rankings of products which are more cheaply produced by developing countries. Therefore, the rankings which fall the most are likely to be indicators of products over which a particular developed country and developing countries have conflicting interests. If developing countries have an important advantage in a product, particularly if the advantage has grown over the period of study, the rank changes will be substantial due to their comparative static nature. The most reliable ranking changes are those which occur at the extremes because products which fall near the middle of the rankings have relatively similar indexes.

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[2]Indicating less of an advantage.

[3]For the most part, this means developing countries.

8.3 Revealed Comparative Advantage for Five Countries and the EEC-6

The revealed comparative advantage rankings are presented in Table 8.1. Rankings for each country (or economic unit) are calculated by using the two previously discussed bases. Compared to the sample countries, the U. S. is found to have an advantage in the production of aircraft, made up textiles, cotton fabrics, office machinery, tractors, cinematic and photographic goods, fertilizers, power generating machinery, wrought aluminum, and articles of paper. Computing revealed comparative advantage relative to world exports, the rankings for made up textiles and cotton fabrics drop to around 20th, which still indicates a relative advantage. New products in the top then are then nickel, explosives, electric generating equipment, scientific, medical and optical goods, and railway vehicles. Of these new entrants to the top ten ranks, only scientific medical and optical goods improved its ranking importantly (from 21). Aside from the two aforementioned products, none of the former top ten products dropped farther than 16th in the rankings. The U. S. comparative advantage rankings relative to the world (RCA_W) indicate the importance of technology as a determinant of export strength more clearly than the rankings which are relative to the sample countries (RCA_I). Using RCA_W, the U. S. advantage is revealed to be greatest in aircraft and office machinery (the latter includes computers); these are the two most technological products in the sample, judging from the proportion of scientists and engineers

TABLE 8.1.--Revealed Comparative Advantage

SITC		EEC-6			United Kingdom			Canada			Sweden			Japan			United States		
		Index	Rankings		Index	Rankings		Index	Rankings		Index	Rankings		Index	Rankings		Index	Rankings	
		RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W
512	Organic chemicals	116.4	38	41	120.9	40	37	16.3	54	53	24.3	61	58	79.7	29	29	121.7	20	27
513,4,5	Inorganic chemicals	110.4	42	27	85.6	53	36	127.3	15	14	68.3	45	34	55.7	40	30	133.1	17	11
531	Synthetic organic dye	161.8	13	36	179.6	15	32	0.0	72	72	10.9	66	65	64.6	34	41	36.0	60	57
533	Paints & varnishes	149.2	18	24	170.5	19	22	49.7	26	26	117.4	24	24	48.4	41	40	57.7	49	45
541	Pharmaceutical	134.5	30	16	193.3	14	11	26.1	48	40	89.2	35	26	14.3	63	57	97.7	26	23
551	Essential oil & perfume	145.3	21	49	172.6	18	39	3.6	65	64	7.4	70	67	17.1	60	63	110.4	24	40
553,4	Perfumery & cosmetics	155.4	16	3	195.9	13	7	12.5	58	51	44.4	53	40	8.1	67	61	80.7	34	22
561	Fertilizers, mfg.	86.1	54	38	33.5	68	58	215.9	8	7	12.1	64	59	109.1	17	15	159.1	7	5
571	Explosives	108.2	43	17	177.4	16	10	22.2	52	41	280.3	5	3	6.5	69	64	138.2	13	6
581	Plastics	146.9	19	30	94.5	52	48	13.4	55	56	103.1	28	31	85.7	26	27	70.0	40	42
599	Chemical products	125.9	32	18	149.3	25	16	26.4	47	36	72.2	43	32	29.5	55	44	125.9	19	13
611	Leather	76.4	64	60	138.6	29	34	29.8	41	45	91.0	34	36	449.3	2	2	117.6	22	29
612	Leather, mfg.	224.7	3	4	125.5	39	31	47.3	29	25	45.6	51	46	15.5	62	58	33.1	62	54
613	Fur skins	167.5	10	11	254.0	11	9	29.1	43	42	122.3	21	21	6.9	68	65	42.2	58	52
621	Rubber products	243.9	1	1	126.8	38	15	22.4	51	34	153.7	12	7	31.5	51	39	90.8	31	17
629.0	Other rubber products	65.7	68	53	624.3	1	2	5.2	64	63	159.5	11	11	56.9	39	28	43.9	57	44
629.1	Rubber tires & tubes	102.8	47	15	109.8	43	18	90.7	20	16	.0	71	71	145.6	11	6	69.0	41	25
641	Paper & paperboard	37.2	71	67	44.5	64	64	561.5	4	4	607.5	1	2	40.4	45	45	95.1	27	35
642	Paper products	95.2	51	46	131.4	35	29	32.1	37	35	317.0	4	4	25.2	56	49	146.2	10	15
651.2	Wool yarn	116.9	37	66	366.5	4	49	8.9	61	65	26.3	59	66	72.6	32	51	2.0	72	72
651.3	Cotton yarn, unbleached	103.2	45	69	260.4	9	54	0.0	71	71	9.1	67	68	133.0	12	47	67.2	44	61
651.4	Cotton yarn, bleached	168.5	9	50	127.2	36	52	0.0	70	70	91.7	33	47	43.7	43	48	76.0	37	53
651.6	Yarn of synthetic fibers	141.0	26	23	103.0	49	40	2327.3	2	2	25.2	60	57	106.2	19	20	53.0	51	47
652	Cotton fabrics	95.4	50	62	69.9	59	60	24.3	50	55	87.9	37	45	81.1	28	39	218.7	3	24
653.0	Other wooven textiles	68.3	67	40	567.1	2	1	30.8	39	24	120.4	22	12	100.5	21	14	12.6	68	58
653.2	Woolen fabrics	159.4	15	13	355.0	5	4	6.8	62	62	9.0	68	62	30.9	52	43	4.3	71	70
653,5,68	Synthetic fabrics	100.5	48	39	46.0	63	56	35.7	35	30	28.4	57	54	207.8	7	8	49.8	52	46
654	Tulle, lace & embroidery	112.0	41	58	149.9	24	44	11.3	59	61	49.9	48	53	114.2	16	26	66.6	42	43
655	Special textile fabrics	145.1	22	29	101.9	50	46	28.8	44	46	101.1	29	29	75.9	30	32	68.9	42	43
656.0	Made up textiles	77.7	62	64	165.8	20	41	44.5	32	44	98.2	31	41	29.7	54	54	227.8	2	18
656.6	Blankets	171.5	8	42	222.7	12	30	13.2	56	60	48.5	49	56	33.0	50	52	17.6	64	67
657	Floor coverings	86.0	55	59	347.0	6	8	29.5	42	49	52.9	46	48	19.8	58	59	136.8	16	26
664	Glass	113.8	40	31	143.4	26	23	0.0	69	69	134.2	18	16	44.9	42	37	137.0	14	14
665	Glassware	164.8	11	12	114.1	41	35	171.0	12	11	131.3	19	18	15.7	61	56	72.5	38	33
666	Pottery	83.6	58	35	262.6	8	6	0.0	68	68	21.7	62	55	173.6	9	5	7.5	70	68

TABLE 8.1.--Continued

SITC		EEC-6 Index	EEC-6 Rankings		United Kingdom Index	United Kingdom Rankings		Canada Index	Canada Rankings		Sweden Index	Sweden Rankings		Japan Index	Japan Rankings		United States Index	United States Rankings	
		RCA_I	PCA_I	RCA_W	RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W	RCA_I	RCA_I	RCA_W
671	Pig iron	73.2	65	61	35.7	67	68	207.3	9	12	318.0	3	4	577.3	1	1	39.5	59	55
673	Iron & Steel bars	118.4	36	47	59.3	60	57	30.3	40	50	104.2	27	37	222.2	4	11	16.0	66	64
674	Universals, plates & sheets	119.0	35	43	23.1	72	69	31.6	38	43	118.1	23	27	220.4	5	10	15.9	67	62
675	Hoops & strips	146.9	20	37	42.7	65	63	0.0	67	67	269.9	6	9	131.7	13	21	23.3	63	59
676	Railway construction material	145.0	24	14	50.5	61	53	78.8	21	20	48.4	50	42	116.7	15	16	92.3	29	28
678	Tubes, pipes & fittings	121.1	34	26	28.6	69	67	50.8	25	22	44.4	52	43	172.6	10	9	61.8	47	39
682.2	Copper, wrought	114.0	39	68	160.5	22	62	78.8	22	52	185.4	8	49	93.8	22	50	47.2	55	66
683.2	Nickel, wrought	92.2	53	21	134.8	32	13	314.1	6	3	88.1	36	20	35.0	49	35	139.3	11	4
684.2	Aluminum, wrought	127.7	31	33	76.9	56	51	10.0	60	57	150.7	14	17	39.6	46	42	148.1	9	16
685.2	Lead, wrought	145.1	23	--	95.1	51	--	413.6	5	--	78.2	41	--	24.7	57	--	58.0	48	--
686.2	Zinc, wrought	141.0	27	--	104.6	47	--	77.7	23	--	31.7	56	--	30.7	53	--	126.2	18	--
687.2	Tin, wrought	177.0	7	--	255.9	10	--	0.0	66	--	78.4	40	--	74.4	31	--	48.7	53	--
711	Power generating machinery	79.9	59	56	160.1	23	20	143.7	14	17	71.5	44	38	57.9	37	34	150.3	8	12
712.0	Agricultural machinery	83.8	57	45	482.9	3	3	187.7	10	8	141.5	15	15	4.8	70	67	87.4	32	30
712.5	Tractors	68.9	66	48	137.6	30	17	157.4	13	9	.0	72	72	125.4	14	12	178.8	5	3
714	Office machinery	61.2	70	57	132.5	33	19	113.3	16	18	91.8	32	22	89.5	23	17	183.3	4	2
715	Metal working machinery	154.2	17	10	85.1	54	42	36.3	34	29	78.7	39	30	57.1	38	33	82.2	33	31
717.1	Textile machinery	160.7	14	9	110.4	42	33	12.6	57	54	43.9	54	44	83.5	27	22	44.8	56	48
72.0	Other electrical machinery	106.1	44	34	335.9	7	5	28.6	45	37	99.7	30	23	61.4	36	31	71.9	39	32
722.1	Electric generators	102.8	46	20	107.9	46	25	26.9	46	31	137.7	17	13	62.7	35	25	138.9	12	7
731	Railway vehicles	122.5	33	19	27.5	70	65	101.6	18	19	27.4	58	52	88.2	24	19	136.9	15	10
732.1	Bodies, chassis & frames	78.5	61	54	132.1	34	28	176.6	11	10	126.7	20	19	105.6	20	18	114.0	23	21
732.1, 6	Automobiles	95.2	52	44	36.5	66	59	281.8	7	6	86.6	38	28	219.6	6	7	68.7	43	36
732.2, 5, 7	Buses and trucks	192.0	6	2	70.8	58	43	3483.8	1	1	160.6	10	8	65.3	33	24	34.6	61	49
733	Bicycles	135.0	29	7	142.9	27	14	18.2	53	48	140.8	16	14	41.5	44	36	92.3	30	20
734	Aircraft	35.9	72	65	75.5	57	47	32.4	36	32	8.8	69	63	1.0	72	72	376.1	1	1
735	Ships & boats	84.7	56	32	26.6	71	61	105.3	17	13	152.3	13	10	260.4	3	3	11.7	69	60
812	Plumbing & heating	140.6	28	22	161.9	21	21	45.2	31	27	245.5	7	6	17.1	59	55	77.2	36	34
812	Furniture	142.6	25	5	137.3	31	12	97.1	19	15	421.6	2	1	10.3	65	60	48.3	54	38
831	Travel goods & handbags	195.0	5	28	47.5	62	66	49.2	27	33	50.2	47	51	39.6	47	46	106.7	25	37
841	Clothing	161.9	12	52	176.7	17	45	58.4	24	39	164.4	9	33	35.1	48	53	54.4	50	56
842	Fur clothing	77.0	63	63	127.1	37	50	710.5	3	5	117.4	25	39	3.7	71	70	78.3	35	50
851	Footwear	243.6	2	8	77.2	55	55	40.6	33	38	106.9	26	35	9.8	66	66	16.8	64	63
861	Scientific, medical & optical	95.8	49	25	103.2	48	26	46.1	30	21	74.2	42	25	108.0	18	13	120.0	21	9
862	Photographic & cinema	79.3	60	51	139.0	28	27	49.0	28	23	35.4	55	50	87.4	25	23	174.8	6	8
891	Musical instruments	61.5	69	55	109.7	44	24	5.7	63	58	11.4	65	60	203.5	8	4	93.4	28	19
897	Jewelry	200.0	4	6	108.4	45	38	26.0	49	47	14.1	63	61	10.5	64	62	66.4	46	41

SOURCE: Commodity Trade Statistics (Magnetic Tapes)

NOTE: The EEC trade flows used here are external only. The RCA index is calculated according to equation 8-4. The rankings are based on their respective index; only the RCA_I index appears in the table. All rankings are high to low (rank = 1 indicates the greatest advantage.

employed in each industry. Among the remaining top 10 industries, only nickel, tractors, and railway vehicles are not relatively technological. No other particular skilled labor class is highly associated with the products in which the U. S. has its greatest advantage. However, the U. S. advantage is generally concentrated in products which are skill intensive according to index γ_1 used in Chapter III.

Either method of computing RCA identifies the same products as those in which the U. S. has a relative disadvantage. Wool yarn, woolen fabrics, pottery, other woven fabrics, footwear, and blankets are among the lowest ranked products. All of these are relatively intensive in their use of unskilled labor. Ships and boats, universals, plates, and sheets, iron and steel bars, and hoops and strips also fall near the bottom of the RCA rankings. Ships and boats utilize skilled blue collar labor more intensively than any other manufacturing industry. The steel industry products are the fourth most intensive in their use of skilled blue collar labor.[4]

There is little evidence that the EEC as a unit derives an advantage in technologically oriented products. For the most part the RCA_I rankings are dominated by products which use operatives relatively intensively such as materials of rubber, footwear, manufactures of leather, travel goods and handbags, blankets, and bleached cotton yarn. When the RCA_W ranks are computed, travel goods and handbags, blankets, and bleached cotton yarn fall to rankings

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[4]These rankings are from the input-output table sectors used in Chapter III.

between 30 and 50. Also, several more technologically oriented products appear near the top of the rankings; textile machinery and metal working machinery. Bicycles and furniture move into the top ten from rankings in the mid 20's.

At the other end of the spectrum, the RCA_I rankings show the EEC to have a relative disadvantage in aircraft, paper and paper board, office machinery, musical instruments, other rubber articles, other woven fabrics, tractors, pig iron, leather, fur clothing, made up textiles and bodies chasis and frames. When RCA_W is computed, these rankings are affected, but not in terms of the skill requirements of the products.

Two prominent features characterize EEC external export patterns: (1) the lack of importance of technology, except as a determinant of disadvantage, and (2) a concentrated advantage in products which use unskilled and semi-skilled labor relatively intensively, implying a conflict with the export patterns of developing countries.

The products in which the United Kingdom has its greatest advantage are not very similar in terms of their skill content. The RCA_I rankings show the U. K. to have an advantage in agricultural machinery and other electrical machinery; both products are technologically oriented. Other high ranking products are: other rubber products, other woven fabrics, wool yarn, woolen fabrics, floor coverings, and unbleached cotton yarn. All of these use unskilled labor relatively intensively. Pottery and wrought tin, both of which require inputs of skilled blue collar labor intensively, also rank among the U. K.'s top ten products. When these rankings are compared to the RCA_W ranks, two very unskilled intensive products (unbleached cotton yarn and wool yarn) drop around 50^{th}. They are replaced by perfume and cosmetics and explosives; the latter product is relatively technological.

Similar products are identified as those in which the U. K. has a disadvantage by either RCA index. Fertilizers and synthetic fabrics are the most technologically intensive products. Other low ranking products use skilled blue collar labor rather intensively: universals, plates, and sheets, ships and boats, railway vehicles, tubes and pipes, pig iron, autos, hoops and strips, railway construction materials, and iron and steel bars. Travel goods and handbags, paper and paper board, and cotton fabric intensively require unskilled labor and rank near the bottom of the RCA scale.

Canada's comparative advantage is derived from an abundance of natural resources. Paper and paperboard, wrought lead, wrought nickel, and fur clothing have high rankings. Automobiles, buses and trucks, and bodies chassis and frames rank high due to the U. S. - Canadian auto agreement whch took effect just prior to the base period of this study. Canada also has an advantage in several technologically oriented products: synthetic yarn, fertilizer, and agricultural machinery. Canada's revealed comparative advantage with respect to the sample countries is very similar to its advantage with respect to the world.

The Canadian disadvantage is highly concentrated in textiles. Unbleached and bleached cotton yarn, wool yarn, woolen fabrics, blankets, tulle, lace, and embroidery dominate the lower RCA rankings. Canada also has a disadvantage in several natural resource intensive products: wrought tin, glass, and aluminum. The U. S. has an advantage in the last two.

Sweden's comparative advantage is greatest in furniture, paper and paperboard, articles of paper and explosives. Pig iron, ships and boats, hoops and strips, wrought copper, plumbing and heating, apparatus, and buses and trucks are skilled blue collar labor intensive products in which Sweden also has an advantage. High on the comparative advantage scale are other rubber articles, and clothing; both are unskilled labor intensive. When RCA_W is used to assess Sweden's comparative advantage, clothing and wrought copper drop far back in the rankings. Little else substantively changes.

Sweden's disadvantage is revealed to be about the same by either RCA index. Textile products predominate in the lower rankings: woolen fabrics, unbleached cotton yarn, synthetic yarn, wool yarn, and synthetic fabrics. Several specific capital goods also appear: tractors, aircraft, and railroad vehicles. The remaining items are an assortment of non-durable consumer goods and intermediate-inputs: perfume and essential oil, musical instruments, jewelry, tires and tubes, fertilizer, synthetic organic dyes, and pottery. Among these items only railway vehicles and tractors require a relatively intensive amount of skilled blue collar labor. The textile products are relatively intensive in unskilled labor.

Japan's advantage[5] is concentrated in steel and in products which are relatively intensive in their use of steel as an input. Pig iron, iron and steel bars, universals, plates, and sheets, tubes and pipes, and hoops and strips are the top ranking iron and steel products. Japan's advantage in steel is complementary to its advantage in automobiles, ship and boat building, and tractors. All of the above named products are produced with a relatively large proportin of skilled blue collar labor.[6] Japan also has an advantage in leather, synthetic fabrics, unbleached cotton yarn, musical instruments, pottery, and tires and tubes. When the Japanese advantage is assessed relative to the world, unbleached cotton yarn drops substantially in rank. Also, scientific medical and optical equipment rises five rankings to 13th. The former product is unskilled intensive; the latter is relatively technological.

Japan has a general disadvantage in consumer non-durable goods: fur clothing, fur skins (an input), perfume and cosmetics, perfume and essential oil, footwear, glassware, and jewelry. For the most part, these products embody low skill labor. Several very

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[5]Japan's advantage in domestic electronic equipment evidently is hidden by the fact that the "other electrical machinery" grouping is the most aggregated commodity classification employed. The input-output sectors break-out radios and TV's. There, Japan's advantage is clearly shown.

[6]Judging from U. S. skill coefficients (a tentative judgment given the state of the U. S. steel industry) most of the products' names above are produced in input-output sectors which rank among the top five manufacturing sectors in terms of their intensive use of skilled blue collar labor (Chapter III). Only automobiles and tractors (20th) rank lower than 5th.

technologically oriented products also appear among the lowest rankings: aircraft, medical and pharmaceutical products, and explosives.

Recently Jorgenson and Nishimizu completed a study in which they concluded that the level of technology in the Japanese economy as a whole reached parity with the U. S. four years ago (2). In this study Japan's technological edge is assessed by three different methods: (1) the RCA method of this chapter, (2) input-output analysis using skill classes, and (3) multiple regression analysis. Common to all of these methods is the use of U. S. coefficients. Although this is reasonable, it may be inaccurate for Japan's most important product, steel (15.5% of Japan's total exports). Nonetheless, in this section it has been shown that there are several other highly technological products in which Japan has a marked disadvantage: aircraft and drugs. Also, the multiple regression analysis in Chapter IX fails to produce a significant relationship between the percentage of scientists and engineers in an industry and several measures of Japanese export performance. Finally, according to the relative capital endowment rankings, relative skill endowment rankings (both Table 9.3), and the revealed skill intensity rankings (Table 3.4), Japan is not superior to the U. S. in its general abundance or use of technology, capital, or skilled labor. Instead, Japan's advantage has been built by specialization and focusing its strength in several key sectors (see Chapter IX). This has certain consequences for Japan's future growth that will be addressed later in this chapter.

8.4 Comparative Advantage: Changing Patterns

Since Balassa first introduced the concept of revealed comparative advantage, there has been a substantial shift in the RCA rankings among the developed countries. Balassa's study covered the period from 1953 to 1962. Table 8.2 shows the changes in the rankings for several products and product groups between the 1953 to 1962 period and the 1967-1975 period.

Japan shows the most marked shift among the sample countries. Japan has moved from a dominant position in footwear, textiles, and clothing to dominant positions in steel and automobiles, while increasing its strength in ship and boat building. The Japanese position in office machinery has also improved substantially. Thus, over a twenty year period Japan has transformed its pattern of exports from that of a developing country to one more characteristic of a highly developed country.

Over the same period the U. S. has retained its disadvantage in textiles, clothing, footwear, and ship and boat building. The U. S. disadvantage in automobiles has importantly diminished and U. S. strength in office machinery has increased. I have no direct evidence as to why the U. S. disadvantage in automobiles has been lessened. However, Linder's theory appears to provide the relevant explanation. European and Japanese auto producers were familiar with the technology of compact car production and design; through product differentiation, they penetrated the U. S. market--

TABLE 8.2.--Revealed Comparative Advantage: Changing Patterns

Rankings Based on Index	EEC-6	United Kingdom	Canada	Sweden	Japan	United States
			Textiles[1]			
RCA_{I62}	34.3	41.3	48.2	52.2	17.8	52.4
RCA_{I75}	37.3	26.1	47.9	46.6	32.5	43.6
RCA_{w75}	47.2	37.3	49.2	49.1	37.8	48.9
			Clothing			
RCA_{I62}	6	66	49	28	15	59
RCA_{I75}	12	17	24	9	48	50
RCA_{I75}	52	45	39	33	53	56
			Footwear			
RCA_{I62}	4	64	46	61	1	69
RCA_{I75}	2	55	33	26	66	65
RCA_{w75}	8	55	38	35	66	63
			Automobiles			
RCA_{I62}	1	24	53	7	54	60
RCA_{I75}	52	66	7	38	6	43
			Ships and Boats			
RCA_{I62}	41	45	57	3	8	68
RCA_{I75}	56	71	17	13	3	69
			Steel Products[2]			
RCA_{I62}	18.5	51.8	26.8	13.7	33.7	53.8
RCA_{I75}	35.7	65.7	33.3	26.8	8.0	55.2
			Office Machinery			
RCA_{I62}	55	59	17	13	43	14
RCA_{I75}	70	33	16	32	23	4

SOURCE: Balassa (1).

NOTES: RCA_{I62} indicates that the rankings in that row are from Balassa's 1953-62 period and use the index RCA_I. RCA_{I75} indicates that the RCA_{I75} index was used for the period 1967-75. RCA_{w75} indicates that the RCA_w index was used for the period 1967-75.

[1]Includes 651.2, 651.3, 651.4, 651.6, 652, 653.2, 653, 655, 656, 658, 653.10, 654, 655, 656.6, 656.0, and 657--the average rank is reported.

[2]Includes 671, 673, 674, 475, 676, and 678--the average rank is reported.

satisfying a previously neglected demand. In addition, higher oil prices have made this market segment relatively more important. Only in recent years have the U. S. producers offered cars which are essentially similar to the imported models. Therefore, it is the increased responsiveness of U. S. producers to satisfy domestic tastes which has tended to decrease the U. S. disadvantage.

The change in the United Kingdom's comparative advantage pattern is not consistent with respect to the factor intensities of the products whose rankings have changed. The U. K. has developed an advantage in textiles, improving its average comparative advantage ranking from 41.3 to 26.1 between the 1962 and 1975 periods. However, when the 1975 ranking is computed relative to the world standard, the U. K. ranking slips back to 37.3. The same is true of the U. K. position in clothing, and to a lesser degree, footwear. Thus, the U. K. has developed an advantage among products which are better produced by developing nations. The U. K. position in automobiles, ship and boat building, and steel has worsened; but the disadvantage in office machinery has been neutralized, as office machinery moves from 59th to the middle of the RCA scale (33). The pattern for the EEC-6 is highly similar to this.

Canada has cultivated an advantage in clothing, and somewhat improved its position in footwear. Its greatest advance has been in automobiles and ship and boat building. Sweden has lost part of its advantage in ship and boat building, and all of it in automobiles. The Swedish position in office machinery and steel products has also declined substantially. Relative to the sample countries- Sweden has gained in clothing, footwear, and slightly in textiles. This change in the revealed comparative advantage pattern indicates that Sweden has lost her advantage in several important skilled blue collar labor intensive products, and one very technological product. Meanwhile, the Swedish advantage relative to the sample countries has shifted into products which are relatively intensive in their use of unskilled labor. Thus, considering labor as a heterogeneous input clarifies the dislocation in the domestic labor market.

The current conflict between the EEC, U. K., Sweden, and the developing nations is revealed by the differences between the RCA_{I75} RCA_{W75} rankings for clothing and textiles (Table 8.2). Here there are two factors to be considered. The RCA_I rankings improved between the two periods partly because of Japan's withdrawal from these non-durable consuming goods industries. However, the 1975 RCA rankings which are relative to the world standard fall when compared to the sample country's standard partly due to the granting of preferences to developing nations.

Between 1973 and 1975 the EEC-9 accounted for 72% of the world growth in textile imports (6). This has occurred despite the signing of a multi-fiber agreement in 1973, aimed at limiting imports. The European Community is seeking to freeze imports from Hong Kong, Taiwan, and South Korea, but allow export growth for other less developed countries. The developed nations have a true advantage--relative to the world--in only a few textile products. Rising unemployment and stagnant demand for textiles have tended to make short run protectionist solutions overly attractive. The entire picture is clouded further by multinational corporations which are located on both sides of the existing and proposed barriers.

Steel products have also been subjected to trade restrictions. The essence of the steel problem is a lack of aggregate demand for a product with relatively high fixed costs. This creates incentives for dumping. The U. S. steelmakers have accused the Japanese of dumping and receiving government subsidies. The Japanese claim that their advantage is due to superior technology and wage costs that are 30% below U. S. levels. Japan sends 20% of its steel exports to the U. S. (and more counting the steel embodied in automobiles) compared to 4% to the EEC (7). The Japanese steel industry is heavily dependent on exports which comprise 36% of its output. This is 50% of the total amount of steel traded internationally (excluding internal EEC shipments) (8).

The device which has been used to control this potentially dangerous situation is the orderly marketing agreement. Japan and the EEC reached an agreement under which Japanese steel exports to the Community could be limited. Subsequently, the U. S. steel producers claimed that this agreement deflected more steel to the U. S. market. The U. S., failing to reach an orderly marketing agreement with the EEC and Sweden, imposed import quotas on their shipments of specialty steels. However, the U. S. and Japan were able to reach an orderly marketing agreement in speciality steels (9).

The willingness of the Japanese to enter into these agreements is a direct result of their reliance on steel exports. Japan can ill afford a highly restrictive unilaterally imposed barrier against these exports. It is reasonable to assume that a mutually agreed upon limit will be less restrictive than one which is unilaterally imposed. Furthermore, as it is an agreement, it may be open to renegotiation as circumstances change.

The failure of the U. S. and EEC to reach an agreement on steel is due to a basic ideological conflict. The EEC is far more committed to free trade than the U. S. Although the Community is not opposed to the use of the orderly marketing agreement, it is seen as a device of last resort. At the time that the U. S. attempted to negotiate the agreement, the European Community felt that their problems in steel were as great as in those of the U. S., but U. S. economic growth was progressing faster. Given these circumstances, the Community felt the U. S. should not request unwarranted protection (3).

Nonetheless, the EEC has entered into other agreements to protect its markets. The EEC and Japan have negotiated quota agreements concerning imports of steel, cars, ball-bearings, and ships. Similar agreements with other countries may be forthcoming (5).

The increased prominence of orderly marketing agreements has prompted a response from GATT. A GATT study estimates that new restrictions now apply to 3 to 5% of world trade flows (4). The products most commonly restricted are textiles, clothing, shoes, steel, ships, and household electrical appliances. Although these agreements are allowed under current GATT rules, their increased usage tends to subvert the basic GATT goal of free trade. Furthermore, although these are agreements, they are agreements reached between parties with differing bargaining power. The agreements are most commonly struck between developed and developing countries or between Japan and other developed countries. At best this approach constitutes a second best solution to current world problems. The developed countries seek these agreements, not to improve their welfare, but in response to labor union and industry pressures. Consumer lobby groups are too weak to effect a balanced viewpoint on the issue of protection.

8.5 Conclusion

The tendency toward protectionism is world wide. The most fundamental characteristic of protectionism is the unwillingness of countries to reallocate resources from traditional industries where they no longer have an advantage into industries where they have an advantage. This solution is not simple to implement, given the slow upturn of the world economy. Furthermore, multinational corporations located in both developed and developing countries, charges of dumping, and subsidiation, cloud true assessments of comparative advantage. It is probable that these issues will not be resolved until the recession is clearly gone and demand recovers; thus making alternatives to protectionism politically more desirable.

REFERENCES

1. Balassa, B. "Trade Liberalisation and 'Revealed' Comparative Advantage." Manchester School (May 1965): 99-123.

2. Business Week, September 26, 1977, p. 55.

3. European Community, August/September, 1976, no. 196, p. 43.

4. New York Times, September 23, 1977, p. A-1.

5. The Economist, July 9, 1977, p. 51.

6. The Economist, July 30, 1977, p. 75.

7. The Economist, August 6, 1977, p. 75.

8. The Economist, June 28, 1975, p. 91.

9. Wall Street Journal, June 8, 1976.

CHAPTER IX

A MULTIPLE REGRESSION ANALYSIS OF THE HUMAN SKILLS AND HECKSCHER-OHLIN THEORIES: SOME IMPLICATIONS

9.1 Introduction

In this chapter several major themes are brought together. As such it draws heavily on the preceding chapters, especially Chapter III (Human Skills). The major function of this chapter is to provide an empirical assessment of the human skills and Heckscher-Ohlin theories using multiple regression analysis to isolate the effects of the individual theories. These theories are tested by employing the relevant total requirements variables. As most of the current econometric evidence which pertains to these theories is based upon the use of the incorrect immediate and direct requirements, we shall inspect the relationship between skill indexes, compositional skill variables, and capital/labor ratios when both the total and the immediate requirements are utilized. If there is a close positive relationship between variables based upon the total requirements and their immediate counterparts, we may conclude that our current stock of information is left more or less intact. However, to increase the certainty of this conclusion, both the immediate and then the total requirements will be employed as independent variables using the same dependent variable.

Having already completed an input-output evaluation of the human skills theory, we have an opportunity to make a comparison between the inferences drawn from that technique compared to those drawn from the use of multiple regression analysis. From a strict theoretical standpoint, there should be no differences. However, each of these empirical methods has strengths and weaknesses. The critical distinction between I-O and regression testing is that the former procedure assesses aggregated characteristics across countries, while the latter assesses characteristics aggregated at the industry level across industries. By taking these into account and balancing one set of results against another, we can obtain insights that would be unavailable had we simply chosen one mode of analysis.

First, the methodology is set forth. Next, the multiple regression results which provide the proper test of the theory are presented. After comparing these results to those of similar regressions which use the immediate requirements coefficients as explanatory variables, the similarity between the immediate and total requirements is assessed.

9.2 Methodology

Here comparative advantage is measured by two different dependent variables. The choice of dependent variable is important because it is this variable which the theory tested purports to explain. If the variable is a poor measure of comparative advantage, then the test of the theory is not valid. However, for any reasonable measure of comparative advantage the same inferences should be able to be drawn. If this cannot be done, the problem is reduced to a rejection of the theory versus a rejection of the dependent variable as a valid measure to be explained.[1] For each country, the dependent variable is defined as its exports minus imports (net exports) and also its exports as a share of the exports of all the countries in the sample (export share).

From a theoretical standpoint, net exports is the proper variable by which to measure comparative advantage for a factor proportions test. The net exports variable subtracts out the imports and focuses on the net flow of goods. Clearly, a factor proportions account is meant to address exports and imports. Although X/M may also qualify on these grounds, it does not give weight to each industry in accordance with its impact on the allocation of domestic resources. However, when the effects of commercial policy are considered, the inclusion of imports creates a distortion. Tariffs, quotas, nontariff barriers and especially the rise in the prominence of orderly market agreements, distort the trade flows across industries for each country in a fashion specific to the commercial policy of each. If commercial policy is geared for protection, use of the net export variable imparts a bias against the theory so tested. However, because of the year under study (1975), tariff barriers should not affect this analysis as much as they

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[1]Although the latter choice involves circuitous reasoning, it is a rather common conclusion. If a dependent variable constitutes a particularly bad measure of comparative advantage, it should not even be used. However, if there are some problems with a given variable, but we have expectations as to the net inpact of those problems, there may be a rationale for employing that variable.

have affected previous studies due to the lower tariff levels. Orderly market agreements will affect the analysis; however, they are mostly confined to a few particular commodities.[2]

The export share variable does not net out imports, although it is less affected by differences in commercial policy. Since it measures exports to the world, the individual country differences in commercial policy are not as great a factor since all countries face more or less the same barriers. Therefore, the export share variable may be a superior measure against which to test the theories, but both dependent variables should lead to the same general conclusions.

The skill categories employed here are those which are common to the literature (1,2). Although the availability of data allows a far more detailed breakdown of the labor force by occupation, the introduction of too many skill classes increases the probability of spurious correlations. The selection of seven skill categories is considered to embody the optimal trade-off between requirements for detail versus economic distinctiveness among the skill classifications.

The critical question is: Which skill classes are important determinants of trade patterns? The answer to this question determines the functional specification of the empirical test. The skill classes which are most important must be included in the regressions; otherwise, specification errors are introduced. The omission of a

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[2]See Chapter VIII.

relevant explanatory variable introduces a bias and precludes inspection of the excluded variable. These considerations are important because the skill variables sum to unity across industries. Thus, the perfect multicollinearity between the skill variables and the constant term in the regression precludes inclusion of all the skill classes or requires a constrained regression.

The most objective way to deal with these problems is to use a constrained regression. When the constant term in the regression equation is surpressed, the problem of perfect multicollinearity is resolved. The regression is perfectly objective as it is in no way dependent on the researcher's choice of which of the skill variables is most important. By including all skill classes in the regression, information on each nation's comparative advantage among the most skilled variables and among the least skilled variables also can be obtained.

The independent variables entered in the multiple regressions measure three main economic characteristics: skilled labor intensity, unskilled labor intensity, and capital intensity. Four variables measure different aspects of skilled labor intensity; three variables measure unskilled labor intensity. The following analysis sets forth the special aspects of each of these variables within its major group.

High Skill Labor Classes. Expect each of these classes of labor to be positive determinants of comparative advantage for relatively skilled labor abundant countries; negative determinants for relatively unskilled labor abundant countries.

1. Scientists and engineers: This class contains the most skilled of the skilled laborers. In addition to being skilled, these are the laborers most important to research and development activities.

2. Other professional technical and managerial: This class contains the most heterogeneous mix of skilled white collar workers.

3. Clerical and sales: This is the least skilled of the skilled white collar labor classes. However, as the services which workers of this type provide are demanded most intensively by workers with yet more skill, the class can be viewed as a general proxy for skilled white collar labor.

4. Craftsmen and foremen: These are the most highly skilled laborers in the blue collar work force. Workers of this type provide the bulk of the skilled labor services which are most closely related to production activity.

Unskilled Labor Classes.

5. Operatives: This unskilled labor classification contains the largest proportion of unskilled labor.[3] Although these workers are not the least skilled of the unskilled group, they possess skills which are very easily acquired. The factor endowment theorem is based upon the proposition that in a relatively labor abundant country, it is the large supply of unskilled labor which makes labor relatively cheap. Therefore, the relative size of the "operatives" classification across industries makes it the most important classification

[3]Generally speaking, it contains the largest proportion of any type of labor across industries, although for a number of industries the proportion of craftsmen and foremen is the largest (see Table 9.1); nearly double the proportional average of any other labor classification.

with respect to the role of unskilled labor in the context of a factor proportions model.

6. Nonfarm laborers and service: this too is one of the most unskilled of the unskilled labor classes, but it is relatively less important than the operatives class. As workers in this classification hold no special skills, their sole affect on the trade patterns is through the relative wage effect which has only one third of the impact of the operatives classification.

Unskilled Labor--Special Considerations

7. Farm laborers: Workers in this class are at least as unskilled as workers in the previous unskilled class. However, no manufacturing sector demands this variety of labor service in the immediate sense.[4] Consequently, the variable performs more as a proxy for the extent to which agricultural strength is "passed on" to the manufacturing sectors.[5] If national advantages in agriculture are passed along, this variable ought to indicate an advantage for Canada, the United States, and Australia.[6]

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[4]For this reason the farm labor variable is not defined when immediate skill coefficients are used.

[5]Note that the processed food sectors are not included in the multiple regression analysis.

[6]Agricultural goods and therefore farm labor is a most intensive input in the textile sectors, but least intensive in the capital goods sectors. Developing countries have a very large volume of their exports concentrated in textile products. For these countries the farm labor variable will probably have a positive coefficient. However, in these cases the variable does not necessarily imply national agricultural strength. Instead, it merely indicates that the exports of the country are relatively intensive in agricultural inputs. In fact, the agricultural inputs may not even be provided

Capital/Labor Ratio

7. Capital/labor ratio: Relatively capital abundant countries derive an advantage in the production of relatively capital intensive commodities; relatively labor abundant countries derive a disadvantage in those commodities.

Table 9.1 summarizes the average relative importance of each of the skill classes across industries.[7]

TABLE 9.1.--Average Relative Importance of Skill Classes Across Sectors; U. S. Labor Coefficients

Skill Class*	I	II	III	IV	V	VI	VII
Percent of Total Labor Force	3.4	14.3	19.1	18.1	31.6	9.4	4.1

SOURCE: 1970 U. S. Census of Population.

*Roman numerals correspond to the arabic numerals above which designate the skill classes.

9.3 The Human Skills and Heckscher-Ohlin Theories of International Trade: An Empirical Analysis

In this section the comparative advantage of nineteen countries is assessed using the total requirements characteristics

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domestically. Developed skill abundant countries have a disadvantage in textile products due to the high unskilled labor content of these products. Therefore, if despite this conceptual bias the farm labor variable is a positive source of comparative advantage for the particular countries named above, this is even stronger evidence that national agricultural strength is passed on to the manufacturing sectors. Due to the complementarity between farm labor and this particular natural resource characteristic, the asymmetrical interpretation is thought to be advisable.

[7] In Chapter II the non-occurrence of factor intensity reversals was established.

estimated from United States data. Table 9.2 summarizes the results of fifty-seven regressions.[8] The following regressions were estimated,

$$X\text{-}M = a_1\bar{s}_1 + a_2\bar{s}_2 + a_3\bar{s}_3 + a_4\bar{s}_4 + a_5\bar{s}_5 + a_6\bar{s}_6 + a_7\bar{s}_7 + a_8\bar{k}/l + e_i \qquad (9\text{-}1)$$

$$X/\Sigma X = a_1\bar{s}_1 + a_2\bar{s}_2 + a_3\bar{s}_3 + a_4\bar{s}_4 + a_5\bar{s}_5 + a_6\bar{s}_6 + a_7\bar{s}_7 + a_8\bar{k}/l + e_i \qquad (9\text{-}2)$$

where e_i is the error term and for each country:

$X\text{-}M$ is net exports (thousands of dollars)

$X/\Sigma X$ is each country's share of exports among sample countries

$\bar{s}_i$ is the proportion of laborers of class i required by each industry computed from the total requirements coefficients.

The regressions are estimated across the manufacturing sectors for each country.

The relevant regressions for each country are summarized in Table 9.2 as (X-M)-T and (X/ΣX)-T where the T indicates that the independent variables used are measured by the total requirements.[9] Table 9.3 presents the measured relative factor endowment position of each country. For the sake of completeness,

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[8]The full results which underlie this table are presented in the appendix. The summary table only provides the sign of the coefficient and its level of significance for coefficients which are significant at the .20 (20%) level. Thus, the table sifts out insignificant results to reveal more clearly the most important trends. The significance levels are rounded to two decimal places.

[9]For the moment the regression results produced by using the immediate requirements will be ignored.

TABLE 9.2.--The Sensitivity of the Theoretical Tests of the Human Skills and Heckscher-Ohlin Theories to the Use of Immediate Versus Total Factor Requirements and to the Selection of a Dependent Variable: An International Comparison for 1975 Manufactures Trade--A Summary of Results

Dependent Variable and Type of Factor[1]	Coefficient Signs and Significance Levels for Independent Variables																R^2_{am}
	I Scientists and Engineers		II Other Professional Technical and Managerial		III Clerical and Sales		IV Craftsmen and Foremen		V Operatives		VI Nonfarm Laborers and Service		VII Farmers and Farm Laborers		Ratio of Capital to Labor		
	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	
Ungrouped																	
United States																	
(X-M)-T	+	(.00)							-	(.01)			+	(.05)	-	(.19)	.30
(X/ΣX)-T	+	(.00)	-	(.01)	+	(.02)			-	(.06)					-	(.00)	.47
(X/ΣX)-I	+	(.00)	-	(.03)	+	(.03)	+	(.10)			+	(.00)			-	(.01)	.42
Canada																	
(X-M)-T																	.15
(X/ΣX)-T											+	(.04)			+	(.03)	.28
(X/ΣX)-I													+	(.00)	+	(.01)	.28
Japan																	
(X-M)-T							+	(.01)									.18
(X/ΣX)-T			+	(.19)	-	(.07)	+	(.00)			-	(.20)					.18
(X/ΣX)-I					-	(.16)	+	(.00)									.15
EEC-9																	
United Kingdom																	
(X-M)-T	+	(.15)			+	(.15)	+	(.20)							-	(.17)	.21
(X/ΣX)-T					+	(.07)											.24
(X/ΣX)-I					+	(.04)	+	(.17)	+	(.04)							.21
West Germany																	
(X-M)-T							+	(.02)	-	(.19)							.16
(X/ΣX)-T	-	(.04)	+	(.08)			+	(.04)	+	(.01)			-	(.20)			.18
(X/ΣX)-I	-	(.20)	+	(.10)			+	(.00)	+	(.00)							.12
Netherlands																	
(X-M)-T									-	(.00)	-	(.09)			+	(.02)	.24
(X/ΣX)-T											-	(.19)			+	(.00)	.28
(X/ΣX)-I									+	(.04)					+	(.00)	.24

TABLE 9.2.--Continued

Dependent Variable and Type of Factor[1]	Coefficient Signs and Significance Levels for Independent Variables																
	I Scientists and Engineers		II Other Professional Technical and Managerial		III Clerical and Sales		IV Craftsmen and Foremen		V Operatives		VI Nonfarm Laborers and Service		VII Farmers and Farm Laborers		Ratio of Capital to Labor		R^2_{am}
	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	
France																	
(X-M)-T			-	(.19)													.08
(X/ΣX)-T	-	(.03)							+	(.00)							.20
(X/ΣX)-I	-	(.08)			+	(.12)			+	(.00)							.16
Italy																	
(X-M)-T									+	(.00)			-	(.06)			.30
(X/ΣX)-T	-	(.01)							+	(.00)			-	(.10)			.38
(X/ΣX)-I	-	(.03)	+	(.19)					+	(.00)	-	(.15)			-	(.18)	.32
Belgium-Luxembourg																	
(X-M)-T									-	(.15)	+	(.18)			+	(.18)	.11
(X/ΣX)-T															+	(.00)	.23
(X/ΣX)-I									+	(.02)					+	(.00)	.21
Denmark																	
(X-M)-T															-	(.09)	.21
(X/ΣX)-T									+	(.16)					-	(.09)	.15
(X/ΣX)-I							+	(.12)	+	(.05)					-	(.01)	.15
Ireland																	
(X-M)-T	-	(.11)	+	(.06)	-	(.18)					-	(.06)					.35
(X/ΣX)-T	-	(.00)	+	(.00)	-	(.05)			+	(.00)	-	(.00)					.47
(X/ΣX)-I	-	(.00)	+	(.00)			-	(.03)	+	(.00)							.42
<u>Other Europe</u>																	
Spain																	
(X-M)-T	-	(.16)							+	(.02)			-	(.09)	-	(.20)	.29
(X/ΣX)-T	-	(.04)							+	(.02)			-	(.12)	-	(.03)	.29
(X/ΣX)-I									+	(.15)	+	(.07)			+	(.00)	.22
Yugoslavia																	
(X-M)-T									+	(.14)							.15
(X/ΣX)-T															+	(.00)	.37
(X/ΣX)-I									+	(.15)	+	(.07)			+	(.00)	.37

TABLE 9.2.--Continued

Dependent Variable and Type of Factor[1]	I Scientists and Engineers		II Other Professional Technical and Managerial		III Clerical and Sales		IV Craftsmen and Foremen		V Operatives		VI Nonfarm Laborers and Service		VII Farmers and Farm Laborers		Ratio of Capital to Labor		R^2_{am}
	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	Sign	Sgnf	
Oceana																	
Australia																	
(X-M)-T									-	(.11)			+	(.02)	+	(.05)	.25
(XΣX)-T							+	(.20)			-	(.20)	+	(.01)	+	(.00)	.27
(X/ΣX)-I															+	(.00)	.17
New Zealand																	
(X-M)-T													+	(.03)			.23
(X/ΣX)-T											-	(.16)	+	(.00)	+	(.00)	.28
(X/ΣX)-I															+	(.03)	.12
Asia																	
Hong Kong																	
(X-M)-T	-	(.09)					-	(.06)	+	(.00)			-	(.01)			.34
(X/ΣX)-T	-	(.10)					-	(.06)	+	(.00)	-	(.05)					.47
(X/ΣX)-I	-	(.18)					-	(.02)	+	(.00)	-	(.04)			-	(.16)	.40
Korea																	
(X-M)-T	-	(.03)					-	(.01)	+	(.00)			+	(.13)			.49
(X/ΣX)-T							-	(.12)	+	(.00)					-	(.08)	.41
(X/ΣX)-I	-	(.17)					-	(.10)	+	(.00)					-	(.02)	.34
India																	
(X-M)-T									+	(.01)	-	(.13)	+	(.08)			.28
(X/ΣX)-T									+	(.00)	-	(.14)	+	(.01)			.33
(X/ΣX)-I	-	(.15)					-	(.11)	+	(.00)							.24
Pakistan																	
(X-M)-T									+	(.05)	-	(.00)	+	(.00)			.60
(X/ΣX)-T									+	(.01)	-	(.00)	+	(.00)			.57
(X/ΣX)-I	-	(.18)					-	(.07)	+	(.00)							.22

SOURCE: Tables

NOTE: All regressions have all variables included. Only those coefficients significant at the 20% level are included in the table. The figures in parentheses give the significance level of the coefficient reported at the head of the table. All regressions are forced through the origin because of the indeterminancy resulting from the fact that the skill level percentages add to unity in each industry. All equations are significant at the 5% level with the exception of Canada (X-M), 15% Belgium-Luxembourg (X-M), 41%; France (X-M), 34%, Yugoslavia (X-M), 22%. The value of R^2 which is reported (R^2_{am}) is the R^2 adjusted for the mean of the dependent variable. The capital/labor ratio is for capital relative to all types of labor.

[1] For each country, Y(X-M) indicates that the dependent variable is net exports expressed in thousands of U. S. dollars; (X/ΣX) indicates that the dependent variable is that country's exports as a proportion of the exports of the nineteen countries in the sample. The designation T or I after the dependent variable denotes whether the independent variables named at the head of the table were measured from this total requirements (T) or their immediate counterparts (I).

both New Zealand and Australia are included in the skill ranking, although these rankings are suspected of being exaggerated (see Chapter III).

Regardless of the dependent variable used, the United States is revealed to derive an advantage from highly skilled technically oriented labor (class I). The U. S. disadvantage is centered in unskilled labor (class V) and, surprisingly, relatively capital intensive commodities. The latter finding is perverse based on the relatively high U. S. capital endowment ranking, but corresponds to Leontief. However, the three factor approach used in Chapter III revealed the U. S. to be relatively more skill abundant than capital abundant. This implies that the U. S. strength derived from skilled labor does, in fact, "swamp" the U. S. capital advantage effect. The U. S. manufacturing advantage derived in agricultural intensive industries is indicated when net exports is used as the dependent variable. When the export share variable is used, the farm labor coefficient is positive, but significant, at only the 22% level. The export share variable also reveals a U. S. advantage in generally skilled labor (class III) and, surprisingly, a disadvantage in managerial labor.

Among other relatively skill abundant countries, the chief advantage is derived from blue collar skilled labor. Japan, the United Kingdom, and West Germany fall into this classification. A statistically significant disadvantage due to unskilled labor intensity is not generally found for these three countries; in fact, West Germany and the United Kingdom are revealed to derive an

TABLE 9.3.--Measured Relative Factor Abundance 1975

Country	Capital/Labor[1]	Rank	Skilled Labor/ Unskilled Labor[2]	Rank
Ungrouped				
United States	1.742	5	.814	1
Canada	1.758	2	.804	2
Japan	1.053	9	.522	8
EEC				
United Kingdom	.762	11	.598	5
West Germany	1.786	1	.555	6
Netherlands	1.345	5	.617	3
France	1.517	4	.443	11
Italy	.727	13	.274	13
Belgium-Luxembourg	1.283	6	.505	9
Denmark	1.247	7	.444	10
Ireland	.454	15	.342	12
Other Europe				
Spain	.535	14	.209	15
Yugoslavia	n.a.	--	.200	16
Oceana				
Australia	.994	10	.613	4
New Zealand	.746	12	.550	7
Asia				
Hong Kong	1.112	8	.216	14
Korea	.103	16	.128	17
India	.019	18	.075	18
Pakistan	.030	17	.059	19

SOURCE: United Nations, Yearbook of National Accounts Statistics.

[1]Thousands of dollars of fixed capital consumed per laborer.

[2]Reproduced from Table 3.7.

n.a. = not available

advantage from unskilled labor (class V) when the export share variable is used. However, employing this variable implies that each country is effectively "competing" against the U. S. export pattern which is concentrated in high technology industries. So that, relative to the U. S., no other country derives a general advantage in high technology products. The technological advantage of any other nation is not revealed because, to the extent that it exists, it is concentrated in a few industries and is not general. This can be seen by noticing that when the net export dependent variable is used, only the United Kingdom exhibits a weakly significant indication of technological advantage.

For several notable cases, the regression analysis fails to agree with the input-output results. For example, among technologically intensive industries, West Germany has an advantage compared to most countries in the sample (Table 3.7). However, as industries become more technologically intensive, the German advantage does not increase; it decreases (Table 9.2). Furthermore, although West Germany does tend to export commodities, which are technological relative to most other sample countries, there are several notable exceptions: aircraft, computers, and electronic components.[10]

The failure of West Germany to exhibit a technological advantage through the multiple regression analysis is surprising. However, the above discussion is not meant to imply that the regression results are wrong. In fact, the regressions discriminate very well among the independent variables. If the German trade data were partitioned

[10]When ranked on the proportion of scientists and engineers in the industry, these commodities rank 2, 6, and 9 respectively.

into two groups, one technological and the other untechnological, the German advantage would be found to lie in the former group, not the latter. This, however, does not imply that the German advantage is caused by the technological nature of those products. Instead, Germany exploit's its advantage in skilled blue collar labor (class IV), among products which are relatively, but not highly technological.

The same general statements apply to Japan, although Japan is characterized by a great deal of specialization. Four (highly visible I-O sectors, steel (15%), ship and boat building (12%), motor vehicles (12%), and radio and T.V. receiving sets (8%) are responsible for 46% of Japan's exports. Of these sectors only radio and T.V. production is measured as highly technoloigcal by skill class one (rank = 7).

There is one important flaw in this analysis: the steel industry. From a statistical standpoint, steel is the extreme observation for Japan; the second most extreme for West Germany (7.5% of exports). Since the U. S. steel industry is unheathly, not being able to compete with foreign steel, its coefficients may be mismeasured with respect to the true optimum skill mix. The extent to which this affects the analysis is unknown.

For the less developed Asian countries, support for the human skill hypothesis is found. Each of these countries derives an advantage from the most important unskilled labor class. Paradoxically, the other unskilled labor class (VI) appears as a source of disadvantage for several of them. The lack of technical labor constitutes a disadvantage for Korea and Hong Kong. These two countries also suffer a disadvantage due to the lack of skilled blue collar labor.

For the remaining countries the skill results are not very clear. It is very difficult to decide what to expect of the trade performance for a country which is neither highly capital nor skill abundant. However. the Netherlands is found to derive an advantage from its relative capital abundance. as does Belgium-Luxembourg. In Chapter III both of these countries were found to have a factor content in their trade structure which implied that they exchange capital for labor of either type (skilled or unskilled), Denmark derives a disadvantage in capital intensive goods according to regression analysis and Chapter III's three factor results. However, Denmark's capital endowment rank is not relatively low.

The conclusions drawn here would have been impossible without the aid of the input-output results in Chapter III. Input-output analysis is useful because it allows us to place countries in an international ordering according to selected criteria (γ_i's of Chapter III). However, regression analysis provides the opportunity to identify the causal factors. Together the two modes of analysis allow a more precise understanding of the underlying dynamics. Using these results it has been shown that the U. S. advantage in technologically oriented skilled labor is unsurpassed. Only for the United Kingdom is there evidence that a technological advantage is general to the domestic economy. Germany and Japan are found to have an advantage in middle technology which is derived from skilled blue collar labor. Japan has advanced its advantage through specialization.

9.4 Total and Immediate Factor Requirements

Input-output analysis requires a great deal of effort and is very restrictive. The researcher is limited to the industrial detail provided by the table. Although I-O analysis is the theoretically correct method by which to test a factor proportions theory, it may not be necessary if the same inferences can be drawn from the immediate requirements.[11] If tests can be performed using a greater degree of disaggregation, more may be learned because more may be taken into account. For example, the I-O table may require far too much aggregation for a test of the scale economy theory; it is certainly too aggregated to test the product cycle theory.

Table 9.2 provides the summary of the multiple regression results for each country using immediate coefficients. The dependent variable is identical to the one used in the equation listed above it (for each country). For each country the following regression was estimated across 71 manufacturing sectors:

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[11]Preliminary evidence indicates that the two types of coefficients are quite similar across industries. Each immediate skill class coefficient has a simple correlation of .92 or more with its total requirement counterpart (excepting farm labor).

$$X/\Sigma X = a_1 s_1 + a_2 s_2 + a_3 s_3 + a_4 s_4 + a_5 s_5 + a_6 s_6 + a_7 s_7 + a_8 k/l + e \qquad (9\text{-}3)$$

The s_i's are entered as proportions and are defined by the roman numerals for the skill classes listed in Table 9.2. The immediate capital/labor ratio is k/l. The error term is e. The dependent variable for each country is its share of world[12] exports.

The regression results are very similar to those obtained using the total requirements and the same dependent variable. The coefficient signs and the levels of significance are highly similar. We can cautiously conclude that there does not seem to be a substantial difference in the theoretical tests when total requirements or immediate requirements are used. The latter may be preferable because they allow more detail although whether these results are sensitive to aggregation is not known.

In order to further inspect the similarity of the two sets of requirements, the skill coefficients for each industry were complied according to the skill index definitions used in Chapter III (see Table 9.4). The skill indexes for both total and immediate requirements were calculated and the correlations appear in Table 9.4. For each skill index there is a high positive correlation. This is the reason that regression results using total requirements are highly similar to those using the immediate requirements.

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[12]The world is defined as the nineteen sample countries.

TABLE 9.4.--Correlations Between Total and Immediate Requirements Skill Indexes

Type of Correlation	γ_1 - IMM. with γ_1 - TOT	γ_2 - IMM. with γ_2 - TOT	γ_3 - IMM with γ_3 - TOT	γ_4 - IMM with γ_4 - TOT
All Traded Goods Sectors Included				
Kendall	.869	.842	.855	.906
(Significance)	(.001)	(.001)	(.001)	(.001)
Spearman's	.972	.951	.961	.983
(Significance)	(.001)	(.001)	(.001)	(.001)

NOTE: γ_1 = I/VI, γ_2 = (I + II)/(V + VI)

γ_3 = (I + II + III + IV)/(V + VI)

γ_4 = I/(I + II + IV + V + VI + VII)

The roman numerals refer to the skill classes in Table 9.2. The correlations are between γ_{ij}IMM and γ_{ij}TOT for i = 1, 2, 3, 4 across industries j = 1, 2, . . ., 92 (each γ_{ij}-IMM is computed from the immediate requirements, γ_{ij}-TOT are from the total requirements)

9.5 Conclusion

Conclusions drawn solely from regression analysis can be quite different from those drawn from input-output studies. This problem is not great when the countries being studied are at the far extremes of the factor endowment rankings. However, as the inspection moves to countries with less extreme relative endowment rankings, it becomes more difficult to rely on one mode of analysis alone. Because the U. S. lies at one extreme of the skill endowment ranking, and because most skill tests relying on occupational groupings have not used multiple regression analysis across countries, these problems have not previously been encountered.

The results of the human skills tests are in accordance with the theory, but not as strongly supportive as the test results of Chapter III. The theory is most clearly supported by U. S. and developing countries' trade patterns. The trade patterns of other developed nations produce mixed results. The Heckscher-Ohlin theory test produces mixed results also, but appears more consistent in the context of a three factor model. When the dependent variable is changed, the theoretical interpretation of U. S. test results is unchanged. But when this is done for the analysis of other countries, the relative standard of comparison also is changed, so the interpretations must be made more carefully.

REFERENCES

1. Baldwin, R. "Determinants of the Commodity Structure of U. S. Trade." American Economic Review (March 1971): 126-146.

2. Keesing, D. "Labor Skills and International Trade: Evaluating Many Trade Flows with a Single Measuring Device." Review of Economics and Statistics (August 1965): 287-94.

3. Kmenta, J. Elements of Econometrics. New York: Macmillan, 1971.

CHAPTER X

SUMMARY AND CONCLUSIONS

The pure theory of international trade attempts to identify the causal factors which influence trade between countries. Once the causal factors are identified and the production requirements of commodities are known, trade patterns are predicted by the relative national abundance of the specified factors. This study has identified five characteristics which generally are throught to influence trade patterns. The four orthodox characteristics are: scale economies, skill intensity, capital intensity, and technology. The fifth factor is preference similarity as put forth by Linder.[1]

With the exception of preference similarity, each of these characteristics has been tested within the framework imposed by the 1970 U. S. input-output table. Throughout, the total requirements of these characteristics have been used to test the respective theories. The year 1975 was chosen first, because it was the most recent year for which data were available and, second, because fluctuating exchange rates had been in existence long enough to have settled at their equilibrium level.

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[1]Linder also suggested that scale economies influence trade patterns within the framework of his theory.

None of the individual theories tested has been rejected unequivocally.[2] Although the scale economy theory performed the worst in the multiple regression analysis, the format imposed by the input-output table is too confining to allow that to be a final judgment. The hesistancy to reject the theory is largely due to its ability to achieve consistent predictions across countries by measuring the "average scale content" of imports compared to exports.

The test of Linder's preference similarity hypothesis supports the notion that Linder's theory best explains the trade patterns among the rich developed countries. Orthodox theory best explains trade between rich and poor countries. Due to problems with multicollinearity, we cannot confidently conclude that Linder's theory explains trade patterns among the rich countries. Nonetheless, we can conclude with confidence that the theory cannot be rejected for trade among those countries.

The human skill theory produced the best and most consistent explanation of trade patterns. The input-output tests of the human skill theory produced very consistent results across countries for export skill indexes, import skill indexes, and the ratio of the latter to the former. These patterns were found to be consistent in their correspondence to the national skill abundance rankings of the countries tested. The multiple regression analysis of the human skill theory did not produce high R^2 values. This was expected. Due to the constrained regressions, the R^2 values are

[2]Table 10.1 provides a summary of the results.

lower than if the regressions were not constrained. However, the purpose of the regression analysis was to inspect the signs and significance of the relevant coefficients; not to maximize R^2. The information gathered in this manner supports the human skill theory.

The combination of the human skill and Heckscher-Ohlin theories produces the highest R^2 values for countries at the extremes of the endowment rankings; the United States, Hong Kong, Korea, India, and Pakistan. As the countries in the sample become more developed, the R^2 values get smaller. This result is consistent with the previous statement that Linder's preference similarity hypothesis best explains trade patterns among the more developed countries. Nonetheless, for those equations where the F statistic is significant, the significant coefficients generally conform to the human skill hypothesis.

In testing the human skill theory, Australia and New Zealand were found to be the most perverse in their performance with respect to the ILO skill endowment rankings. However, Australia has over 50% of its total exports concentrated in mining and agriculture. Over 50% of New Zealand's exports are concentrated in processed foods. Although these industries are omitted in the regression analysis, it is not surprising to find that the major inputs of these industries influence trade patterns of other domestic industries. Given that total factor requirements are used, this suggests that the advantage derived by each of these countries from major sectors of the domestic economy is passed on to other sectors of the economy. This argument is supported by the positive and significant showing of the farm labor variable for each of these countries.

Hong Kong's anomalous performance with respect to its import skill index has been identified also. The anomaly is not particular to this study (see Chapter III). It is explained by Hong Kong's extremely large proportion of imported inputs which have a skill content similar to that nation's exports. When the import to export skill index ratio is computed,[3] Hong Kong conforms to the human skill theory. We, therefore, conclude that there is a great deal of support for the human skill theory.

The "high skill" or technological content of trade flows is measured by the proportional labor service contribution of scientists and engineers embodied in a given trade flow. Judging from the export flow content of technological services, the United States, the Netherlands, the United Kingdom, Japan, Germany, and France are the technological leaders. Aside from the U. S., only the U. K. exhibits an export pattern which indicates that technology confers a general advantage across manufacturing industries. The other nations, although highly technologically endowed by world standards, appear to derive their advantage in middle technology industries. Japan's advantage is concentrated in several capital intensive manufacturing sectors, that appears to be derived from the development rather than the research aspect of technology.

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[3]This ratio divides out the effect of imported inputs which become embodied in a country's exports.

The Heckscher-Ohlin theory tests produce some interesting results. Although relative capital intensity does not explain net exports very well, it succeeds in explaining export shares. According to the capital endowment rankings, the U. S. and Canada are similarly endowed with capital relative to labor. However, as the three factor relative endowment rankings show, Canada is more abundant in capital than either skilled or unskilled labor. The U. S., although abundant in capital relative to total labor, is relatively more abundant in skilled labor. Given the geographical proximity of these two countries and their similar endowments of capital relative to labor, the three factor rankings (Table 10.1) are consistent with the multiple regression test of the H-O theory. The three factor model is also consistent with the regression results (where they are significant) for all of the countries so tested, except Yugoslavia. This is strong evidence that a three factor model with capital, skilled labor, and unskilled labor is relevant to the explanation of the commodity composition of trade.

The factor proportions theories (human skills and Heckscher-Ohlin) produce results that are the most consistent with their predictions. These improve when put in the context of a three factor model. Taken in isolation, the human skill theory best explains the trade patterns of countries at either end of the relative endowment rankings when multiple regression analysis is used. Technology is an important determinant of U. S. trade patterns and the lack of technology importantly influences the trade patterns of several developing countries. The issue with respect to scale

TABLE 10.1.--Summary Table of Test Results: 1975 Manufactures Trade

Country	Human Skill I-O[1] $R_{end}-R_{Y2x}$	Human Skill[2] Regression (X-M)		Linder[3]		Scale Economy[4] $R_{mfg} - R_s$	Technology[5] R_{Y4x}	H-O Regression[6] (X-M)	$(X/\Sigma X)$	Three Factor Relative Endowment Inferences[7]
		Skill	Unskill	$\bar{m}$	$\bar{x}$					
Ungrouped										
United States	0	I	V, VII	L	L	-5	1		-A	sk > k > un
Canada	-4			L	L	-2	8		+A	k > un > sk
Japan	+2	IV				+1	4			k > sk > un
EEC										
United Kingdom	+2	I				+1	3			X
West Germany	0	IV			L	+1	5			X
Netherlands	0		V, VI	L		+4	2	+A	+A	k > sk > un
France	+1			L		+1	6			X
Italy	-1					+2	11			X
Beligum-Luxembourg	-3		V	L	L	+5	10		+A	k > un > sk
Denmark	+1			L		+5	7	-A	-A	sk > un > k
Ireland	+1	I	VI		o	+1	9			X
Other Europe										
Spain	+2			o	o	+1	13		-A	X
Yugoslavia	+1		V	o	o	-5	12		+P	un > sk > k
Oceana										
Australia	X		VII	L		-8		+A	+A	k > un > sk
New Zealand	X		VII		L	+13				un > k > sk

TABLE 10.1.--Continued

Country	Human Skill I-O[1] $R_{end}-R_{\gamma 2x}$	Human Skill[2] Regression (X-M)		Linder[3]		Scale Economy[4] $R_{mfg} - R_s$	Technology[5] $R_{\gamma 4x}$	H-O Regression[6] (X-M)	$(X/\Sigma X)$	Three Factor Relative Endowment Inferences[7]
		Skill	Unskill	$\bar{m}$	$\bar{x}$					
Asia										
Hong Kong	-4	I, IV	V			0	15			X
Korea	+1	I, IV	V	o	o	-5	14		-A	un > sk > k
India	+1		V	o	o	-6	16			X
Pakistan	0		V	o	o	-1	17			X

SOURCE: Adapted from Tables 3.7, 3.8, 5.1, 7.3, 7.5 and 9.2.

NOTES: X - not included in the test.

[1]The tabled values are the differences between the national skill endowment rankings and export skill index rankings ($\gamma 2x$). A value of zero indicates a perfect correspondence between the two rankings, thus strong support for the theory; input-output results.

[2]Skill classes are: I--Scientists and Engineers, IV--Craftsmen and Foremen, V--Operatives, IV--Unskilled Nonfarm Laborers, VIII--Farm Laborers. The tabled skill classes are those which agreed with the theory and were significant (approximate 10% level except United Kingdom--15%); regression results.

[3]$\bar{m}$ indicates that the tabled results are for a comparison of one country's import vector to the export vectors of other countries ($\bar{x}$ similarly defined) ; L indicates the test results are consistent with Linder; o indicates the results are consistent with orthodox theory.

[4]Difference between national manufacturing employment size ranking and ratio of scale embodied in export/import rankings. A difference of zero implies perfect correspondence with the theory.

[5]Rankings of countries according to γ_{4x}, the proportional R & D labor service content embodied in exports (skill class I).

[6]The tabled values are the signs of the significant (10%) capital/labor ratio variables in the regressions named at the head of the table. A indicates agreement with the theory, P indicates a perverse result.

[7]Inferences of relative factor endowments for selected countries (from table 3.8). Un--unskilled labor, k--physical capital, sk--skilled labor.

economies is left largely unresolved. The regression model's failure to importantly explain the trade patterns of developed countries other than the U. S. is notable.

In Chapter VIII we discovered that the EEC has an advantage relative to developed countries in the production of footwear, clothing, travel goods, and handbags and several textile products. Although these products are produced more cheaply in the developing countries, they are not exactly the same products due to product differentation. French and Italian shoes, British woolen goods, and tweeds, and French high fashion apparel compete only indirectly with "similar" goods produced by developing countries. This is support for Linder's hypothesis which is not captured by the use of the cosine measure of similarity. The results of Chapter VII imply that developed and developing countries export and import different products. The above argument states that even for the same products, there are differences. It is, therefore, suggested that a variable which can capture this differentiation effect--at the product level--could help to increase the explanatory power of Linder's hypothesis among developed countries.

However, even this pattern is changing. Hong Kong is beginning to export apparel intended for the high income segment of that market. Some high fashion French "designer" products are being produced in Hong Kong. Thus, there is evidence of a product cycle working in textiles.

Given these rapidly changing trends, the existence of multinational corporations, and international diffusion of technology, it is becoming more difficult to adequately test the most generally accepted theories of international trade. Due to the existence of characteristics which are specific to particular commodity groups, it is difficult to assess trade patterns across a broad range of products. A further difficulty is that these characteristics (such as technology and product differentiation) are difficult to measure adequately. Despite these problems, the general tests performed in the previous chapters support the existing theories.

The finding in Chapter IX that the immediate and total factor requirements are similar indicates that we may be able to achieve increased detail which is necessary to test the currently changing patterns without losing a theoretical basis for those tests. This is very important because many complex relationships are undoubtedly aggregated out of existence by the use of input-output classifications. The similarity of characteristics does not imply that the regressions based on immediate characteristics will produce equally similar results to those employing total requirements. However highly similar results were obtained when both sets of coefficients were used (Chapter IX). We, therefore, have reason to believe that the application of the immediate coefficients may be both warranted and useful.

APPENDICES

APPENDIX A

1970 INPUT-OUTPUT SECTORS

TABLE A.1.--Input Output Sectors of the 1970 U. S. Input-Output Table

Sector Number	Sector Name
	Agriculture, Forestry, and Fisheries
1 (NR)	Livestock and livestock products
2 (NR)	Crops and other agricultural products
3 (NR)	Forestry and fisheries
4 (NR)	Agriculture, forestry, and fishery services
	Printing
5 (NR)	Iron and ore mining
6 (NR)	Copper ore mining
7 (NR)	Other nonferrous metal ore mining
8 (NR)	Coal mining
9 (NR)	(Oil) Crude petroleum
10 (NR)	Stone and clay mining and quarrying
11 (NR)	Chemical and fertilizer mining
	Construction
12**	New-residential construction
13**	New nonresidential construction
14**	New publc utilities construction
15**	New highway construction
16**	All other new construction
17**	Maintenance construction

Table A.1.--Continued

Sector Number	Sector Name
	Manufacturing
18	Guided missiles and space vehicles
19	Other ordnance
20*	Food products
21*	Tobacco manufacturing
22	Broad and narrow fabrics, yarn and thread mills
23	Miscellaneous textiles and floor coverings
24	Hosiery and knit goods
25	Apparel
26	Miscellaneous fabricated textile products
27	Logging, sawmills, and planning mills
28	Millwork and plywood and miscellaneous wood products
29	Household furniture
30	Other furniture
31	Paper products
32	Paperboard
33	Publishing
34	Printing
35	Chemical products
36	Agricultural chemicals
37	Plastic materials and synthetic rubber
38	Synthetic fibers
39	Drugs

Table A.1.--Continued

Sector Number	Sector Name
40	Cleaning and toilet preparations
41	Paint
42	(Oil) petroleum products
43	Rubber products
44	Plastic products
45	Leather, footwear, and leather products
46	Glass
47	Cement, clay, concrete products
48	Miscellaneous stone and clay products
49	Blast furnaces and basic steel products
50	Iron and steel foundries, forging and miscellaneous products
51	Primary copper metals
52	Primary aluminum
53	Other primary nonferrous metal and secondary nonferrous metal
54	Copper rolling and drawing
55	Aluminum rolling and drawing
56	Other nonferrous rolling and drawing
57	Miscellaneous nonferrous metal products
58	Metal containers
59	Heating apparatus and plumbing fixtures
60	Fabricated structural metal
61	Screw machine products

TABLE A.1.--Continued

Sector Number	Sector Name
62	Other fabricated metal products
63	Engines, turbines and generators
64	Farm machinery
65	Construction, mining, and oil field machinery
66	Material handling equipment
67	Metal working machinery
68	Special industry machinery
69	General industrial machinery
70	Machine shop products
71	Computers and peripheral equipment
72	Typewriters and other office machines
73	Service industry machines
74	Electric transmission and distribution equipment
75	Electrical industrial apparatus
76	Household appliances
77	Electric lighting and wiring
78	Radio and TV receiving sets
79	Telephone and telegraph apparatus
80	Radio TV transmitting, signaling, and detection equipment
81	Electronic components
82	Miscellaneous electrical machinery
83	Motor vehicles
84	Aircraft

TABLE A.1.--Continued

Sector Number	Sector Name
85	Ship and boat building and repair
86	Railroad and other miscellaneous transportation equipment
87	Transportation equipment, NEC
88	Professional, scientific and controlling instruments
89	Medical and dental instruments
90	Optical and ophthalmic equipment
91	Photographic equipment and supplies
92*	Miscellaneous manufactured products
	Transportation, Communication, and Public Utilities
93	Railroad transportation
94	Local, suburban and interurban highway transportation
95	Truck transportation
96	Water transportation
97	Air transportation
98	Other transportation
99	Communications, except radio and TV
100	Radio and TV broadcasting
101	Electric utilities
102	Gas utilities
103	Water and sanitary services

TABLE A.1.--Continued

Sector Number	Sector Name
	Wholesale and Retail Trade
104	Wholesale trade
105	Retail trade
	Finance, Insurance, and Real Estate
106	Finance
107	Insurance
108	Owner occupied dwelling
109	Other real estate
	Services
110	Hotels and lodging places
111	Other personal services
112	Miscellaneous business services
113	Advertising
114	Miscellaneous professional services
115	Automobile repair
116	Motion pictures
117	Other amusements
118	Doctor, dentist, and other medical services
119	Hospitals

TABLE A.1.--Continued

Sector Number	Sector Name
120	Educational services
121	Nonprofit organizations

SOURCE: Bureau of Labor Statistics.

NOTES: (NR) indicates natural resource intensive sectors

(Oil) indicates oil producing sectors

* indicates the manufacturing sectors omitted from the multiple regression analysis. Manufacturing sectors included are 18 and 22-91 without 42.

** indicates dummy sectors not utilized in any analysis as $r_{ij} = o$ for $i \neq j$ where r_{ij} is the element in the ith row and jth column of the Leontief inverse matrix.

APPENDIX B

REGRESSIONS: NINETEEN COUNTRIES

TABLE B-1.--Multiple Regression Analysis of Nineteen Countries' Trade Patterns: 1975 Manufactures Trade with the World, Using Total and Immediate Factor Requirements Measured from U. S. Coefficients

Dependent Variable and Type of Factor	I Scientists and Engineers	II Other Professional Technical and Managerial	III Clerical and Sales	IV Craftsmen and Foremen	V Operatives	VI Nonfarm Laborers and Service	VII Farmers and Farm Laborers	Ratio of Capital to Labor	R^2_{am}	F
Country										
Ungrouped										
United States										
(X-M)-T	36.07	-13.08	7.38	3.53	-3.12	1.46	14.61	-13.46	.300	4.33
	(3.34)	(-1.25)	(1.07)	(1.22)	(-2.70)	(.26)	(1.99)	(-1.32)		
(X/ΣX)-T	7.109	3.178	1.942	.117	- .254	2.136	1.032	-3.517	.467	34.45
	(5.86)	(2.70)	(2.51)	(.36)	(-1.95)	(3.36)	(1.251)	(-3.08)		
(X/ΣX)-I	3.703	-1.390	.965	.273	-.035	1.070	--	-1.605	.422	36.20
	(5.75)*	(-2.28)*	(2.28)*	(1.68)**	(-.45)	(3.08)*	--	(-2.85)*		
Canada										
(X-M)-T	-2.07	1.43	-1.89	-1.03	-.61	3.68	.63	6.77	.147	1.33
	(-.36)	(.26)	(-.52)	(-.67)	(-1.00)	(1.23)	(.16)	(1.26)		
(X/ΣX)-T	-.099	.367	-.582	-.007	-.007	.871	-.030	1.700	.276	6.38
	(-.12)	(.47)	(-1.14)	(-.01)	(-.89)	(2.07)	(-.01)	(2.26)		
(X/ΣX)-I	-.173	.188	-.220	-.013	-.020	.663	--	.892	.279	.749
	(-.42)	(.49)	(-.82)	(-.13)	(-.41)	(3.02)*	--	(2.51)*		
Japan										
(X-M)-T	11.57	-11.24	-.41	12.79	-.85	-3.60	-3.66	1.35	.180	2.75
	(.67)	(-.67)	(-.04)	(2.75)*	(-.46)	(-.40)	(-.31)	(.08)		
(X/ΣX)-T	.148	1.286	-1.143	.869	.083	-.675	.553	-.082	.179	13.06
	(.15)	(1.34)	(-1.82)	(3.27)	(.78)	(-1.30)	(.82)	(-.09)		
(X/ΣX)-I	.468	.469	-.482	.421	.067	-.096	--	-.289	.150	14.35
	(.92)	(.97)	(-1.45)	(3.26)*	(1.08)	(-.35)	--	(-.418		

TABLE B-1.--Continued

Dependent Variable and Type of Factor	I Scientists and Engineers	II Other Professional Technical and Managerial	III Clerical and Sales	IV Craftsmen and Foremen	V Operatives	VI Nonfarm Laborers and Service	VII Farmers and From Laborers	Ratio of Capital to Labor	R^2_{am}	F
EEC										
United Kingdom										
(X-M)-T	6.17 (1.46)	-4.83 (-1.78)	3.96 (1.47)	1.48 (1.30)	-.35 (-.77)	-1.77 (-.80)	-.79 (-.27)	-5.57 (-1.40)	.217	2.74
(X/ΣX)-T	-.359 (-.82)	.135 (.32)	.510 (1.83)**	.056 (.47)	.036 (.76)	-.219 (-.95)	-.704 (-.24)	-.419 (-1.01)	.237	50.71
(X/ΣX)-I	-.140 (-.61)	.171 (.79)	.314 (2.10)*	.080 (.140)	.059 (2.13)*	-.139 (-1.13)	-- --	-.020 (-.10)	.212	56.72
West Germany										
(X-M)-T	9.60 (.70)	-6.99 (-.52)	1.82 (-.20)	8.59 (-.32)*	-1.94 (-1.32)	2.27 (.31)	-4.49 (-.48)	-7.02 (-.54)	.155	3.06
(X/ΣX)-T	-1.600 (-2.10)*	1.305 (1.76)**	-.174 (0.36)	.428 (2.09)*	.206 (2.53)*	-.400 (-.99)	-.669 (-1.29)	-.232 (-.32)	.182	69.39
(X/ΣX)-I	-.524 (-.130)	.645 (1.69)**	.054 (.20)	.360 (3.56)*	.174 (3.58)*	-.250 (-1.15)	-- --	-.052 (-.15)	.124	74.70
Netherlands										
(X-M)-T	1.13 (.41)	1.22 (.46)	-.62 (-.35)	.81 (1.09)	-.89 (3.02)*	-2.48 (-1.71)**	2.57 (1.37)	6.03 (2.32)*	.238	2.42
(X/ΣX)-T	-.124 (-.39)	.168 (.54)	.120 (.58)	-.102 (-1.17)	.019 (.55)	-.22 (-1.32)	.084 (.39)	1.182 (3.89)*	.282	34.07
(X/ΣX)-I	-.076 (-.45)	.128 (.79)	.099 (.89)	-.031 (-.73)	.042 (2.07)*	-.068 (-.74)	-- --	.580 (3.92)*	.242	37.03

TABLE B-1.--Continued

Dependent Variable and Type of Factor	I Scientists and Engineers	II Other Professional Technical and Managerial	III Clerical and Sales	IV Craftsmen and Foremen	V Operatives	VI Nonfarm Laborers and Service	VII Farmers and From Laborers	Ratio of Capital to Labor	R^2_{am}	F
France										
(X-M)-T	4.98 (.93)	-7.00 (-1.34)	3.90 (1.14)	.44 (.30)	.29 (.50)	2.59 (.92)	-3.41 (-.93)	-5.25 (-1.03)	.076	1.16
(X/ΣX)-T	-.979 (-2.19)*	.364 (.84)	.234 (.82)	.091 (-.76)	.157 (3.27)*	.019 (.08)	-.387 (-1.27)	.267 (.63)	.197	60.28
(X/ΣX)-I	-.423 (-1.81)*	.182 (.82)	.243 (1.58)	.025 (.43)	.118 (4.17)*	.041 (.32)	-- --	.191 (.93)	.155	66.07
Italy										
(X-M)-T	-3.06 (-.76)	-3.27 (-.84)	2.21 (.86)	-.16 (-.15)	1.79 (4.17)	-.62 (-.29)	-5.32 (-1.95)*	-4.29 (-1.29)	.304	4.94
(X/ΣX)-T	-1.390 (-2.64)*	.531 (1.04)	-.931 (-.29)	-.099 (-.70)	.368 (6.55)*	-.151 (-.55)	-.598 (-1.67)**	-.547 (-1.10)	.382	24.92
(X/ΣX)-I	-.628 (-2.24)*	.35 (1.32)	-.113 (-.62)	.030 (.41)	.225 (6.62)*	-.221 (-1.46)	-- --	-.331 (-1.35)	.320	25.47
Belgium-Luxembourg										
(X-M)-T	3.41 (.81)	-5.00 (-1.23)	2.05 (.77)	.60 (.54)	.65 (1.45)	1.39 (.63)	1.24 (.44)	5.33 (1.35)	.108	1.05
(X/ΣX)-T	-.268 (-.59)	-.200 (-.46)	.216 (.75)	-.084 (-.69)	.048 (1.00)	.028 (.12)	.033 (.11)	1.342 (3.17)*	.226	19.05
(X/ΣX)-I	-.264 (-1.14)	.164 (.12)	.092 (.61)	-.020 (-.35)	.068 (2.43)*	.035 (.28)	-- --	.691 (3.38)*	.214	22.15

TABLE B-1.--Continued

Dependent Variable and Type of Factor	I Scientists and Engineers	II Other Professional Technical and Managerial	III Clerical and Sales	IV Craftsmen and Foremen	V Operatives	VI Nonfarm Laborers and Service	VII Farmers and Farm Laborers	Ratio of Capital to Labor	R^2_{am}	F
Denmark										
(X-M)-T	.65 (.64)	.20 (.20)	.10 (.14)	.28 (1.00)	.02 (.17)	.57 (1.06)	-.16 (-.23)	-1.66 (-1.72)*	.209	2.04
(X/ΣX)-T	-.104 (-.76)	.032 (.24)	.037 (.43)	.039 (1.07)	.021 (1.44)	.070 (.97)	.002 (.02)	-.370 (-2.87)*	.150	12.91
(X/ΣX)-I	-.029 (-.41)	-.004 (-.05)	.056 (1.22)	.027 (1.56)	.017 (2.01)*	.029 (.75)	-- --	-.167 (-2.74)*	.147	17.22
Ireland										
(X-M)-T	-.51 (-1.63)**	.60 (1.95)*	-.27 (-1.37)	-.03 (-.39)	.03 (.82)	-.32 (-1.92)**	-.05 (-.22)	-.09 (-.32)	.345	4.09
(X/ΣX)-T	-.222 (-5.25)*	.196 (4.77)*	-.055 (-2.04)*	-.012 (-1.02)	.014 (3.11)*	-.076 (-3.40)*	.030 (1.06)	-.018 (-.45)	.473	20.69
(X/ΣX)-T	-.107 (-4.72)*	.094 (4.41)*	-.010 (-.66)	-.013 (-2.21)*	.009 (3.18)*	-.015 (-1.25)	-- --	-.010 (.48)	.421	21.05
Other Europe										
Spain										
(X-M)-T	-2.13 (-1.43)	-.70 (-.48)	.43 (.46)	.02 (.04)	.38 (2.37)*	.13 (.17)	-1.72 (-1.71)**	-1.80 (-1.29)	.285	3.10
(X/ΣX)-T	-.340 (-2.12)*	-.032 (-.20)	.125 (1.22)	-.007 (-.51)	.041 (2.39)*	.107 (1.26)	-.173 (-1.58)	-.340 (-2.25)*	.290	12.50
(X/ΣX)-I	-.200 (-2.35)*	.031 (.39)	.055 (.97)	.024 (1.11)	.022 (2.13)*	.024 (.51)	-- --	-.110 (-1.47)	.223	12.50

TABLE B-1.--Continued

Dependent Variable and Type of Factor	I Scientists and Engineers	II Other Professional Technical and Managerial	III Clerical and Sales	IV Craftsmen and Foremen	V Operatives	VI Nonfarm Laborers and Service	VII Farmers and Farm Laborers	Ratio of Capital to Labor	R^2_{am}	F
Yugoslavia										
(X-M)-T	-1.55 (-1.22)	1.01 (.81)	-.53 (-.65)	-.28 (-.83)	.20 (1.49)	.03 (.04)	-.64 (-.74)	-.76 (-.63)	1.53	1.40
(X/ΣX)-T	-.079 (-.61)	-.044 (-.35)	-.051 (-.62)	.017 (.48)	.012 (.89)	.082 (1.22)	-.008 (-.09)*	.476 (3.93)*	.378	15.41
(X/ΣX)-I	-.063 (-.95)	-.028 (-.45)	-.006 (-.45)	.014 (.84)	.012 (1.46)	.067 (1.87)**	-- --	.213 (3.69)*	.369	17.47
Oceana										
Australia										
(X-M)-T	.73 (.37)	-1.68 (-.90)	.49 (.40)	.35 (.67)	.33 (-1.62	-.81 (-.80)	3.21 (2.45)*	3.63 (2.00)*	.251	2.6
(X/ΣX)-T	.108 (.49)	-.165 (-.77)	.032 (.22)	.076 (1.28)	-.025 (-1.05)	-.150 (-1.30)	.439 (2.93)*	.695 (3.35)*	.269	5.59
(X/ΣX)-I	-.034 (-.28)	-.078 (-.683)	.045 (.57)	-.002 (-.06)	.008 (.57)	.009 (.45)	-- --	.316 (3.00)*	.165	4.57
New Zealand										
(X-M)-T	-.42 (-.60)	.26 (.39)	-.19 (-.43)	-.06 (-.33)	.02 (.30)	-.42 (-1.14)	1.08 (2.27)*	.52 (.79)	.234	2.37
(X/ΣX)-T	-.009 (-.10)	-.005 (-.01)	-.019 (-.39)	.016 (.80)	-.005 (-.67)	-.057 (-1.41)	.172 (3.33)*	.229 (3.19)*	.280	4.02
(X/ΣX)-I	-.27 (-.63)	-.012 (-.30)	.008 (.27)	-.006 (-.57)	.004 (.72)	.009 (.39)	-- --	.082 (2.17)*	.119	2.18

TABLE B-1.--Continued

Dependent Variable and Type of Factor	I Scientists and Engineers	II Other Professional Technical and Managerial	III Clerical and Sales	IV Craftsmen and Foremen	V Operatives	VI Nonfarm Laborers and Service	VII Farmers and From Laborers	Ratio of Capital to Labor	R^2_{am}	F
Asia										
Hong Kong										
(X-M)-T	-2.93	1.03	-.33	-.89	.93	-.25	-3.05	-1.85	.337	3.94
	(-1.72)**	(.62)	(-.30)	(-1.95)**	(5.12)*	(-.28)	(-2.63)*	(-1.15)		
(X/ΣX)-T	-.406	.177	-.047	-.124	.175	-.253	.072	-.150	.471	9.22
	(-1.69)**	(.76)	(-.30)	(-1.92)**	(6.77)*	(-2.00)*	(.44)	(-.66)		
(X/ΣX)-I	-.176	.097	-.040	-.075	.106	-.152	--	-.163	.403	8.49
	(-1.35)	(.784)	(-.47)	(-2.30)*	(6.72)*	(-2.16)*	--	(-1.45)		
Korea										
(X-M)-T	-2.53	.43	.02	-.80	.83	-.59	-1.20	-1.27	.488	7.39
	(-2.19)*	(.38)	(.09)	(-2.59)*	(6.76)*	(-.96)	(-1.53)	(-1.17)		
(X/ΣX)-T	-.248	.114	-.085	-.085	.116	.104	.020	-.335	.407	8.98
	(-1.25)	(.59)	(-.68)	(-1.59)	(5.48)*	(1.00)	(.15)	(-1.80)**		
(X/ΣX)-I	-.148	.104	-.065	-.045	.069	.050	--	-.217	.343	8.52
	(-1.39)	(1.03)	(-.94)	(-1.67)**	(5.41)*	(.87)	--	(-2.34)*		
India										
(X-M)-T	-1.34	.58	-.36	.04	.39	-1.01	1.55	-1.45	.280	3.01
	(-1.08)	(.48)	(-.46)	(.13)	(2.95)*	(-1.55)	(1.84)**	(-1.22)		
(X/ΣX)-T	-.104	-.051	.037	-.021	.050	-.111	.245	.084	.332	5.92
	(-.74)	(-.37)	(.41)	(-.56)	(3.30)*	(-1.50)	(2.57)*	(.64)		
(X/ΣX)-I	-.111	.017	.001	-.031	.040	-.039	--	.026	.236	4.89
	(-1.46)	(.228)	(.02)	(-.62)	(4.32)	(-.94)	--	(.39)		

TABLE B-1.--Continued

Dependent Variable and Type of Factor	I Scientists and Engineers	II Other Professional Technical and Managerial	III Clerical and Sales	IV Craftsmen and Foremen	V Operatives	VI Nonfarm Laborers and Service	VII Farmers and From Laborers	Ratio of Capital To Labor	R^2_{am}	F
Pakistan										
(X-M)-T	-.35	.31	-.19	.11	.08	-.86	1.93	-.01	.603	11.76
	(-.95)	(.85)	(-.81)	(1.09)	(1.97)*	(-4.42)*	(7.64)*	(-.07)		
(X/ΣX)-T	-.037	.001	-.001	-.012	.016	-.105	.253	.335	.572	11.76
	(-.69)	(.052)	(-.03)	(-.87)	(2.73)*	(-3.75)*	(6.97)*	(.67)		
(X/ΣX)-I	-.050	.008	.007	-.017	.017	-.015	--	-.017	.223	3.48
	(-1.36)	(.23)	(.28)	(-1.87)**	(3.91)*	(-.78)	--	(-.54)		

SOURCE: U. N. Commodity Trade Statistics (Magnetic Tapes)

NOTE: R^2_{am} indicates that the reported R^2 value is adjusted for the mean of the dependent variable.

(X-M)-T indicates that the dependent variable is exports minus imports (millions of dollars); the independent variables are measured from the total requirements.

(X/ΣX)-T indicates that the dependent variable is the country's share of sample country exports; the independent variables are measured from the total requirements.

(X/ΣX)-I indicates that the dependent variable is the country's share of sample country exports; the independent variables are measured from the immediate requirements.

*significant at the 5% confidence level; ** significant at the 10% confidence level.

The figures in parentheses are the t statistics. The equations were estimated across the manufacturing sectors of the I-O table, sectors 18-91 excluding 20, 21, and 42 (see Table A.1). U. S. coefficients used throughout the skill coefficients are entered as percentages. The capital/labor ratio is the ratio of physical capital to total labor. All regressions are forced through the origin.