CLASSICAL COMPARATIVE COST THEORY: TIME SERIES AND CROSS-SECTIONAL EVIDENCE FOR THE UNITED STATES, JAPAN, AND EUROPE

by

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ABSTRACT

CLASSICAL COMPARATIVE COST THEORY: TIME SERIES AND CROSS-SECTIONAL EVIDENCE FOR THE UNITED STATES, JAPAN, AND EUROPE

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The purpose of this dissertation was to investigate the comparative cost advantage of manufacturing industries in the United States, Japan, and Europe between 1967 and 1980. Since it was not possible to derive accurately all the costs of production, the internal ranking of industries by comparative advantage was approximated using the inverse of unit labor cost and its components, labor productivity and labor compensation.

The results for 1967 and 1980 indicated that the United States held a comparative advantage, as approximated by unit labor costs, in the following industries: agricultural manufacturing, paper, nonferrous metals, publishing, industrial chemicals, plastics, office and computing equipment, and professional goods. It held a comparative disadvantage in traditional low technology products, wood products, furniture, pottery, glass, rubber, iron and steel, and most transport equipment.

The three major industries in the U.S. economy which experienced a reduction in international competition between 1967 and 1980 were iron and steel, transport, and rubber. It was seen that these significantly increased their unit labor

costs relative to other manufactures, causing them to fall sharply in the internal ranking. This was reflected in the large trade deficits they incurred. In contrast, the iron and steel, transport and rubber industries in Japan and Germany were able to maintain their internal ranking.

In 1967 and 1980, Japan held a comparative advantage in glass, iron and steel, nonferrous metals, transport equipment, and industrial chemicals; a comparative disadvantage in tobacco, food products, traditionally low technology products, and professional goods. Japan's comparative advantage remained relatively stable between 1967 and 1980.

In 1980, Germany held a comparative advantage in tobacco, food products, wood products, pottery, and professional goods; a comparative disadvantage in paper, nonferrous products, metal products, rubber, industrial chemicals, and machinery. Italy held a comparative advantage in leather, forest products, and pottery. It displayed a comparative disadvantage in tobacco, nonferrous metals, rubber, plastics, and electrical machinery. Great Britain held a comparative advantage in industrial chemicals, plastics, tobacco, printing, and other nonmetal products. Its comparative disadvantage lay in wearing apparel, furniture, pottery and china, iron and steel, and transport equipment.

To Janet and Anya

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Although it appears to be our comparative disadvantage, let there be peace on earth!

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CHAPTER I

INTRODUCTION

The main objective of this dissertation is to investigate the comparative advantage of manufacturing industries in the United States, Japan, and Europe during the period 1967 to 1980. A nation's ranking of industries by comparative advantage can be obtained from the inverse of the production costs. Since it is difficult, if not impossible, to derive accurately the actual costs of production, unit labor costs are used as an approximation.

Most previous studies comparing unit labor cost and its components, labor productivity and labor compensation, across countries have limited their scope to one industry at a given time. The problem with this approach is that a country's labor compensation is expressed in a domestic currency and must be converted to a common currency for comparison by employing exchange rates. However, these are often managed by central banks and deviate from their long-run equilibriums, causing the analysis to be invalid. To correct for these distortions, an approach developed by Kreinin (1981, 1982, 1984, 1985) was extended to encompass the performance of unit labor costs in each industry relative to the national manufacturing average. Therefore, comparative cost advantages "are embedded in the total economy", shifting the focus to relative rather than absolute unit labor costs (Kreinin, 1984, p. 42).

An important objective of this dissertation is to construct internal rankings of industries approximating a country's comparative advantage at different times, 1967 and 1980, within each country. The exchange rate between the countries separates the internal rankings into export industries, nontraded goods, and import-competing industries. The performance of unit labor costs is analyzed to explain shifts in the rankings over time.

Comparative advantage plays an important role in determining a country's trade flows. In light of the large U.S. current account deficits recently registered, industries which lose their comparative advantage face severe international competition and often seek trade restrictions. Since factors affecting a country's comparative advantage can have important policy implications, close examination of the performance of relative unit labor costs is required.

Chapter II develops the theoretical foundations of the comparative cost theory, beginning with the Ricardian hypothesis. Money wages, a multigood framework, transportation costs, incomplete specialization, and variable costs of production are incorporated in order to construct a more realistic model. These additional factors provide an added dimension to the theory without adversely affecting the results derived from the simple Ricardian hypothesis. Differences and similarities between the comparative cost theory and the Heckscher-Ohlin model are also examined, and an effort is made to reconcile the two theories.

The empirical literature which tests the Ricardian hypothesis, beginning with the study by MacDougall, is reviewed in Chapter III. Challenges to the Ricardian hypothesis by Bhagwati, Kreinin, and Stern as well as supporting evidence for it by Daly and Stryker are presented. Related material by Kreinin which does not directly test the Ricardian hypothesis but which is based on comparative cost theory is also reviewed in this chapter.

Chapter IV investigates the effect of unit labor costs on the trade flows of 139 U.S. manufacturing industries categorized by the Standard Industrial Classification (SIC) system at the two-, three-, and four- digit level for 1967 and 1980. The first part develops an internal ranking for these years and formulates a cross-sectional model determining the effect of unit labor costs on trade performance. The second part arranges the industries into low, medium, and high technology categories and analyzes the performance of their unit labor cost and its components.

Cross-sectional and time series evidence for the United States, Japan, Germany, the United Kingdom, and Italy is examined in Chapter V. A ranking of 28 manufacturing industries, classified by International Standard Industrial Classification (ISIC), is constructed for 1967 and 1980, and a cross-sectional model is developed to determine the effect of differential unit labor costs on trade performance. The second part analyzes time series data for individual industries to determine the effect of changes in labor productivity and compensation on the trade performance of individual industries. In addition, all time series and cross-sectional data combined with dummy variables are "pooled" into one equation to remove the biases of trade discrimination and exchange rate changes over time on trade performance.[1]

Chapter VI integrates the statistical analysis of the previous chapter and examines the performance of unit labor costs and trade flows of individual industries. The industries are grouped into low, medium, and high technology categories, consistent with Chapter IV, as a basis for analysis.

The final chapter summarizes the empirical findings of the dissertation and offers a broader interpretation of the main findings with regard to methodology and economic policy.

Footnotes

[1]The "pooling" or panel data models are based on models from Kmenta (1972) and Judge et al. (1980).

CHAPTER II

THE CLASSICAL COMPARATIVE COST THEORY

This chapter develops the theoretical foundations of the classical comparative cost model for ranking industries by unit labor costs. The examination begins with the Ricardian hypothesis, the restrictive assumptions of which are relaxed by introducing money wages, a multicommodity framework, transportation costs, and incomplete specialization. In addition, similarities and differences between the classical comparative cost model and the Heckscher-Ohlin theory are highlighted. Within this framework, comparative cost theory attempts to answer the following three questions:

1. What is the basis for trade, and what goods should a country export and import?

2. On what terms are the traded goods exchanged?

3. Should disturbances occur in the trade patterns, what forces will bring about an adjustment?

This chapter will concentrate on question 1, although the other two questions will receive minor consideration.

The pure theory of international trade differs structurally from positive theories in the kinds of questions asked rather than in the kinds of assumptions made. As Viner (1937, p. 437) has stated, "the classical theory of international trade was formulated primarily with a view to its providing guidance on questions of national policy .... Recognition of its welfare analysis orientation is essential to the understanding and the appraisal of the classical doctrine." Thus, a clear understanding of comparative cost theory is important in formulating policy for industries concerned with international competition.

The Ricardian Model

The first clear statement of the comparative cost theory was developed by David Ricardo.[1] TheRicardian model assumes:

1. Two countries and two commodities.
2. One factor of production - homogeneous labor.[2]
3. Labor is completely mobile within a country, and all occupations pay the same wage rate.
4. Labor is immobile between countries, so that factor endowments cannot change.
5. Commodities move freely between countries without transportation costs.
6. The average productivity of labor is different in the two countries.
7. Constant unit labor costs.

Ricardo assumedthat one of the two countries could produce both goods using less labor, thus having an absolute advantage in both goods. In his example, England is able to produce a unit of cloth by employing 100 hours of labor, or to produce a unit of wine by employing 120 hours of labor. Portugal is able to produce a unit of cloth by employing 90 hours of labor, or to produce a unit of wine by employing 80 hours of labor.

Portugal is more efficient than England in the production of both goods since Portugal can produce each good with less labor than England. One English worker is worth 90/100 of a Portuguese worker in the production of cloth, and 80/120 of a Portuguese worker in the production of wine. Although English workers are less efficient than their Portuguese counterparts in the production of both goods, England's degree of lower efficiency is smaller in the production of cloth. Alternatively, Portugal's degree of superiority is greater in the production of wine.

Thus as Ricardo has pointed out, although Portugal has an absolute advantage in the production of both goods, Portugal has a comparative advantage in the production of wine, while England has a comparative advantage in the production of cloth. The degree of comparative advantage can be summarized in the following inequalities: 90/100 > 80/120 (comparing the same commodity in different countries), or 90/80 > 100/120 (comparing different commodities in the same country).

Limits to the Terms of Trade

Starting from autarky, each country can increase the production of one commodity only by switching some labor from the production of the other commodity. [3] The cost of cloth is the amount of wine that can be produced by the labor necessary to produce an additional unit of cloth. In the Ricardian example, a domestic exchange ratio (relative price) in terms of relative costs will be established in

England of 1 unit of wine for 1.2 units of cloth, and in Portugal of 1 unit of wine for 0.88 units of cloth. These domestic cost ratios define the limits to the terms of trade.

Taking account of the domestic exchange ratios, it would be profitable for Portugal to engage in international trade if 1 unit of wine could be exchanged for more than 0.88 units of cloth. For England to profit, less than 1.2 units of cloth must be exchanged for 1 unit of wine. Thus, the limits to mutually beneficial trade must lie between 0.88 and 1.2 units of cloth for 1 unit of wine. The domestic cost ratios of the two commodities in the two countries determine the limits to mutually beneficial trade (Kreinin, 1983). Within these limits, each country should specialize in the production of the commodity in which it has a comparative advantage and obtain the other commodity through international trade.

The classical comparative cost theory states that once free trade is established, the terms of trade will settle within these limits set by comparative costs. Both Mill and Marshall concluded that, within these limits, the forcesof reciprocal demand would determine the equilibrium terms of trade. Thus, the burden of adjustment to a change in tastes would fall primarily on changes in relative prices with only secondary effects on responses in supply. [4]

Introduction of Money

The first significant expansion of the Ricardian model was the introduction of money wages by Taussig (1927). He elaborated on the three types of situations: absolute cost, equal cost, and comparative cost. The Ricardo-Mill model is easily elaborated in money terms since labor is assumed to be the only input and the only requirement is the money wage rate. As did the earlier writers, Taussig uses two countries and two products.

The equal cost situation is $a_1/a_2 = b_1/b_2$ or $a_1/b_1 = a_2/b_2$, where:

a_1 = labor cost of one unit of good A in country I;
a_2 = labor cost of one unit of good A in country II;
b_1 = labor cost of one unit of good B in country I; and
b_2 = labor cost of one unit of good B in country II.

Since the cost ratios are the same, the domestic terms of trade are the same in both countries, thus providing no basis for trade.

When the condition $a_1/a_2 < 1 < b_1/b_2$ holds, the principle of absolute cost advantage is displayed. With $a_1 < a_2$ and $b_1 > b_2$, country I has an advantage in product A, while country II has an advantage in product B. If there is to be trade between the two countries, $a_1 * W_1 < a_2 * W_2$ and $b_1 * W_1 > b_2 * W_2$. The relative wage ratio, W_1/W_2, can thus fluctuate within the limits set by the money costs of the products, but not including $W_1/W_2 = a_2/a_1$ or $W_1/W_2 = B_2/b_1$.

If one country is superior in both commodities, but by different proportions ($a_1/a_2 < b_1/b_2 < 1$), then we satisfy the comparative costs principle. In order for country I to export product A, $a_1 * W_1 < a_2 * W_2$, therefore, $1 > a_1/a_2 < W_2/W_1$, as with the absolute costs advantage example. This allows the wages to fluctuate within limits and still permit trade. For country II to export product B, $b_1 * W_1 > b_2 * W_2$, and by cross-multiplying, the result is $1 > b_1/b_2 > W_2/W_1$, or $1 > W_2/W_1$, $W_1/W_2 > 1$. Thus, the wage rate in country I, which may be considered the technologically superior country, must be higher than in country II if there is to be bilateral trading. The proportion of wages, W_1/W_2, must be at least as high as the ratio b_2/b_1, but no higher than a_2/a_1.

When $W_2 > W_1$, a disequilibrium condition occurs, and one country is cheaper, in money terms, in the production of both goods and thus exports both. To correct for this situation, the classical economists relied on Hume's specie-flow theory as an equilibrating device. Since country I will be exporting more because of the wage differential, it will be acquiring more foreign currency and gold. The increase in the country's monetary base will increase its money supply and drive up wages and prices. At the same time, country II will lose its currency and gold, thus contracting its money supply. This will drive down wages and prices until $a_1 * W_1 = a_2 * W_2$; after this process of adjustment, normal trade conditions would be restored.

While the choice of the money wage is arbitrary, the ratio of money wages between the two countries lies between an upper and lower limit, as explained above. Only the choice within these limits is arbitrary. The exact ratio is determined by relative demand conditions, subject to the constraint that total value of exports must equal the total value of imports.

In examining the relationship between absolute advantage and wage rates, Taussig finds that "those countries have high money wages whose exported commodities command a good price in the world's markets", (Angel, p. 105). Following Senior and Mill, Taussig makes the range of money incomes dependent on the terms of international demand and the relative productivity of labor. In addition, competitive markets are assumed in order for the marginal productivity of labor to equal the wage rate.

Within this framework, the exporting industries in each country are the primary determinant in setting the general rate of money incomes and wages. But the exporting industries set only nominal wages and not real wages. Because of labor mobility, the money wage rate set by the exporting industries will become, under perfect competition, the ruling wage rate in the country at large (nonexporting as well). In nonexporting industries, prices will vary with changes in wages and incomes, as in the exporting industries, but import prices will not reflect these changes. Because of international trade, incomes would rise, leading to lower real prices of imports.

Limits to a Sustainable Exchange Rate

The limits to the exchange ratio can be derived from the limits to the commodity terms of trade.[5] The latter is expressed as an upper and lower limit where mutually beneficial trade occurs. If both commodities in each country are assigned prices in their own domestic currency, the limits to the commodity terms of trade are converted into the limits to a sustainable exchange rate.

Within the limits specified, the precise exchange rate is determined by reciprocal demand subject to the balance-of-payments equilibrium. If the exchange rate were outside these limits, one country could undersell the other in both commodities. This would lead to an external imbalance which would require an exchange rate adjustment. Thus, the exchange rate must reflect the cost/price relationship between the two countries.

More Than Two Goods

Frank Graham (1923) employed the classical model and made it more realistic by incorporating a multicommodity and multicountry framework. This section will discuss Graham's contribution to trade theory in a multicommodity framework.

Graham, in the classical tradition, dealt with a single input -labor- and constant costs of production. He felt, however, that concentration on two countries and two commodities severely limited the scope of the Ricardian analysis. Thus he states that "the classical theory of international values seems to be open to grave objections which, while they do not subvert its foundations, nevertheless call for a substantial modification of its conclusions", (1923, pp. 54-5). Within a Ricardian two-country, two-commodity model, adjustments in international demand are not found in changes in production (supply). Instead the adjustment process is a reciprocal demand phenomenon, reflected by changes in trade volumes and the terms of trade. Graham's emphasis, in contrast, is directed toward changes in supply, involving shifting of productive resources and altering the composition of trade. With additional countries and commodities, adjustments to changes in demand incorporate shifts in production, along with the possibility of a change in commodity composition. These shifts in output and alterations in trade composition and direction would tend to minimize the changes in the terms of trade and thus are a long-run phenomenon.

In a rigorous fashion, let the number of units of labor-cost needed to produce a unit of the goods A, B, ..., F in country I be denoted by a_1, b_1,...., f_1 and a_2, b_2,....,f_2 in country II. If R is the exchange rate, then (a_1 * W_1 * R) < (a_2 * W_2) holds for any commodity A that country I exports.

A good will be exported only if its supply price (money cost) is lower than in the foreign country. For any commodity B that is imported by country I, the condition (b_1 * W_1 * R) > (b_2 * W_2) holds. Then $a_1/a_2 < [W_2/(W_1 * R)]$, where $W_2/(W_1 * R)$ is the ratio of money wages.

Thus, $a_1/a_2 < b_1/b_2$ means that country I enjoys a comparative advantage over country II in production of commodity A. We can then arrange the various goods in the order of comparative advantage of country I over country II in goods A, B, C, D, and F in the following way:

$a_1/a_2 < b_1/b_2 < c_1/c_2 < d_1/d_2 < e_1/e_2 < f_1/f_2$.

We can then draw a line dividing the commodities which country I exports from those it imports by the quotient $W_2/(W_1 * R)$. To determine the exact position of the dividing line, we must introduce reciprocal demand, subject to the balance-of-payments constraint.

This principle is illustrated in Table 2.1. For trade to be possible, country II will export product A, and country I will export product F. At least three of the remaining four products could also be traded, depending on the ratio of money wages, $W_2/(W_1*R)$. If $W_2/(W_1*R) = 1.2$ is chosen, country II will export products A and B, since in country I compared to country II, the input cost of these goods is proportionally greater than the proportion of the money wage ratio, $W_2/(W_1*R)$. The money cost of product C is equal in both countries, and thus this product will not be traded. With the same analysis, country I will export products D, E, and F.

Table 2.1. Introduction of a Multicommodity Framework

Goods	Labor Cost Per Unit Country I	 Country II	I/II
A	14	10	1.4
B	13	10	1.3
C	12	10	1.2
D	11	10	1.1
E	10	10	1.0
F	9	10	0.9

Since product C will be produced by both countries in order for there to be a balance in trade, the total money value of country II's exports of A and B must equal the total value of its imports in products D, E, and F from country I. If this state of equilibrium is upset by a shift in demand in country II away from its domestic goods (A,B,C) to foreign goods (D,E,F,), a disequilibrium in the balance of payments will occur. To finance these additional imports, country II must export an appropriate amount of product C. Since full employment of a constant amount of labor is assumed, there must be a reduced consumption of goods A, B, and C in country II to supply additional exports.

In moving from the initial to the new equilibrium, there does not have to be any change in the production of any of the six products. The entire adjustment process could consist of country II consuming only a portion of product C and exporting the rest, meanwhile importing more of products D, E, and F. Throughout this process of adjustment, all prices and the terms of trade would remain unchanged. If the terms of trade were to move against a country because of excessive exports of one commodity, it would export other commodities in which its comparative advantage was less and stop the adverse movement of the terms of trade.

Graham viewed the terms of trade as normally equal to the cost ratio in one of the countries, with at least one commodity (intermediate) produced in common by more than one country. This intermediate commodity could serve as a link between the two countries' cost structures. In a three-commodity, two-country example, each country could produce the commodity in which it had the greatest comparative advantage as well as the intermediate commodity. Labor costs in each country would then link the price of the intermediate commodity to each of the other two commodities. A change in world demand would then cause a reallocation of labor in each country between the two goods it produces without any change in the terms of trade.

Although the multicommodity framework was first designed for comparing the cost ratios of producing the same commodity between different countries, Viner (1937) and Takayama (1972) pointed out that comparing the cost ratios of different commodities within the same country produces the identical pattern of comparative advantage. This was illustrated in the first Ricardian example. [6] Thus, it is possible to obtain an internal ranking of all industries by their cost ratios within each individual country, yielding a ranking by comparative advantage.

Unit Labor Cost

All commodities produced by a country can be ranked internally in the order of their domestic costs of production. [7] These are defined as the ratio of total compensation per unit of input to productivity per unit of input. Each country exports the commodities in which its comparative advantage in terms of production costs is greatest and imports those commodities which rank lowest (highest production costs). The cutoff point between what is exported and imported depends on reciprocal demand considerations subject to the balance-of-payments equilibrium.

This ranking system can have important implications for economic policy. If an industry's costs of production are high relative to other industries, the industry would be ranked low in terms of comparative advantage. For an industry to improve its ranking by comparative advantage, it must reduce factor compensation and improve factor productivity.

Although there are many factors of production, a ranking of industries based on labor costs of production is important. Takayama (1972) states that if fixed coefficients of production are assumed, comparative labor costs can be meaningful even in a multifactor model. Since all factors are used in fixed proportions, they can be represented by only one factor, labor. Thus, a fixed coefficients production function can be represented by a labor theory of value.

The conditions under which a fixed coefficients production function and a labor theory of value display the same properties were first developed by Samuelson (1951). These conditions, which hold true even if each industry has a choice of several methods of production are as follows:

1. All methods available to any one industry have only one and the same output (the product of that industry).

2. All methods in the technology have among their inputs one and only one scarce primary commodity (labor), drawn in from the outside, and this commodity is the same for all methods and industries.

An elementary exposition presented by Koopmans (1953) states that any efficient nonnegative bill of goods (net outputs) can be sustained by only one price constellation (by one ray of prices kp1, kp2,..., kpn, where $k > 0$). Given this price constellation, even though many processes of production may be available to each firm or industry, only one such process will actually be used. Thus, the only costs that need to be considered within this framework are labor costs.

Transportation Costs

The introduction of transportation costs can lead to a third class of goods, nontraded goods, which enter only into domestic trade. To obtain the conditions for nontraded goods, ${}_at_{12}$ is denoted to represent the real cost in units of labor for transporting commodity A from country I to country II and ${}_at_{21}$ for transportation from country II to country I.

If the country exporting the commodity pays the cost of transportation, commodity A will be exported only if $(a_1 + {}_at_{12})/a_2 < W_2/(W_1 * R)$ and imported if $a_1/(a_2 + {}_at_{21}) < W_2/(W_1 * R)$. But if $W_2/(W_1 * R)$ lies between $(a_1 + {}_at_{12})/a_2$ and $(a_1 + {}_at_{12})/a_2$ such that $a_1/(a_2 + {}_at_{21}) < W_2/(W_1 * R) < (a_1 + {}_at_{12})/a_2$, commodity A will not be exported or imported unless the difference in its cost of production between the two countries exceeds the cost of transporting it from one to the other.

The export performance of a country now depends on its comparative costs of production and its transportation costs. This would cause the international division of labor to be carried out to a lesser degree than with zero transportation costs.

Incomplete Specialization and Variable Costs of Production

Classical theory held that partial specialization could not exist. As Mill (1909, p. 589) stated, "cost of carriage has one effect more. But for it every commodity would (if trade be supposed free) be either regularly imported or regularly exported. A country would make nothing for itself which it did not also make for other countries." Even if no transportation costs and constant costs are assumed, it is possible that only one country would specialize completely, while the other country produces both commodities. As Graham has pointed out, this would occur when one country was economically small and the other large. Here, the first country could not by itself meet the total demand of both countries for the good in which it specializes. Thus, the large country would have to produce both commodities to satisfy its demand, being incompletely specialized, while the small country is completely specialized.

The assumption of constant unit cost can also be relaxed. Increasing costs (diminishing marginal returns) and decreasing costs (increasing marginal returns) can be examined in a comparative cost framework without negating the general results of the model.

To relax the assumption of constant costs, other factors of production must be introduced. The assumptions of the labor theory of value can easily be replaced with the opportunity costs: assuming the availability of all its resources, a country can shift some of them from one line of production to another. [8] Then the price ratio (or rate of exchange) between commodities can be obtained from their opportunity costs. The opportunity cost of steel is the amount of textile that must be given up to get an additional amount of steel regardless of whether it were labor, capital, or some other factor that were shifted from textile to steel production. Its opportunity cost is the amount of steel that must be sacrificed for an additional quantity of textile.

In a constant cost model, there is a constant rate of substitution in production between any two commodities. In a multifactor model with diminishing marginal returns, the substitution in production of the two commodities becomes limited so that the possibility of incomplete specialization emerges as the general result of the model. In addition, the division of labor will be carried out less than under constant costs, since the comparative disadvantage at the margin diminishes and finally disappears.

Graham takes this one step farther and states that because trade leads to the development of specialization, the combined output may be smaller than if there were no trade at all. This condition would occur when a country's exports are produced under diminishing returns, while non-traded and import competing goods are produced under increasing returns. This is provided that the increase in total money values of production in one country is less than the decrease in the other country.

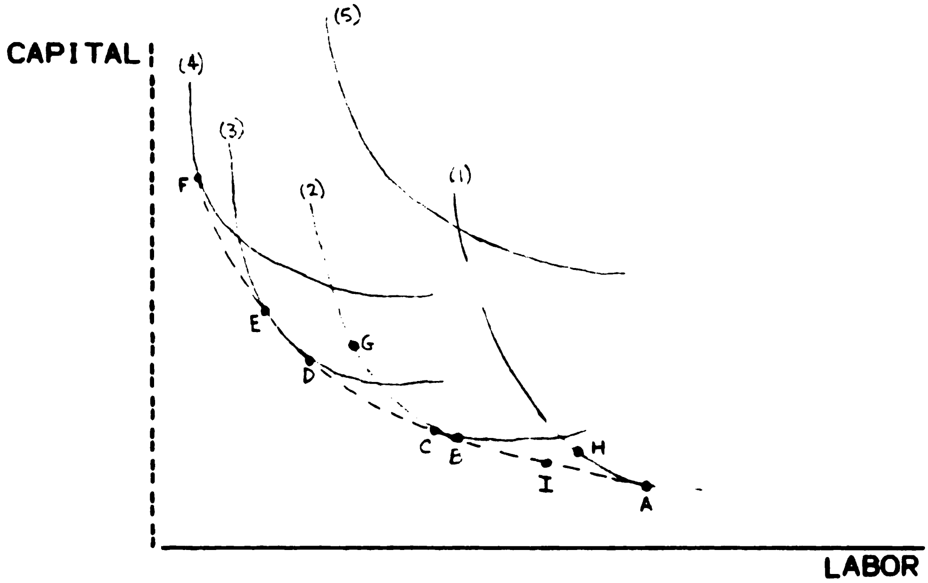
Ricardian vs. Heckscher-Ohlin Models

Jones (1979) argues that the sharp distinction often drawn between the Ricardian comparative cost and the Heckscher-Ohlin models can disappear when a multicommodity, multicountry framework such, as Graham's, is employed. The Ricardian and Heckscher-Ohlin models are distinguished from each other by the assumption concerning a commonly shared technology. The Ricardian model assumes that the average productivity of labor is different between countries because they do not share the same common technological knowledge. If countries do not share the same technology, then factor prices will not equalize as in the Ricardian two by two model. The Heckscher-Ohlin model assumes that countries share a common technology, and thus factor prices do equalize. However, as will be shown in the analysis, this is only a necessary and not a sufficient condition for factor price equalization. By employing a multicommodity framework, it is demonstrated that factor prices need not equalize,and thus the sharp distinction of the two models fades.

The Ricardian and Heckscher-Ohlin models have two significant distinguihing features which are not dependent on the number of commodities and countries considered. The first is that the Ricardian model completely ignores differences in factor intensity. Homogeneous productive resources are converted into outputs at constant costs, so that in the Ricardian model it is necessary to concentrate on only one factor of production - labor. The Ricardian model also assumes that countries differ in the average productivity of labor in the same occupation without specifying the cause, whereas the Heckscher-Ohlin model is based on an assumption that knowledge of the best productive techniques is available to all countries.

Jones concentrates on the role of factor endowments in determining production and trade patterns by considering two small countries which share access to the same technology but differ in their endowments of capital and labor. Unit-value isoquants are constructed for five commodities for these countries. Each unit-value isoquant shows all combinations of capital and labor that can produce $1 worth of output of that particular good. The country's capital-labor endowment ratio would dictate the location of production along this composite unit-value isoquant and the country's wage/rent ratio. These unit-value isoquants are represented in Figure 2.1.

Figure 2.1. Unit-value Isoquant

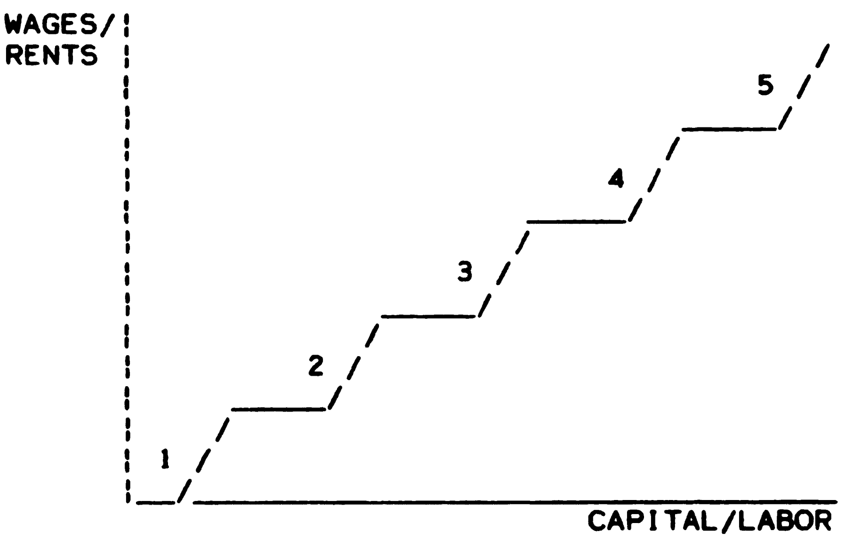


The following information about possible production patterns for this small country can be derived from Figure 2.1. (1) Some commodities will never be produced by this country because its technology in these commodities is inferior to that prevailing elsewhere in the world. This is illustrated by commodity 5. (2) Certain techniques for producing some commodities will never be observed regardless of the community's endowment base. This is illustrated by point G.

If a ray from the origin representing the country's capital/labor endowment ratio cuts the locus between points D and E in Figure 2.1, then this country would specialize in commodity 3. It would then export commodity 3 in exchange for all the other commodities. If the economy had a higher endowment proportion of capital, so that a ray from the origin to the endowment point cut the locus between E and F, the country would produce both commodities 3 and 4, and import commodities 1,2, and 5. In this way, the pattern of production depends on factor endowments.

Figure 2.1 can be used to illustrate the wage/rent ratio that would correspond to any factor-proportions. The factor price ratio is shown by the slope of the inner locus ABCDEF at the point where it crosses the factor endowment ray. Figure 2.2 traces out the relationship between factor endowments and factor prices for a given set of world prices.

Figure 2.2 Factor Endowments and Factor Prices



At a low capital/labor ratio, the wage/rent ratio would also be low, and the country would specialize in commodity 1. If the country's capital/labor endowment ratio increases, it would now produce both commodities 2 and 1. For local variations of the capital/labor ratio near this production point the country remains incompletely specialized in 2 and

1, and factor prices are equalized at this level, corresponding to a two-by-two model.

From this analysis, it can now be determined whether two small countries facing the same set of world prices and sharing the same technological knowledge will have their factor prices equalized. As illustrated in Figure 2.2, even when two countries share the same technology and are incompletely specialized in two commodities, their factor prices need not be equalized. This would occur when one country produces commodities 2 and 3, and the othercountry produces commodities 3 and 4.

Although production functions may be identical, as assumed by the Heckscher-Ohlin model, the techniques actually adopted to produce commodity 3 will differ between countries because the wage/rent ratio is higher in the relatively capital-abundant country. The difference between countries in comparative labor productivities that is asserted by assumption in the Ricardian model can be deduced from differences in relative factor endowments in a Heckscher-Ohlin model. Thus, there is very little difference between the two models in a multicommodity framework.

Conclusion

This chapter developed the theoretical foundationsof the classical comparative cost model beginning with the Ricardian model. The assumptions of the latter were relaxed with the introduction of money wages, a multicommodity framework, transportation costs, and incomplete specialization to construct a more realistic model. With the relaxation of the assumptions, Jones demonstrated that the sharp distinction often drawn between the Ricardian and Heckscher-Ohlin models disappeared when a multicommodity, multicountry framework was employed, since factor prices need not equalize. The difference between countries in comparative labor productivities that is asserted by assumption in the Ricardian model can be deduced from differences in relative factor endowments in a Heckscher-Ohlin model.

Viner (1937) pointed out that comparing the cost ratios of different commodities within the same country was valid if the ratios between costs are examined. All commodities produced by a country can be ranked internally in the order of their domestic costs of production. Each country would export the commodities in which its comparative advantage in terms of production costs is greatest and import those commodities which rank lowest (highest production costs). This provides the theoretical foundations for ranking industries in the subsequent chapters.

The empirical tests of the comparative cost theory are reviewed in the next chapter, beginning with MacDougall's analysis of the Ricardian hypothesis. Challenges to the Ricardian hypothesis and the subsequent relaxation of its assumptions are also examined.

Footnotes

[1]The question of whether Ricardo can claim the credit for establishing the theory has been debated in the literature. The controversy stems from the fact that Colonel Torrens published an analysis of comparative advantage in 1808, The Economists Refuted, and in 1815, An Essay on the External Corn Trade, while Ricardo's Principles appeared in 1817. However, Viner (1937) believes that despite Torrens' earlier publication, Ricardo is entitled to the credit for being the first to place an emphasis on the theory, the first to place the theory in an appropriate setting, and for obtaining a general acceptance of it by economists.

In a similar vein, Chipman (1965) states that although Ricardo was influenced by Torrens's External Corn Trade, Ricardo added a great deal to the theory. He also states that both Torrens and Ricardo contributed in essential ways to the development of comparative advantage, but Torrens should be given credit for the principal discovery.

[2]The early comparative cost theories relied heavily on the labor theory of value. Haberler (1936) showed that the deductions obtained from using the labor theory of value do not depend on the validity of its assumptions. Thus it is possible to discard the labor theory, along with its unrealistic assumptions, without having to discard the results obtained from it.

[3]This section is based on Kreinin (1983), chapter 11.

[4]In contrast, Graham (1923) objected to the normal equilibrium position lying between the cost ratios and called this a "limbo" ratio. Graham demonstrated conditions under which the terms of trade would lie at one of the limits set by comparative advantage. This would occur when the two countries were of different economic sizes, and the economic importance of the two products were not the same in each country. Thus the demand of country A for country B products would not be the same as the reciprocal demand. Since these two demands will not be balanced, the terms of trade will be forced to one of the limits set by comparative costs. The appearance of a balance inside these limits would only be a slight coincidence.

[5]This section is based on Kreinin (1983), chapter 11.

[6]If we consider two countries, m and n, each producing goods 1,2,...,i, then their respective unit labor costs can be represented as lim and lin. The degree of comparative advantage can be expressed as the ratio $[(l_{im}/Avg(l_{im}))/(l_{in}/Avg(l_{in})]$ = $[(l_{im}/l_{im})*(Avg(l_{in})/Avg(l_{im})]$ = C. The industries in each country are examined relative to the manufacturing average. If C > 1, then country m has a comparative advantage in the

production of good i. If $C < 1$, the country n has the advantage. Thus, the unit labor costs are first ranked internally and then international comparisons are made. See Deardorff (1980) and Kreinin (1982) for the justification of using the manufacturing average as the denominator.

[7]This section of the reformulated comparative costs theory is based on Kreinin (1983), chapter 11.

[8]Viner (1937, p. 490) is opposed to the linking of the labor theory to the classical theory of comparative advantage. "Except for Ricardo, none of the classical expounders of the doctrine of the comparative costs, with the relatively unimportant and partial exception of James Mill, was an exponent of a labor-cost theory of value." Viner also states that "the association of the comparative-cost doctrine with the labor cost theory of value is a historical accident."

CHAPTER III

REVIEW OF THE EMPIRICAL LITERATURE

Classical trade theory states that international specialization is determined by comparative advantage based on relative productivity differentials among countries. It does not attempt to explain why the differences occur; rather, the assumption is that they exist and make trade be possible and beneficial. Relative differences in the wage structure and capital-labor ratios of some industries may distort the relative rankings determined by productivity differentials. Nevertheless, labor productivity captures the greatest portion of the variations, and hence the classical economists believed that additional factors were not sufficiently important to cause significant changes in the pattern of international trade as determined by relative labor productivity differences.

The classical comparative cost theory was tested empirically several times, beginning with MacDougall, but these tests had limited success. A review of this empirical literature follows.

MacDougall's Original Formulation

Using Rostas's productivity data for twenty-five British and U.S. industries, MacDougall (1951,1952) tested selected aspects of the classical comparative cost theory.

The empirical results were based on the Ricardian labor theory of value. Assuming a two-country world, Great Britain and the United States, each country will have a comparative advantage and export those goods for which its relative output per worker, (U.S./U.K.), exceeds its relative money wage rate in the respective industries. However, bilateral trade flows could not be utilized because the bulk of U.S. and U.K. exports in 1937 went to third markets, which became the basis for the tests.

According to pre-World War II statistics from the Ministry of Labour and the Department of Labor, U.S. weekly wages in manufacturing industries were on average double those in Great Britain. Where U.S. output per worker was more than twice that of the British, the United States was expected to dominate the export market, and where the U.S. output per worker was less than twice that of the British, Britain was expected to dominate the export market. The empirical results indicated that 20 of the 25 industries (covering 97 percent of the sample by value) conformed to theoretical expectation. MacDougall found a strong inverse relationship between relative wage costs per unit of output (relative wages/output) and relative exports, and a positive relationship between relative output per worker and relative exports. When relative output per worker was plotted against relative exports on a double logarithmic scale, the regression line had a slope of almost four and the resulting R^2 was 0.64. This indicates that a one percent difference in relative output per worker for a commodity was associated with 3-4 percent higher exports for the country with the greater productivity level.

In the traditional Ricardian framework, with perfect markets and homogeneous products, the exports of each country should go to the other. Where either country had a comparative advantage, however small, the country would capture the whole export market. Instead, the majority of U.S. and U.K. exports in 1937 went to third markets, with little trade between themselves. In industries where Britain had the comparative advantage in 1937, U.K. exports to the United States were only a fraction of one percent of total U.S. consumption in that commodity. Similarly, in industries where the United States had the comparative advantage in 1937, U.S. exports to Britain were more substantial, but still only a small percentage of total British consumption in that commodity.

One explanation is that the assumptions of the Ricardian model do not hold in the real world. Instead, with imperfect markets, each country obtained the larger share of the third market where it had the comparative advantage, and each countrytended to capture a larger share of the third market the greater its comparative advantage. As theory would suggest, this was the expected result when the assumptions are relaxed, confirming the labor theory of comparative costs.

The existence of high tariffs is a second explanation for the lack of penetration of the U.S. and U.K. domestic markets. In 1937, U.S. tariffs fully offset Britain's comparative advantage in almost every commodity with the exceptions of cement and coke, where transportation costs are high, and footwear, where the British advantage was small. U.S. tariffs were much higher on commodities where Britain had a comparative advantage than on other commodities. British tariffs fully offset U.S. comparative advantage in paper and glass, while they only partly offset U.S. comparative advantage in machinery, motor cars, wireless sets and values, pig iron, and tin cans. But by 1950, MacDougall (1962) found a general reduction in U.S. tariffs. In particular, this was most noticeable for the commodities in which the United States had a comparative disadvantage. In contrast to the 1937 U.S. tariff rates, the 1950 rates seldom offset Britain's comparative advantage.

Tests of the Comparative Cost Theory

Balassa (1963) and Stern (1962) continued and updated MacDougall's original work. They examined the relative importance of productivity, wages, and capital costs in determining the pattern of exports for selected manufacturing industries in the United States and Great Britain. In addition, Stern examined the relative wage structure and export performance of the two countries in 1959 to determine whether changes in comparative advantage had occurred.

Paige and Bombach's 1950 productivity estimates for 44 manufacturing industries in the United States and the United

Kingdom were utilized by Stern. Balassa's sample covered only 28 industries, representing 43.1 percent of the manufacturing output in Britain and 41.4 percent in the United States. The productivity data were measured as net output per worker: gross output minus purchased inputs other than labor, divided by total employees. The relative wage and output per worker measures are man-year figures, while the employment figures include direct and indirect labor.

Net cost ratios were included as an explanatory variable to measure capital costs and profit per unit of output in addition to the unit labor costs. Thus, net cost ratios could provide some indication of relative resource productivity and could be important if the assumptions of the labor theory of value were relaxed.

In 1950, the U.S. and U.K. mutual trade was still a small percentage of the total trade of each. Since most of the U.S. and U.K. trade was with third countries, Stern treated the rest of the world as a third country, examining total U.S. and British exports in addition to their mutual trade.

Balassa, in contrast, excluded mutual trade between the United States and Britain since the differential tariff rates would distort trade patterns. Instead, the effect of 1950 relative productivity differentials on relative export performance for 1951 in third countries was examined. Still, corrections for the discriminatory effects of commonwealth preferences and other distorting factors were not accounted for.

In examining the impact of productivity differences on export performance, the elasticity of substitution between U.S. and British exports of the same commodity was assumed to exceed unity. Thus, a positive relationship was expected between relative productivity differentials and export performance with the resulting regressions in logarithmic form as follows:

<u>Balassa</u>

$$\log EI/EII = -1.76 + \underset{(0.18)}{1.59} \log PI/PII \qquad R^2 = 0.74; \qquad (3.1)$$

<u>Stern</u>

$$\log EI/EII = -0.68 + \underset{(0.43)}{1.27} \log PI/PII \qquad R^2 = 0.19; \qquad (3.2)$$

where E is the export performance, P is productivity, I is country one, and II is country two. To provide consistent reporting, all regression results providing R have been converted to R^2.

The coefficients in both equations were significant and have the correct signs. The difference in the magnitude of the coefficients and R^2 between the two equations is due to Balassa's smaller sample size. By excluding industries which may be dominated by demand factors or are nontraded, he was able to obtain a higher R^2. In addition, Stern found that relative wage differentials between the two countries had narrowed between 1950 and 1959. When comparing the two periods, each country experienced export gains in the industries in which it had a comparative disadvantage. This wasattributed to relative productivity increases in the comparative disadvantage industries for each country.

In an attempt to improve the regression results, wage ratios were added as a determinant of export performance. The resulting regression results are:

Balassa

$$\log EI/EII = -5.16 + \underset{(0.33)}{1.46} \log PI/PII + \underset{(0.57)}{1.25} \log WI/WII. \quad (3.3)$$

$R^2 = 0.77$

Stern incorporates wage ratios into unit labor costs by dividing the output per worker ratios into the wage ratios. The results are as follows:

Stern

$$\log EI/EII = 0.01 \underset{(0.59)}{-1.40} \log y \qquad R^2 = 0.18; \qquad (3.4)$$

where y is unit labor costs.

These results are similar to the ones obtained in equations 3.1 and 3.2; however, although the wage variable in equation 3.3 was significant at the 95 percent level, it had the wrong sign. Despite the statistical significance of log WI/WII, Balassa states that no definite relationship between wage rates and relative export performance can be established since the R^2 did not differ significantly between equations 3.1 and 3.3. [1] His reason is that productivity differences were not offset by higher wages in high productivity industries; instead, productivity differences were the primary factors in determining export performance. One reason wage ratios might not be an important factor in explaining relative export performance is that causation runs in both directions between the variables. While lower wages could lead to improved export performance, the latter may also cause wages to increase in an industry.

Another reason wage ratios and export performance might not be correlated is that wage rankings of industries are similar among countries. A similar proposition, first advanced by Taussig, states that wage ranking are similar among countries because there is little competition between the labor forces of various industries. Interindustry wage differentials are determined by the disutility and regularity of work, the required skill levels, and other factors which are uniform in all countries; thus, wage differentials should be smaller than productivity differentials.

In empirical tests of this proposition, Caves (1960), Kravis (1956b), Lary (1968), Lebergott (1947), and Balassa (1963) have shown that the rankings of industries by hourly earnings of workers are similar. Kravis compared the ranking of average hourly earnings in 20 manufacturing industries for Japan and the United States obtaining a coefficient of rank correlation of 0.82; he concluded that "for most industries, international differences in productivity are greater than international differences in wages" (1956b, p. 68). Lary analyzed average annual wages in 13 industry groups for 11 countries. The ranking of industries from low to high wages was found to be similar in the seven developed countries (the United States, Canada, Sweden, Australia, the

United Kingdom, Germany, and France), but among the four developing countries (Mexico, Japan, Brazil, and India) the ranking was less consistent. Stanley Lebergott found that in the post-World War II years, interindustry wage differentials were almost identical among the United States, the United Kingdom, and Canada, while differing slightly for Sweden. This was brought out by Balassa, who obtained a coefficient of variance of 37.1 for productivity ratios and 10.7 for wage ratios.

The last relationship explored is between relative export performance and net cost ratios, where net costs refer to per unit cost and profits in addition to labor costs. The results are as follows:

<u>Balassa</u>

$$\log EI/EII = 6.16 - \underset{(0.30)}{1.59} \log NI/NII \qquad R^2 = .50; \qquad (3.5)$$

<u>Stern</u>

$$\log EI/EII = 0.01 - \underset{(0.59)}{1.41} \log NI/NII \qquad R^2 = 0.13; \qquad (3.6)$$

where NI/NII = relative unit costs. The results are also similar to equations 3.1 and 3.2 but with a higher standard error and lower coefficient of determination.

These results confirm the classical theory, indicating that the relative export performance of the United States and the United Kingdom followed established lines of comparative advantage as suggested by labor productivity. The introduction of additional variables seemed to modify the results slightly, while differences in capital costs per unit of output did not seem to have any significant effect on export performance.

Additional Tests for Other Pairs of Countries

Kreinin (1969) provides a critical analysis of the comparative cost theory as formulated by MacDougall. He expands the analysis by examining cross-sectional data for three pairs of countries other than the United States and the United Kingdom. Canada and Australia, Canada and the United Kingdom, and the United States and Canada were examined for the years 1948 and 1950-1951. Time series data were also examined for the United States and the United Kingdom over the period 1958-1965.

Intracountry trade was negligible in the cross-sectional analysis for Canada and Australia because they serve different markets due to the distance involved and other traditional factors; thus, exports to third markets had to be considered. At the official exchange rate prevailing in 1950, average earnings per employee in Canadian manufacturing industries were double those in Australia. According to the Ricardian hypothesis, Canadian export volume should exceed Australia's in industries where the productivity index is above 200 percent, and Canadian export volume should fall below Australia's where the ratio is less than 200 percent. However, more than half of the 20 industries examined performed contrary to theory.

Relative wage costs were derived by dividing the productivity ratio into the wage rate ratio. Relative exports were then correlated with relative wage costs, with the expectation of a negative coefficient. However, this relationship was insignificant. Kreinin attributed this to the lack of variation in the interindustry wage structure in the two countries and in the ranking by comparative advantage. An additional factor is that the dependent variable, relative export, is limited by the fact that Canada and Australia have few common markets. Thus, extension of MacDougall's analysis to this pair of countries is questionable.

In the analysis for Canada and the United Kingdom, relative exports were not found to be correlated with either relative costs or price variables. However, the regression was severely limited by its small sample size, and no conclusive results are possible.

The U.S. and Canadian results indicated that a large share of their industries, total trade was intracountry. Thus, a study of this pair of countries provides a close approximation of the simple Ricardian two-country model. Unlike that model, incomplete specialization due to increasing costs, product differentiation, and trade barriers prevented post-trade commodity prices from being equalized internationally. These factors also caused trade in each commodity group to flow in both directions. Taking this into consideration, intracountry exports were found to be correlated with labor productivity and labor costs. The results expressed in logarithmic form are as follows:

$$x_i = 0.37 + \underset{(1.76)}{5.50}\, y_1 \qquad R^2 = 0.43; \qquad (3.8)$$

$$x_i = 1.37 - \underset{(2.24)}{6.68}\, y_2 \qquad R^2 = 0.38; \qquad (3.9)$$

where x_i is intracountry exports, y_1 is the labor productivity ratio, and y_2 the labor cost ratio.

These results adhere more closely to the Ricardian hypothesis than do the previous results. Nevertheless, this sample deleted one fourth of the industry groups; when all 21 industries were included, the R^2 dropped to 0.2, while the parameters became statistically insignificant.

Time series data was also examined for the United States and the United Kingdom in 25 industries for the period 1958-1965. Changes over time in relative labor productivity were correlated with changes in relative export performance to third markets, with the expectation of a positive coefficient. Only six industries exhibited significant positive relationships, while eight exhibited negative relationships, and eleven exhibited none. Three of the six which showed strong positive relationships - leather, pulp, and glass - are characterized by homogeneous commodities. The problem is that with only eight annual observations there are not enough degrees of freedom on which to base any definitive conclusions.

The MacDougall-Stern analysis was then integrated by examining the common commodities in both studies. Changes over time for relative labor productivity were then correlated to changes in relative export performance for the United States and the United Kingdom over the years 1937, 1950, and 1959. The results indicate that one-third of the sample did not conform to expected behavior. Because this analysis is based on one or two degrees of freedom, no definitive conclusions can be reached.

Finally, time series data was examined for automobiles in six European countries for the years 1955, 1960, and 1965. When changes in relative labor productivity were correlated with relative export performance for sets of these European countries, Kreinin found little or no support for the Ricardian hypothesis.

Kreinin concluded that his evidence did not support the simple Ricardian hypothesis. Rather, factors other than supply, such as product differentiation and demand, determine the pattern of trade. For the case of differentiated commodities, labor productivity may only set the limits to the terms of trade, whereas demand conditions determine the exact terms of trade. The major constraint to using labor productivities for differentiated commodities is that the limits to trade may be wide.

Evaluation of the MacDougall Approach

Bhagwati (1969) and Stern (1975) were critical of the MacDougall-Balassa-Stern (M-B-S) approach because these early empirical tests (including Stern's) were too simplistic. Since M-B-S assumed labor was the only significant factor of production, measures of comparative labor productivity were employed as a proxy for comparative costs. Bhagwati and Stern call for a general framework for determining trade patterns and are skeptical of the simple Ricardian approach, finding it difficult to adapt the one-factor Ricardian model to a multifactored world.

Stern and Bhagwati state that treating labor productivity as an exogenous variable and as the most important determinant of comparative cost differences is limiting; therefore, concentration on labor productivity instead of other factor productivities is purely arbitrary. If human capital and other capital inputs into natural resources are considered, comparative capital productivity could be significant, and a multifactor model should be adopted. Thus, tests of the Ricardian hypothesis should be based on intercountry differences in total factor productivity, not just labor. Nevertheless, because of the increasing importance of multinationals in international trade, capital inputs have become mobile among countries and its price equalized. If there is little variation in capital prices, differential labor costs remain the important factor.

Bhagwati and Stern state that since the Ricardian model emphasizes comparative differences in production functions, tests of the Ricardian model should be developed in terms of comparisons of production functions. The expected results are that a country's exports would be concentrated in its relatively most efficient industries and its imports in its least efficient ones. Along these lines, Minhas (1962) has compared the isoquants of several countries and found that except for a pure scale factor, all the isoquants had essentially the same parameters. Bhagwati and Stern conclude that Minhas has devised a method for testing the Ricardian hypothesis in a more general manner. Stryker (1968) attempts to incorporate this approach in testing the comparative cost model. The problem with this method lies in the choice of the production function to estimate. Since different production functions exhibit different properties, the choice of any particular type will influence the results. Thus, this more general approach needs further theoretical development.

Bhagwati states that a sufficient assumption for the Ricardian hypothesis to hold is for the labor productivity ratios to be a monotonically increasing function of the price ratios. In testing this assumption, Bhagwati found that the linear regression between labor productivity and price ratios fit poorly. In addition, the linear relationship between comparative unit labor costs and export price ratios had a poor fit. From these results, Bhagwati concluded that both relationships are insignificant. 2 When relative inter-country wage rates were included as a separate and additional explanatory variable, a slight improvement over the simple correlation between export price ratios and labor productivities alone was found.

Bhagwati (1969, pp. 22-23) states that his results "cast sufficient doubt on the usefulness of the Ricardian approach" and that there is no evidence to support the Ricardian hypothesis since "labor productivity ... is not a datum in the sense that production functions are."

Even if an empirical relationship is established between relative exports and variations in relative labor productivity, the fundamental question of what determines comparative cost differences cannot be answered. The reason is that the Ricardian model simply assumes the existence of comparative cost differences. Thus, Bhagwati and Stern conclude that the Ricardian model is of limited importance in explaining the composition of international trade.

Extension of the MacDougall Approach

J.D. Stryker (1968) extends the M-B-S analysis by incorporating capital inputs, labor inputs, differences in technology, economies of scale, and relative factor prices into a comparative cost model, thus meeting some of the criticism of Bhagwati and Stern. Time series and cross-sectional data are examined for the United States and Canada for the period 1949-1962.

The first part of Stryker's study develops a two-country, partial equilibrium model which examines some of the factors underlying international price competition. The model is:

$$O = AL^{\alpha}K^{\beta} + R; \qquad (3.10)$$

where O is the quantity of output produced; L is the labor input; K is the capital input; R is the raw material input; A is a proportionality parameter; α and β are the elasticity coefficients of value added with respect to labor and capital ($V = O - R$, where V is value added). Value added is in constant dollars; labor input is in man-hours of production and nonproduction workers; the capital variable was estimated as the deflated book value of the gross capital stock.

The assumptions of the model are as follows:

1. The manufacturing production function is subject to constant returns.
2. Labor and capital are homogeneous.
3. Raw materials are obtained from outside the manufacturing sector and are initially supplied by domestic sources.
4. The production of raw materials is subject to diminishing returns.
5. Perfect competition exists in all markets.
6. All firms are in long run equilibrium so that a single set of factor prices faces each within a country.
7. The parameters of the production functions differ between countries.
8. All firms engage in average cost pricing.

The supply of manufacturing commodities is a positive function of the ratio of foreign to domestic prices for the commodity, and although scale effects in manufacturing can change the slope of commodity supply curves, the analysis is fundamentally the same.

The model expressing the relationship between relative export growth in the United States and Canada and the relative growth of labor productivity for a cross-sectional analysis of 24 industries is as follows:

$$[(\dot{X}/X)_{us} - (\dot{X}/X)_{ca}]_i = a + b[((\dot{V/L})/(V/L))_{us} - ((\dot{V/L})/(V/L))_{ca}]_i. \quad (3.11)$$

Value added and labor data were collected on an establishmentbasis, while capital stock data were collected from firms. Since the two are not always classified in the same industry, problems in data compatibility may occur. In some cases where large firms own plants in several industries, part of the value of capital stock reported for a particular industry exists in establishments classified in another industry.

Since tariffs can affect the exports of two countries differently at a given time, exports in three separate markets are examined. The first dependent variable is the difference between the relative rates of change of exports to third markets; the second is the difference between the relative rates of growth of reciprocal exports. The latter examines the effects of average cost changes on both exports and imports, since exports from the United States to Canada are the same as imports of Canada from the United States and vice versa. The third dependent variable is the difference between relative rates of growth of total exports.

While tariffs affect the exports of two countries differently at a given time, changes in relative cost advantages will not be affected as long as the tariff rates are not changed during the period considered. Changes in external demand do not affect this analysis since a change in world demand is reflected in a change in international prices, and this affects all countries equally. However, international prices are not the sole factor for international competition, and thus product differentiation may be an important factor for international competition which may modify the results.

The results of equation 3.11 are as follows:

Dependent variable	a	b	R^2
Third-market exports	-0.022	1.975 (0.871)	0.153
Reciprocal exports	-0.019	1.715 (0.823)	0.128
Total exports	-0.024	1.927 (0.728)	0.207

The results indicate that the coefficients and the coefficients of determination are significantly different from zero at the 0.05 level, although the R^2's are low. Thus these results indicate that labor productivity is an important factor in determining the pattern of trade.

An attempt is then made to determine whether increases in the amount of capital employed in production may have offset changes in labor productivity. The findings show that the relationship between changes in exports and changes in labor productivity have not been offset by changes in the capital stock. This is due to capital being mobile between the United States and Canada, thus equalizing its cost.

The role of technological innovation is also examined in an attempt to determine the underlying cause of differences in productivity of the two countries. The findings are that the increases in productivity and the growth of exports over time are related to the differing rates of technological progress taking place within manufacturing industries.

Stryker's evidence suggests that changes in the structure of U.S. and Canadian exports were related to changes in average labor costs for the period examined. Within this framework, labor productivity is a useful proxy for total factor productivity, however, the differences in labor productivity are not explained by the comparative cost model. Stryker attributes these differences in productivity to differences in technological innovation.

Justification of Labor Costs

In examining labor's importance as a factor of production and a major component of total cost, labor's share of national income must be determined. Dennison (1967) found that labor income was almost 80 percent of net national income for the United States, Canada, and northwestern Europe. Labor shares this high can only occur if high proportions for labor income characterize a majority of the individual industries. If labor costs are a large part of value added, differences in either relative wage rates or relative labor productivities will play an important role in the structure of trade.

In an analysis of the steel and motor vehicle industries, Kreinin (1984, pp. 41-42) concentrates on the labor cost of production because of "its overwhelming contribution to total production costs." Labor costs were estimated to constitute 46 percent of total production costs for the motor vehicle industry. In addition, that industry is composed of multinationals which transfer capital in the production of components, parts, and final assembly among many nations so as to minimize costs. In this way, labor costs determine plant location. Thus, an emphasis on wage and labor productivity differences for countries by industry appears to be justified.

The question of whether the differences in output per worker are reflected in export prices and international trade is an important one. Rostas's 1937 data on productivity levels in the United States and the United Kingdom are a measure of the gross output of an industry in real terms. In contrast, Paige and Bombach's 1950 data are a measure of the net value added in an industry in real terms. The export price ratios used in all the studies were unit values of individual commodities, which are conceptually closer to measures of gross output rather than to net value added. Studies employing the 1937 data displayed a close correlation between export price ratios and labor productivity while studies employing 1950 data showed little or no correlation. From the way the data are constructed, a close correlation between prices and net value added could occur only if the commodity and industry definitions were the same and the relationships between output and material purchases from other industries were the same between the two countries. Thus previous attempts to establish a correlation between export price ratios and labor productivity ratios failed due to the lack of conceptual and statistical compatibility in the data, and they do not provide evidence against the Ricardian hypothesis.

Comparative Cost Theory Reformulated

Anderson and Kreinin (1981) and Kreinin (1982,1984,1985) analyzed the motor vehicle and steel industries by examining the cost advantage of an industry relative to all other manufacturing industries within the same country instead of between countries. This approach allows industries to be ranked internally by the inverse of their production costs equivalent to a ranking by comparative advantage. Unit labor costs, consisting of labor compensation and productivity, were employed as an approximation of total production costs. If an industry experiences a rise in labor compensation, or a fall in productivity relative to the national manufacturing average, it will fall in ranking by comparative advantage.

Anderson and Kreinin confined their study to the United States over the period 1957-1977, while Kreinin in the three later articles examined the United States, Japan, and the industrialized European countries (German automobiles, and steel and iron only for the rest) over the period 1964-1980. The results indicated that between 1957 and 1977, labor compensation in the U.S. iron and steel industries increased faster than in all manufactures, but labor productivity increased at a rate below the manufacturing average, causing a fall in the ranking. Over the period 1964-1980, unit labor costs in U.S. iron and steel grew faster than the manufacturing average, with the difference between the two widening. Thus, U.S. steel fell in ranking by comparative advantage because of relatively high labor compensation and relatively low labor productivity.

In contrast, Japan's iron and steel industry was able to keep its unit labor costs in line with the manufacturing average and maintain its ranking by unit labor costs. German iron and steel also improved its internal ranking with increases in labor productivity and decreases in compensation relative to the manufacturing average. French and British iron and steel lost ground by comparative advantage in a manner similar to the United States.

U.S. motor vehicles improved their ranking between 1957 and 1967. While labor productivity increased rapidly after 1967, compensation increased even faster, causing the motor vehicle industry to fall in ranking after 1967. Other factors relating to managerial decisions, such as product mix (large verses small cars), also played a role in the motor vehicle industry's deterioration.

The Japanese motor vehicle industry was able to keep unit labor costs in line with the Japanese manufacturing average and maintain its ranking. German motor vehicles were able to increase labor productivity at the same rate as all manufactures between 1962 and 1966. After 1967, labor productivity increased at a rate below that of all German manufacturing, with a pronounced moderation after 1974. Labor compensation kept pace with the manufacturing average, causing unit labor costs to increase after 1975. Therefore, Kreinin states that the German motor vehicle industry appears to be losing its comparative advantage.

Summary

The work of MacDougall, Balassa, Stern, and Stryker confirms the comparative cost theory. Using 1937 data, MacDougall found a strong inverse relationship between relative U.S. and U.K. wage costs per unit of output and relative exports, and a positive relationship between relative output per worker and relative exports. Balassa and Stern's results indicated that the 1950 relative U.S. and U.K. export performance followed established lines of comparative advantage as suggested by labor productivity. The introduction of differences in capital costs per unit of output did not have any significant effect on export performance. Stryker's time series evidence suggested that changes in U.S. and Canadian exports were correlated with changes in labor productivity, and that the latter is a useful proxy for total factor productivity, although its differences are not explained by the comparative cost model. Stryker attributed these differences to technological innovation.

In contrast, Kreinin concluded that his evidence did not support the simple Ricardian hypothesis, and that factors other than supply, such as product differentiation and demand, determined the pattern of trade. For differentiated commodities, labor productivity sets the limits to the terms of trade, which may be wide, whereas demand conditions determine the exact terms of trade.

Bhagwati and Stern were also critical of the M-B-S approach because it was too simplistic, and they call for a multifactor framework in determining trade patterns. In tests of the Ricardian hypothesis, Bhagwati found a poor fit between 1950 relative labor productivity and price ratios and the relationship between comparative unit labor costs and export price ratios. When relative intercountry wage rates were included as an explanatory variable, a slight improvement was found.

The question of whether the differences in output per worker are reflected in export prices was addressed by Daly. Since earlier studies measured export prices and labor productivity on a different basis, their failure to establish a correlation between export price ratios and labor productivity ratios was due to the lack of conceptual and statistical compatibility in the data; they did not provide evidence against the Ricardian hypothesis.

By reformulating the comparative cost theory to examine internal changes in unit labor costs, Kreinin has developed an effective tool which yields information useful in making policy decisions. Industries concerned with import competition can decrease their unit labor costs by decreasing labor compensation, increasing productivity, or both, to improve their ranking by comparative advantage and trade performance.

The next chapters incorporate the Kreinin approach in the analysis of manufacturing industries in the United States, Japan, Germany, the United Kingdom, and Italy. The performance of each industry's unit labor cost and its components are examined in relation to the manufacturing average to determine the effect on its internal ranking.

Footnotes

[1]Simply because the wage variable has the wrong sign and does not "add much" to the R^2, is not a valid reason to declare it insignificant. See Schmidt (1976) and Johnson (1972).

[2]Goodness of fit is not the correct criterion for judging whether a relationship is significant. See Schmidt(1976) and Johnson (1972).

CHAPTER IV

DISAGREGATED CROSS-SECTIONAL EVIDENCE FOR UNIT LABOR COSTS IN THE UNITED STATES

This chapter investigates the effect of unit labor costs on the trade flows of U.S. manufacturing industries for 1967 and 1980. The first part develops an internal ranking of 139 industries for these years and formulates a cross-sectional model for determining the effect of unit labor costs on international trade. The second part arranges the industries into low, medium, and high technology categories and analyzes the performance of their unit labor costs.

The unit costs of production is the inverse of comparative advantage and is the criterion for the internal rankings. The lower the unit costs of production, the higher is an industry's ranking by comparative advantage. Unit costs of production can be approximated by unit labor costs, which in turn are defined as the ratio of total labor compensation to labor productivity. Value added per employee is used as a proxy for labor productivity.

Policy implications can be derived from the internal ranking of industries. If an industry's level of labor costs is high relative to other industries, it would be ranked low by comparative advantage. For the industry to improve its ranking, it must cut unit labor costs through a reduction in labor compensation or an increase in productivity.

Data

The industries are categorized by the Standard Industrial Classification (SIC) system at the two-, three-, and four-digit level. U.S. data for total compensation, value added, and total employees were obtained from various issues of two Bureau of the Census publications, Annual Survey of Manufactures and the Census of Manufactures for 1967, 1972, and 1977.

This chapter departs from past studies by using the total compensation of employees instead of merely wages. Total compensation is a more comprehensive measure of the cost structure among industries and is the better specified variable. Besides wages, it includes social security payments and employee fringe benefits, and among these are paid vacation time, health care, paid holidays, and personal absences. Total employees include production as well as clerical and administrative workers.

U.S. data for export and import values by two-, three-, and four-digit SIC breakdown were collected from various issues of the Bureau of the Census, U.S. Commodity Exports and Imports as Related to Output. Data for export and import values by eight-digit SIC breakdown were drawn from the U.S. Department of Commerce, U.S. Imports, Consumption by World Areas, FT210, and U.S. Exports Domestic Merchanise, FT610.

The unit labor costs and net trade positions of U.S.

industries for 1967 and 1980 are displayed in Table 4.1. The complete tables, including the components of unit labor costs, are presented in the Appendix.

TABLE 4.1 Unit Labor Costs and Net Trade Positions of U.S. Industries, 1967 and 1980

Industry	1980 Unit a Labor Costs	1980 X-M b	1967 Unit a Labor Costs	1967 X-M b
Meat Products	0.562	-766.1	0.612	-428.9
Dairy Products	0.370	-266.9	0.465	22.5
Preserved Fruits	0.379	N.A.	0.386	1.6
Grain Mill Products	0.265	2714.9	0.294	515.3
Bakery Products	0.488	-90.8	0.532	-13.1
Sugar, Confectionery	0.294	-2214.7	0.363	-624.4
Fats and Oils	0.303	3143.1	0.389	-48.5
Beverages	0.320	-1946.2	0.356	-477.8
Misc.Foods Kindred	0.297	237.4	0.321	381.6
Tobacco Products	0.220	991.6	0.216	129.6
Weaving Mills, Cotton	0.615	181.8	0.630	-28.2
Weaving Mills, Manmade	0.562	212.0	0.627	20.8
Weaving, Finished, Wool	0.554	-81.9	0.553	-88.0
Narrow Fabric Mills	0.607	36.2	0.621	5.0
Knitting Mills	0.571	90.2	0.593	11.8
Textile Finishing	0.524	N.A.	0.645	N.A.
Floor Covering Mills	0.463	7.2	0.420	-45.7
Yarn and Thread Mills	0.610	41.2	0.586	-39.3
Miscellaneous Textiles	0.535	-40.3	0.560	-273.2
Men's and Boys' Suits	0.626	-278.7	0.681	-20.7
Men's and Boys' Furnishing	0.531	-1249.0	0.609	-92.7
Women's and Misses' Out.	0.562	-1013.9	0.600	-89.6
Women's, Children's Under.	0.543	-84.2	0.561	1.5
Hats, Caps, and Millinery	0.560	-2264.6	0.676	-12.4
Children's Outerwear	0.554	-100.2	0.607	-226.5
Fur Goods	0.491	-10.4	0.545	1.8
Misc. Apparel and Accs.	0.575	-497.8	0.612	-28.1
Misc. Fabricated Textile	0.574	176.7	0.594	35.7
Sawmills and Planing Mill	0.621	-1026.5	0.535	173
Millwork, Plywood, Struc.	0.643	-335.2	0.637	-272.2
Wood Containers	0.602	13.1	0.658	-169.6
Wood Buildings,Mobile Home	0.594	107.6	0.622	1.0
Misc. Wood Products	0.557	-445.8	0.587	-63.6
Household Furniture	0.583	N.A.	0.603	N.A.
Office Furniture	0.506	N.A.	0.528	N.A.
Public Bldg.,Related Furn.	0.585	N.A.	0.631	N.A.
Partitions and Fixtures	0.598	N.A.	0.607	N.A.
Misc. Furniture and Fixt.	0.541	N.A.	0.605	N.A.

Table 4.1 continued

Pulp Mills	0.383	0.2	0.418	-148.4
Paper Mills,Building Paper	0.467	-2595.8	0.534	-805.4
Paperboard Mills	0.481	1293.9	0.396	208.4
Misc. Converted Paper	0.418	480.1	0.465	86.9
Paperboard Cont. Boxes	0.597	134.1	0.606	21.9
Building Paper,Board Mills	0.605	-51.8	0.506	N.A.
Newspapers	0.527	-26.5	0.582	-0.6
Periodicals	0.295	161.7	0.372	72.6
Books	0.370	198.4	0.385	73.5
Misc. Publishing	0.420	N.A.	0.515	-14.7
Commercial Printing	0.617	92.1	0.647	52.4
Manifold Business Forms	0.427	4.3	0.476	N.A.
Greeting Card Publishing	0.362	4.2	0.454	-0.2
Blankbooks and Bookbinding	0.545	N.A.	0.640	-2.1
Printing Trade Services	0.624	7.3	0.722	N.A.
Industrial Inorganic Chem.	0.352	454.9	0.306	739.1
Plastic Materials, Syn.	0.403	4219.5	0.389	625.2
Drugs	0.306	674.9	0.260	232.3
Soaps, Cleaners, Toilet	0.201	536.5	0.195	105.8
Paints, Allied Products	0.366	213.4	0.416	50.9
Industrial Organic Chem.	0.290	4260.3	0.374	38.7
Agricultural Chem.	0.220	2365.9	0.311	111.4
Misc. Chemicals	0.348	513.6	0.441	209.3
Petroleum Refining	0.158	-11538.0	0.234	-550
Paving and Roofing Mat.	0.433	12.4	0.458	11.9
Misc. Petroleum,Coal Prod.	0.319	348.3	0.323	2.0
Tires and Inner Tubes	0.558	-746.3	0.496	-11.8
Rubber, Plastic Footwear	0.679	-489.7	0.667	-81.5
Reclaimed Rubber	0.459	-0.2	0.611	2.4
Rubber, Plastic Hose	0.872	117.5	0.607	N.A.
Fabricated Rubber	0.634	N.A.	N.A.	N.A.
Misc. Plastics	0.514	N.A.	0.538	N.A.
Leather Tanning	0.549	43.3	0.652	-26.1
Boot, Shoe Cut Stock	0.547	-72.7	0.596	-0.4
Footwear, Expt. Rubber	0.512	-2348.3	0.605	-171.5
Leather Gloves	0.731	-46.9	0.680	-27.3
Luggage	0.503	-222.2	0.568	-10.9
Handbags and Purses	0.589	-444.6	0.643	-62.1
Leather Goods	0.509	-43.9	0.631	-0.9

Table 4.1 continued

Flat Glass	0.613	118.1	0.539	-29.9
Glass	0.562	-88.5	0.511	56.3
Products of Glass	0.586	116.6	0.515	0.3
Cement, Hydraulic	0.417	-211.0	0.353	-10.2
Structural Clay	0.583	-97.0	0.626	5.5
Pottery	0.603	-632.2	0.661	-79.2
Concrete, Gypsum, Plaster	0.495	11.6	0.490	3.5
Cut Stone	0.609	-91.8	0.667	-13.3
Misc. Nonmetallic Miner.	0.461	336.0	0.528	52.8
Blast Furnace, Steel	0.713	-5380.6	0.580	-864.3
Iron, Steel Foundries	0.715	115.1	0.718	48.0
Primary Nonferrous Metals	0.423	-941.1	0.337	-1083.1
Secondary Nonferrous	0.455	-2672.5	0.510	N.A.
Nonferrous Rolling	0.522	1306.4	0.494	10.3
Nonferrous Foundries	0.654	N.A.	0.640	N.A.
Misc. Primary Metal	0.498	4.3	0.613	23.1
Metal Cans	0.418	N.A.	0.483	N.A.
Cutlery, Handtools	0.545	35.4	0.508	50.1
Plumbing, Heating	0.502	3.7	0.549	50.7
Fabricated Struc.	0.571	N.A.	0.609	209.9
Screw Machine, Bolts	0.579	-375.3	0.582	-15.3
Metal Forgings, Stamp	0.654	N.A.	0.637	201.0
Metal Services	0.559	N.A.	0.608	N.A.
Ordnance	0.657	N.A.	0.605	-31.2
Misc. Fab. Metal	0.533	-45.2	0.564	111.3
Engines, Turbines	0.534	2025.2	0.583	376.3
Farm, Garden Machinery	0.514	344.7	0.534	146.1
Construction Mach.	0.515	N.A.	0.560	N.A.
Metalworking Mach.	0.572	N.A.	0.621	226.3
Special Industry Mach.	0.598	379.4	0.606	N.A.
General Industry Mach.	0.560	2676.1	0.585	415.4
Office, Computing Mach.	0.482	N.A.	0.485	N.A.
Refrigeration	0.529	1730.9	0.500	362.2
Misc. Machinery	0.628	N.A.	0.625	N.A.
Electric Distributing	0.514	264.8	0.547	150.8
Elect. Industrial	0.555	1019.5	0.570	207.0
Household Appliances	0.462	N.A.	0.489	59.3
Elec. Lighting, Wiring	0.494	198.2	0.482	N.A.
Radio, TV Receiving	0.419	-3022.4	0.514	-397.6
Communication Equip.	0.584	87.3	0.699	299.1
Electronic Components	0.549	696.0	0.623	225.9
Misc. Elec. Equip.	0.549	912.1	0.545	22.1

Table 4.1 continued

Motor Vehicles	0.708	-13882.7	0.512	-65.8
Aircraft, Parts	0.598	N.A.	0.715	1737.3
Ship, Boat Building	0.760	526.0	0.806	56.8
Railroad Equipment	0.545	51.0	0.623	131.3
Motorcycles, Bicycles	0.543	-1516.8	0.573	-99.5
Guided Missiles, Space	0.637	N.A.	N.A.	N.A.
Transportation Equip.	0.605	404.7	0.605	-16.8
Engineering, Scien. Inst.	0.508	N.A.	0.583	132.8
Measuring, Controlling	0.576	N.A.	0.579	277.1
Optical Instruments	0.501	202.7	0.631	-29.2
Medical Instruments	0.483	682.0	0.489	113.3
Ophthalmic Goods	0.543	-174.3	0.554	-11.2
Photographic Equip.	0.314	612.3	0.375	192.9
Watches, Clocks	0.527	-941.5	0.595	-125.6
Jewelry, Silver	0.476	-1329.6	0.545	-122.2
Musical Instruments	0.614	36.6	0.667	-28.1
Toys, Sporting Goods	0.418	-1311.4	0.513	-117.3
Pens, Office, Art Goods	0.444	122.5	0.533	27.4
Costume Jewelry	0.542	-378.1	0.526	-83.3
Misc. Manufactures	0.558	83.3	0.568	N.A.
All Manufactures	0.543		0.471	

(a) Unit labor costs are defined as compensation/value added.

(b) Units for net trade are millions of dollars.

The Models

This section examines the effect of unit labor costs on the trade performance of manufacturing industries in a cross sectional model for 1967 and 1980. A double log form of the equation is used to obtain elasticities and because the Ricardian hypothesis traditionally has been tested that way. The equations are as follows:

$$X/M_i = A1 + A2\ L_i + U1_i \qquad (4.1)$$

$$\log(X/M)_i = B1 + B2\ \log(L)_i + U2_i \qquad (4.2)$$

Where

X/M = trade performance;

L = unit labor costs (total compensation/value added);

U1,U2 = error terms; and

i = industries (1,...,139).

The coefficients are

A1,B1 = intercept terms;

A2,B2 = sensitivity of trade performance to changes in unit labor costs. The expected sign of B2 is negative.

Table 4.2 OLS Results from the Cross-Sectional Data

1980 Results:

$$X/M = \underset{(2.18)}{6.70} - \underset{(4.17)}{8.34}\ L \qquad (4.11)$$

$R^2 = 0.04$ F-stat = 4.01 N = 112 D-W stat = 2.21

$$\log(X/M) = \underset{(0.36)}{-1.22} - \underset{(0.48)}{1.60}\ \log(L) \qquad (4.21)$$

$R^2 = 0.09$ F-stat = 11.10 N = 112 D-W stat = 1.93

1967 Results:

$$X/M = \underset{(6.31)}{16.54} - \underset{(11.58)}{21.20}\ L \qquad (4.12)$$

$R^2 = 0.03$ F-stat = 3.35 N = 115 D-W stat = 2.17

$$\log(X/M) = \underset{(0.45)}{-\ 0.90} - \underset{(0.63)}{1.51}\ \log(L) \qquad (4.22)$$

$R^2 = 0.05$ F-stat = 5.68 N = 115 D-W stat = 1.82

The statistical results indicate that unit labor costs were an important factor in explaining the trade flows of the U.S. during the two years examined.Although the R^2 was low in all regressions, the relationship between unit labor costs and trade performance was significant as indicated by the F-statistics. In addition, the coefficients of the explanatory variables were significant and of the correct sign.

The low R^2 are not a cause for concern since all the regression statistics were significant. Considering the multitude of factors affecting international trade flows, a low R^2 was not unexpected since only one explanatory variable was used - unit labor costs. The goal of the analysis was not to obtain high R^2, but instead to generate significant coefficients of the correct sign. In addition to these results, an alternate specification, based on Deardorff's model, is tested in Appendix C.

Analysis of U.S. Manufacturing Industries

This section analyzes the unit labor costs, which are presented in Table 4.1, of low, medium, and high technology manufacturing industries in the United States. The breakdown of industries into these three categories is based on Department of Commerce classifications.

Each industry's level of unit labor costs and its components, labor compensation and productivity, are examined in relation to the manufacturing average. If an industry's unit labor costs increases relative to other manufacturing industries, its trade position is expected to suffer. Since this study concentrates on supply side considerations, all deviations in an industry's trade position cannot be explained. Nevertheless, supply factors can explain a large portion of the trade flows.

Low Technology Industries

The low technology industries have been grouped into four major categories: agricultural-based manufacturing, traditional low technology products, forest products, and nonmetal products.

As shown in Table 4.1, the United States held a strong comparative advantage in 1967 and 1980, as approximated by unit labor costs, in the agricultural-based manufacturing industries, which consists of food products, beverages, and tobacco. They are generally characterized by high labor productivity and low compensation relative to all manufactures. The exception is the meat products industry, which displayed relatively low labor productivity levels and ranked 90 in 1980.

From 1967 to 1980, all U.S. agricultural-based manufacturing industries were able to strengthen their position with decreases in unit labor costs. These reductions stemmed from increases in labor productivity and decreases in compensation relative to the manufacturing average.

Despite lower unit labor costs, its trade position did not improve uniformly. Although grain mill products, fats and oils, and tobacco products showed a significant improvement, the dairy products, sugar, and beverage industries experienced a marked deterioration.

The United States held a comparative disadvantage in the production of traditional low technology products, which encompass textile, wearing apparel, leather products, and footwear. These industries have been grouped together because of similar cost structures and trade positions. Their cost structures are characterized by low levels of labor productivity and compensation relative to the manufacturing average and their trade flows are heavily regulated by multi- and bilateral trade agreements.

The United States was able to reduce its unit labor costs from 1967 to 1980 in the wearing apparel, leather products, and footwear by reducing labor compensation relative to all manufactures. In textiles, unit labor costs in the weaving mill and textile finishing industries were lowered, while those in wool weaving, yarn, thread, and floor covering mills increased.

The wearing apparel and footwear industries suffered trade deficits in 1967 and 1980. Except for children's outerwear products, the deficits increased between these two years even though unit labor costs decreased. Since supply considerations do not explain the trade patterns, trade restrictions and demand factors must be the prime determinants of trade flows in these commodities.

The forest products category consists of wood products, furniture, and paper products industries. All of these incur high transportation costs, which constricts trade flows and causes many of the products to be labeled nontraded goods.

In 1967 and 1980, the United States held a comparative disadvantage in the manufacture of wood products and furniture. The exception was office furniture, which ranked 52 in 1980. The cause for the low rankings were the low levels of labor productivity relative to all manufactures. Since many of the wood and furniture products are non-traded, changes in their unit labor costs are expected to have little effect on trade flows.

As shown in Tables 4.1 and II-B in the Appendix, the United States held a comparative advantage in the manufacture of paper products, with the exceptions of paperboard (ranking 108) and building paper (ranking 114). The high rankings were caused by high labor productivity relative to all manufactures. Except for paperboard mills, the paper products industries were able to reduce unit labor costs between 1967 and 1980. In response, their trade position improved. The exception was paper mills, which despite lower unit labor costs experienced a large increase in its trade deficit.

The nonmetal products classification consists of pottery and china, glass, and other nonmetal products. Generalizations regarding this classification are difficult because of the diversity of the industries.

The United States possessed a comparative disadvantage in the manufacture of pottery and china and glass products because of high unit labor costs. But whereas these were increased in the glass industry from 1967 to 1980, they were reduced in the the pottery and china industry. The latter recorded trade deficits in both years and despite reduction in unit labor costs from 1967 to 1980, its trade deficits mounted. Since its trade position was not responsive to supply considerations, demand factors are the major forces in determining trade flows.

The other nonmetal products industries exhibited widely varying unit labor costs. Unit labor costs were low for cement, concrete, and nonmetallic minerals and high for structural clay and cut stones. Since nonmetal products are subject to steep transportation costs, which cause them to be labeled nontraded goods, changes in unit labor costs in these industries would have little effect on their trade performance.

<u>Medium Technology Industries</u>

The medium technology industries are defined as iron and steel, nonferrous metals, metal products, energy, rubber, transport equipment (except for aircraft and guided missiles), and publishing.

The United States held a comparative disadvantage in the manufacture of rubber in 1967 and 1980. The exception was reclaimed rubber production, where low unit labor costs prevailed. Labor productivity was above average in the tire and reclaimed rubber industries, below average among the rest of the industries. The rubber industry's ranking experienced a significant reduction from 1967 to 1980 because of a decrease in labor productivity and an increase in compensation relative to all manufactures. The escalation of its unit labor costs led to a rapid deterioration in the industry's trade deficit.

In 1967, the United States held a comparative disadvantage in iron and steel foundries, and there were "moderate" unit labor costs in blast furnace steel production. By 1980, the latter was in a position of disadvantage because of escalations in labor compensation relative to all manufactures. These sharp increases aided in turning a small trade deficit in 1967 into a large deficit in 1980.

The United States held a comparative advantage in the primary and secondary nonferrous metals industries because of high labor productivity, and a comparative disadvantage in nonferrous foundries because of low labor productivity relative to all manufactures.

From 1967 to 1980, the primary nonferrous metals and rolling industries increased, while the secondary nonferrous metals decreased their unit labor costs. The response of trade flows to these changes was not consistent with the comparative costs theory, and thus demand is the important determinant of trade flows.

In 1967, the transport equipment category displayed consistently high unit labor costs with the exception of motor vehicles, where these were low. However, by 1980 unit labor costs had increased significantly in this sector so that the entire category possessed high unit labor costs. The sharp increase was reflected in trade position of the motor vehicle industry. In 1967 it registered a small deficit, but by 1980, this had swelled to record proportions.

The metal products industries have a heterogeneous cost structure. The manufacture of metal cans, plumbing materials, and heating equipment involves low unit labor costs while the opposite is true of screw machines and metal forgings. Overall these industries reduced their unit labor costs from 1967 to 1980, but for those for which dataare complete, their trade positions deteriorated. Thus, demand factors are the most important determinants of metal products' trade flows.

The United States held a comparative advantage in the publishing industries except for commercial printing (ranked 123) and printing trade services (ranked 124). All sectors reduced unit labor costs from 1967 to 1980, but since these industries generate low trade volumes, analysis of the category difficult.

The United States appeared to exhibit a comparative advantage in the energy industries that consists of petroleum refining and coal products. Because this category is overwhelmingly dominated by demand, which may distort the ranking, only a brief mention is made here.

The high rankings for the energy industries stem from the extraordinarily high values for labor productivity relative to the manufacturing average. But, despite displaying low unit labor costs, petroleum refining recorded large trade deficits in 1967 and 1980. Clearly, demand outweighed supply in the determination of trade flows because of the special position of petroleum in developed economies.

<u>High Technology Industries</u>

The high technology industries are defined as industrial chemicals, plastics, electrical machinery, office machinery, turbines, aircraft, and professional goods.

The United States held a comparative advantage in the production of industrial chemicals in 1967 and 1980. These sectors are characterized by high labor productivity relative to all manufactures. They were able to maintain their low unit labor costs from 1967 to 1980, with the agricultural chemical industry improving its ranking. Because of low unit labor costs, industrial chemical industries registered trade surpluses in 1967 and 1980. Due to a decline in its unit labor costs, agricultural chemicals significantly increased its trade surplus.

The United States held a comparative advantage in the manufacture of plastics in 1967 and 1980. This strong ranking is attributable to the high level of labor productivity in plastics relative to all manufactures. The industry sustained trade surpluses in both years because of low unit labor costs. With reductions in labor compensation, the plastics industry was able to decrease its relative unit labor costs and increase its trade surplus in 1980.

In 1967 and 1980, the United States held a comparative advantage in the manufacture of office and computing equipment and engines and turbines had moderate unit labor costs. These industries possessed high levels of labor productivity relative to the manufacturing average. In addition, each was able to decrease its unit labor costs from 1967 to 1980. Although trade data were not available for the office and computing equipment industry, the turbine industry registered a trade surplus in 1967 and 1980. With reductions in its cost structure, it was able to improve its trade position in 1980.

The electrical machinery industry encompasses products with varied unit labor costs. These are moderate in electrical distributing, industrial equipment, communications equipment, and electronic components, low for radio and T.V. receiving equipment. All were able to reduce unit labor costs from 1967 to 1980. Except for radio and T.V. equipment, the United States recorded a trade surplus in electrical machinery for 1967 and 1980. In conformity with the comparative costs theory, all industries except for the one noted, were able to improve their trade surpluses.

In 1967, the United States held a comparative disadvantage in manufacture of aircraft. The low ranking was caused by the high labor compensation relative to the manufacturing average. By 1980, aircraft reduced their unit labor costs with significant decreases in relative labor compensation and productivity. Although aircraft registered a surplus in 1967, trade data was not available for 1980, thus further conclusions are not possible at present.

The United States possessed a comparative advantage in the production of professional goods. The exception was measuring and controlling instruments industry, which ranked 99 by unit labor costs. The high levels of labor productivity contributed to the strong ranking of these industries. This ranking was preserved from 1967 to 1980, with the engineering, scientific, medical, and optical instruments industries reducing their unit labor costs.

Professional goods registered a trade surplus in 1980. With reductions in their unit labor costs, the optical and medical instruments industries were able to improve their trade positions.

Conclusion

The statistical results indicated that unit labor costs were an important factor in explaining the trade flows of the United States during the two years examined. Although the R^2 was low in all regressions, the coefficients were significant and had the correct sign.

The results of the rankings by unit labor costs for 1967 and 1980 indicated that the United States held a comparative advantage in manufacture of agricultural manufacturing products, paper products, nonferrous metals, publishing, industrial chemicals, plastics, office and computing equipment, and professional goods. The United States held a comparative disadvantage in traditional low technology products, wood products, furniture, pottery, glass, rubber, iron and steel, and most transport equipment.

Iron and steel, rubber, and transport were the only industries to decline significantly in ranking from 1967 to 1980. This was reflected in the large trade deficits they incurred. In contrast, the aircraft, agricultural chemicals, and professional goods industries decreased their unit labor costs and resulted in improvements in their trade position. But all industries did not conform to comparative cost theory. The trade position of some industries was not affected by supply but instead dominated by demand factors, trade restrictions, and transportation costs. Nevertheless, supply considerations did explain a large portion of the trade flows.

CHAPTER V

CROSS-SECTIONAL AND TIME SERIES EVIDENCE FOR THE UNITED STATES, JAPAN, AND EUROPE

This chapter investigates the effect of unit labor costs on trade flows for the period 1967-1981 in the United States, Japan, and three European countries: Germany, the United Kingdom, and Italy. The first part examines unit labor costs and trade positions of manufacturing industries and develops a cross-sectional model correlating them at two points, 1967 and 1980. The second part analyzes time series data to determine the effect of changes in labor productivity and compensation on the trade performance of individual industries. In addition, all the time series and cross-sectional data, combined with dummy variables, are "pooled" into one equation to remove the biases of trade discrimination and exchange rate changes over time on trade performance.

The only consistent unit labor cost data available for Japanese and European manufacturing industries are categorized by the three-digit International Standard Industrial Classification (ISIC). The ISIC breakdown provides data for 28 manufacturing industries, and it is more aggregated than the SIC breakdown for the United States used in the previous chapter. The problems stemming from the aggregation are discussed in the data section.

Data

German, Japanese, Italian, and British data for labor compensation, value added, and total employees at the three-digit ISIC breakdown were obtained from the United Nations, Yearbook of Industrial Statistics. Italian, British, and German data for 1967 were incomplete. Additional statistics were drawn from the Statistisches Bundesant, Statistisches Jahrbush für die Bundesrepublik Deutschland.

Japanese, German, Italian, and British data for export and import values by two- to four-digit Standard International Trade Classification (SITC) breakdown were collected from the United Nations, Commodity Trade Statistics. The OECD exports are from Trade by Commodities Market Summaries: Exports, series C.

All data were rearranged to conform to the three-digit ISIC breakdown. A table of concordance from SITC to ISIC breakdown is provided in the United Nations, Proceedings of the United Nations Conference on Trade and Development. Additional information is contained in Farhang Niroomand's thesis: Determinants of the Structure of U.S. Foreign Trade in Manufactures: 1963-1980.

A major problem with the ISIC data is its presentation. Low technology industries, such as glass, leather, and footwear, where trade flows are small (partly because of trade restrictions), are presented in a disaggregated form. The trade restrictions are in the form of tariffs and quotas, which are governed by multi- and bilateral agreements.

In contrast, high technology industries, such as machinery and transport equipment, where large trade flows occur, are highly aggregated. For example, the machinery industry consists of such diverse categories as lawn and garden equipment, refrigeration, and laundry equipment, as well as electronic computing equipment, turbines, and oilfield machinery. Lawn and garden equipment and similar categories employ low to medium technologies, while electronic computing uses high technology.

The same problem is true for transport equipment, which consists of such medium technology industries as motor vehicles, ship building, and railroad equipment, as well as the high technology industries of aircraft, guided missiles, and space vehicles. The aggregation of medium and high technology industries makes definitive conclusions impossible because of diverse cost structures. Nevertheless, consistent trends and broad conclusions may still be obtained.

Tables 5.1-5.4, presented at the end of the chapter, show unit labor costs and net trade positions of manufacturing industries in the United States, Japan, and three European countries for 1967 and 1980. The former represents the first year examined in the time series analysis, while the latter is the last year for which ISIC data were available for all the countries. The complete tables, including the breakdown of unit labor costs, are presented in the Appendix.

The Cross-Sectional Models

This section examines the effect of unit labor costs on trade performance in a cross-sectional model. Four alternative specifications, including the double log form, of the comparative cost model were developed. The use of export shares has been employed in the "revealed comparative advantage" literature and is used in equations 5.3 and 5.4 as an alternative specification of trade performance. The equations are judged on their ability to generate significant coefficients of the correct sign, and the R^2 are not an integral part of the analysis. The equations whose complete results are presented in the Appendix are as follows:

$$(X/M)_{in} = A1_n + A1_n L_{in} + U1_n; \qquad (5.1)$$

$$\log(X/M)_{in} = B1_n + B2_n \log(L)_{in} + U2_n; \qquad (5.2)$$

$$(Xs)_{in} = C1_n + C2_n L_{in} + U3_n; \qquad (5.3)$$

$$\log(Xs)_{in} = D1_n + D2_n \log(L)_{in} + U4_n; \qquad (5.4)$$

The additional variables are:

Xs = country's share of total OECD exports (exports/total OECD exports);

i = industries = 1,...,28;

n = countries = 1,...,5 = United States, Germany, Japan, United Kingdom, and Italy.

Considering the distorting effects of differential trade restrictions in a cross-sectional model, most of the models performed well. The dependent variable expressed as a ratio between exports and imports, as in equations 5.1 and 5.2, obtained significant coefficients of the correct sign for unit labor costs for the United States, Germany, and Great Britain. Italy generated correct signs, but they were not significant. Japan consistently obtained a positive sign regardless of the specification for 1967 and 1980, with a significant coefficient for 1967. The implication is that trade restrictions and demand considerations were more important than supply in explaining trade flows in the two years for Japan.

The dependent variable expressed as an industry's export share of total OECD exports, as in equations 5.3 and 5.4, did not perform well. Japan and Germany generated positive coefficients; Italy's were insignificant. Since only exports were explicitly represented in this variable, import-competing industries are underrepresented. Thus this variable is not as well specified as the ratio of exports to imports.

The equations in log linear form did not perform significantly different from the standard form. They do yield elasticities and provide an indication of the responsiveness of a country's trade flow to changes in unit labor costs.

In addition, the Spearman rank correlation coefficients between unit labor cost rankings and export share rankings were estimated. The advantage of nonparametric tests is that they are less restrictive in their assumptions; however, their power is low in comparison with parametric tests. Because of this, the Spearman rank correlations did not provide any additional definitive insights and their results are not reported here.

The conclusion is that the examination of unit labor costs provides important information for policy makers who are concerned with the trade balance of a particular industry. That balance can be improved either by lowering labor compensation or by increasing labor productivity.

Time Series Evidence for the United States

This section analyzes the effect of changes in labor productivity and compensation on U.S. trade performance. The absolute and relative versions of the comparative cost theory are tested in the models below. The absolute version (equations 5.5 and 5.6) correlates changes in the components of unit labor costs with trade performance. By contrast, the relative version (equations 5.7 and 5.8) correlates changes in the components of unit labor costs as a ratio of all manufactures with trade performance. Both versions are estimated in double logarithmic form to obtain elasticities for the explanatory variables. Unit labor cost could not be used as an explanatory variable because it requires too many restrictions on estimation and makes interpretation of the results impossible. [1]

Equations 5.7 and 5.8 are closer to the comparative cost theory as reformulated by Kreinin and the _a priori_ expectations are that equations 5.7 and 5.8 will generate more significant coefficients of the correct sign. The equations whose complete results are presented in the Appendix are as follows:

$$(X-M)_{it} = A1_i + A2P_{it} + A3W_{it} + U1_i; \qquad (5.5)$$

$$\log(X/M)_{it} = B1_i + B2\log(P)_{it} + B3\log(W)_{it} + U2_i; \qquad (5.6)$$

$$(X-M)_{it}/[\text{sum}(X-M)_i]_t = C1_i + C2[P_{it}/(\text{sum}P_i)_t] + C3[W_{it}/(\text{sum}W_i)_t] + U3_i; \qquad (5.7)$$

$$\log[(X/M)_{it}/(\text{sum}X_i/\text{sum}M_i)_t] = D1_i + D2\log[P_{it}/(\text{sum}P_i)_t] + D3\log[W_{it}/(\text{sum}W_{it}/(\text{sum}W_i)_t] + U3_i. \qquad (5.8)$$

The additional variables are:

P = labor productivity per employee in each U.S. industry (value added/employee);

W = labor compensation per employee in each U.S. industry (total compensation/employee).

The additional coefficients are:

A2,B2 C2,D2 = sensitivity of export performance to changes in labor productivity; the expected sign of B2 is positive;

A3,B3 C3,D3 = sensitivity of export performance to changes in labor compensation; the expected sign of B3 is negative.

Productivity per employee in each industry is expected to be positively correlated with export performance since increases in productivity improve an industry's ranking by comparative advantage. Compensation per employee is expected to be negatively correlated with export performance because increases in compensation erode an industry's ranking. The magnitude s of the coefficients are interpreted as elasticities and may be useful for policy decisions.

In general, equations 5.5 and 5.6 performed poorly, as expected, in explaining U.S. trade performance. Equation 5.5 yielded the expected signs for labor productivity in nine cases, but only three were significant. The expected sign was produced in twelve cases for compensation, half of which were significant. Equation 5.6 yielded the expected signs for labor productivity in twelve cases, five of which were significant, and in eleven cases for compensation, five of which were significant. Both equations generally produced high R^2s.

When estimating relative changes in labor productivity and labor compensation, as in equation 5.7, the results performed markedly better. Equation 5.7 yielded the expected signs for labor productivity in nineteen cases, seven of which were significant. The expected sign was produced in twenty-two cases for compensation, ten of which were significant. The logarithmic form did not perform as well as equation 5.7, but it did yield better results than either of the absolute versions. Equation 5.8 yielded the expected signs for labor productivity in half cases, half of which were significant, and in fifteen cases for compensation, seven of which were significant.

A statistical problem present in all the equations is the existence of multicollinearity, since labor compensation is a function of labor productivity, these two variables are correlated. Nevertheless, although some individual industry equations were sensitive to multicollinearity and produced inconsistent results, it was not a restricting problem in general. Despite these statistical difficulties, the relative version of the comparative cost theory performed well.

Pooling Models and Time Effects

Stryker was one of the first to use a time series approach within a comparative cost framework. His method, in a limited way, solved the problem of trade restriction biases. If these restrictions are constant between periods, changes in trade performance are not influenced by differential trade restrictions among industries. Unfortunately, trade restrictions did change within the period studied, and adjustments had to be made to correct for the distortions.

This section attempts to solve the problem with the use of a panel data model, which pools all time series and cross-sectional data along with dummy variables into one equation. The dummy variables portion can correct for distortions over time and thus are called time effects in the literature. [2] The time effects variables in the panel data model captures changes in differential trade restrictions among industries and exchange rate changes over time without distorting the relationship between the explanatory variables and trade performance. The importance of time effects in modeling trade flows is illustrated in Figure 5.1 and 5.2, using unit labor costs as an explanatory variable, *ceteris paribus*.

Figure 5.1. Correlation without Time Effects

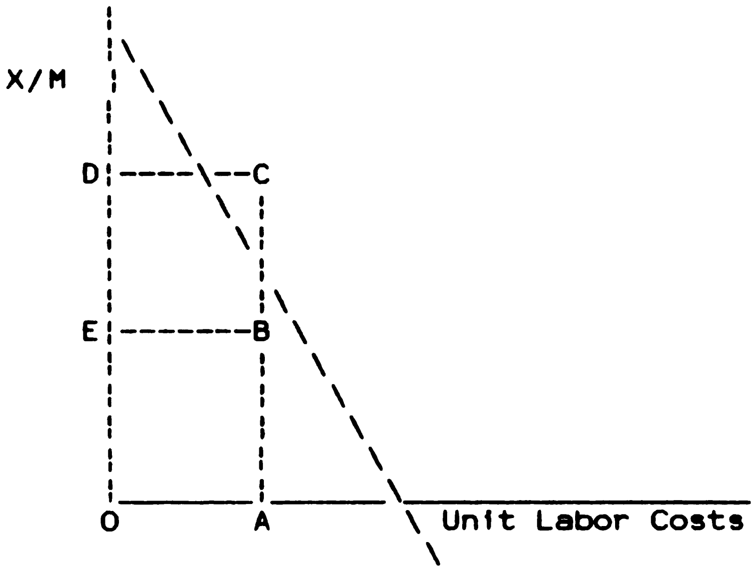
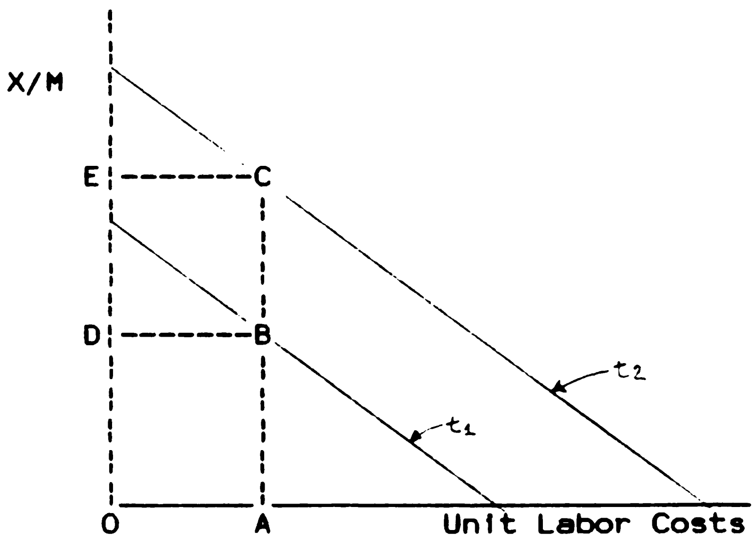


Figure 5.2. Correlation with Time Effects



In time 1, X/M = AB = OE, labor costs = OA. In time 2, X/M = AC = OD, unit labor costs = OA, where X/M = trade performance, t = time periods.

If a decrease in trade restrictions or exchange rate occurs in time period 2, trade performance (X/M) would increase from OE to OD without a change in unit labor costs. If a regression without the time effects (Figure 5.1) were to be estimated, an upward bias would occur in the slope coefficient. If time effects are included (Figure 5.2), a change in trade restrictions would be totally reflected in a change in the intercept, not the slope. Thus this process would yield a lower slope coefficient, and, as expected, lower trade restrictions would be responsible for the increase in trade performance of OD-OE.

The models are:

$$\log(X/M)_{it} = C1 + C2\ \log(P)_{it} + C3\ \log(W)_{it} + Q1\ V_{it} + \ldots + QjV_{it} + U1_t; \quad (5.9)$$

$$\log(X/M)_{it} = C1 + C2\log(P)_{it} + C3\log(W)_{it} + U2_t. \quad (5.10)$$

The additional variables and coefficient are:

j = $t-1 = 1,\ldots,14$;

V = time effects to capture changes in trade discrimination; set of t-1 dummy variables. $V_{it} = \{ 1 \text{ if } i = t,\ 0 \text{ if } i \neq t \}$;

Q = coefficients for the set of dummy variables; adjustment to the intercept term.

The panel data models were estimated with OLS. The time effects in equation 5.9 were assumed to be fixed, which is the least restrictive assumption, and the estimates of the coefficient are consistent since t is large. [3] The results for equation 5.9 are as follows:

$$\log X/M = \underset{(0.53)}{-3.89} + \underset{(0.21)}{1.11}\log P - \underset{(0.40)}{0.43}\log W - \underset{(0.44)}{1.93}V1 - \underset{(0.42)}{1.72}V2$$

$$- \underset{(0.41)}{1.71}V3 - \underset{(0.40)}{1.69}V4 - \underset{(0.39)}{1.50}V5 - \underset{(0.38)}{1.28}V6 - \underset{(0.37)}{1.02}V7$$

$$- \underset{(0.36)}{1.03}V8 - \underset{(0.35)}{0.99}V9 - \underset{(0.35)}{0.95}V10 - \underset{(0.35)}{0.73}V11$$

$$- \underset{(0.34)}{0.45}V12 - \underset{(0.34)}{0.33}V13 - \underset{(0.34)}{0.23}V14$$

(Standard errors in parentheses)

$R^2 = 0.20$ F-stat = 6.45 D-W stat = 2.75 N = 420.

The signs of both the explanatory variables are as expected, but the coefficient for total compensation per employee is not significant at the 95 percent confidence level. In addition, the coefficients of the dummy variables decrease in value over time. One explanation is that trade restrictions have become less influential on trade flows; the second is that trade flows have trended upward over time. [4]

The results of equations 5.10 without the dummy variables are as follows:

$$\log X/M = - \underset{(0.33)}{1.79} + \underset{(0.19)}{1.22}\log P - \underset{(0.26)}{0.93}\log W$$

$R^2 = 0.14$ F-stat = 34.30 D-W stat = 2.42 N = 420.

All the signs were correct, and the explanatory variables are significant. The main difference between equations 5.9 and 5.10 is that W is not significant when dummy variables are included and is significant when they are omitted. One explanation is that wages are correlated with the time trend; since time trends are eliminated with the panel data model, wages become insignificant. Another explanation is that since cross-sectional variations drive the panel data model with time effects, and cross-sectional variations in labor compensation between industries are small, the coefficient would be insignificant.

Conclusion

The statistical results obtained in this chapter confirm the importance of unit labor costs as a determinant of international trade patterns. The cross-sectional model produced significant results of the correct sign for all the countries except Japan, which generated a positive sign for unit labor costs in 1967 and 1980.

For the time series model, correct signs for labor compensation and productivity were produced for two-thirds of the industries when using the relative version of the comparative cost theory. Finally, the panel data model removed the biases of changes in differential trade restrictions and exchange rates and generated positive results based on all available data for the U.S. economy over the period 1967 to 1981.

This evidence establishes the importance of considering the performance of unit labor costs in the formation of policy for industries suffering from international competition. In order for an industry to improve its ranking and strengthen its trade position, it must increase labor productivity and decrease compensation. The performance of the unit labor costs of individual industries based on the empirical evidence gathered here is presented in the next chapter.

TABLE 5.1 U.S. Unit Labor Costs and Trade Position,

1967 and 1980

INDUSTRY	UNIT LABOR COSTS a		X-M b	
	1967	1980	1967	1980
Food Products	0.384	0.377	-376.4	3673.2
Beverages	0.344	0.352	-565.9	-2422.2
Tobacco	0.187	0.220	151.0	1051.7
Textiles	0.536	0.553	-740.4	-1462.7
Wearing Apparel	0.558	0.555	-708.8	-6634.0
Leather and Products	0.570	0.550	-174.7	-984.7
Footwear	0.549	0.515	-260.5	-2763.4
Wood Products	0.574	0.589	-506.6	-817.4
Furniture, Fixtures	0.555	0.569	-76.1	-722.5
Paper and Products	0.455	0.478	-573.6	-985.7
Printing, Publishing	0.498	0.494	184.7	630.2
Industrial Chemicals	0.293	0.461	1665.7	10689.7
Other Chemical Products	0.365	0.279	694.8	2639.1
Petroleum Refineries	0.203	0.158	-626.5	-12952.3
Petroleum, Coal Product	0.368	0.389	N.A.	481.6
Rubber Products	0.483	0.624	-47.0	-992.6
Plastic Products n.e.c.	0.485	0.514	60.1	859.1
Pottery, China, etc.	0.595	0.603	-96.0	-677.6
Glass and Products	0.461	0.573	-7.4	-65.4
Nonmetal Products n.e.c.	0.448	0.482	19.1	125.8
Iron and Steel	0.522	0.714	-1519.0	-9475.1
Nonferrous Metals	0.444	0.511	1305.8	-3356.3
Metal Products	0.516	0.565	642.3	2096.3
Machinery n.e.c.	0.511	0.541	4161.6	25205.7
Electrical Machinery	0.526	0.540	445.2	-999.6
Transport Equipment	0.538	0.656	1232.6	-634.3
Professional Goods	0.452	0.456	529.5	2648.6
Other Industries	0.501	0.495	-481.3	-4143.9
All Manufactures	0.471	0.543		

(a) Unit labor costs are defined as compensation/value-added.

(b) Units for net trade are millions of dollars.

TABLE 5.2 Japanese Unit Labor Costs and Trade Position, 1967 and 1980

INDUSTRY	UNIT LABOR COSTS a		X-M b	
	1967	1980	1967	1980
Food Products	0.304	0.336	126.78	-762.69
Beverages	0.198	0.224	-4.13	-206.56
Tobacco	0	0	-6.68	-57.87
Textiles	0.371	0.439	1239.88	2762.71
Wearing Apparel	0.418	0.526	319.65	-1049.07
Leather and Products	0.383	0.456	36.71	0.48
Footwear	0.393	0.463	97.45	-215.23
Wood Products	0.391	0.444	2.48	-7953.21
Furniture, Fixtures	0.427	0.418	16.61	-73.28
Paper and Products	0.320	0.359	-44.54	-716.54
Printing, Publishing	0.375	0.403	-0.24	1.72
Industrial Chemicals	0.187	0.254	234.80	1577.97
Other Chemical Products	0.188	0.193	-161.08	-887.15
Petroleum Refineries	0.109	0.084	-749.39	-6427.01
Petroleum, Coal Products	0.267	0.204	N.A.	-12089.54
Rubber Products	0.322	0.391	107.74	1743.82
Plastic Products n.e.c.	0.338	0.370	48.24	117.61
Pottery, China, etc.	0.453	0.466	94.95	517.76
Glass and Products	0.254	0.298	42.40	127.55
Nonmetal Products n.e.c.	0.301	0.319	82.78	714.41
Iron and Steel	0.299	0.271	903.31	14560.40
Nonferrous Metals	0.282	0.272	-483.88	-2569.42
Metal Products	0.379	0.407	383.49	3541.10
Machinery n.e.c.	0.359	0.399	308.36	16330.09
Electrical Machinery	0.312	0.372	964.11	19035.22
Transport Equipment	0.316	0.379	1573.19	32114.97
Professional Goods	0.417	0.445	292.51	4749.72
Other Industries	0.355	0.414	546.77	1917.62
All Manufactures	0.319	0.355		

(a) Unit labor costs are defined as compensation/value-added.

(b) Units for net trade are in millions of dollars.

TABLE 5.3 German Unit Labor Costs and Trade Performance, 1967 and 1980

INDUSTRY	UNIT LABOR COSTS a	X-M b	
	1980	1980	1967
Food Products	0.290	-1696.34	-332.30
Beverages	0.317	-602.36	-68.30
Tobacco	0.060	247.63	20.98
Textiles	0.641	-898.08	94.97
Wearing Apparel	0.498	-5444.13	-178.34
Leather, Footwear, etc.	0.534	-2768.74	-83.11
Wood, Furniture, etc.	0.471	-1689.58	-71.50
Paper and Products	0.580	-1847.18	-329.28
Printing, Publishing	0.585	891.65	102.07
Industrial Chemicals	0.538	11004.29	1763.83
Petroleum Refineries	0.061	-10217.00	155.59
Rubber Products	0.592	172.69	47.27
Plastic Products n.e.c.	0.549	645.39	54.24
Pottery, China, etc.	0.441	95.29	48.53
Glass and Products	0.531	151.27	72.89
Nonmetal Products n.e.c.	0.405	270.87	56.94
Iron and Steel	0.519	4818.90	1024.66
Nonferrous Metals	0.824	-1185.28	-445.50
Metal Products	0.626	3230.25	678.89
Machinery n.e.c.	0.625	25470.81	3800.80
Electrical Machinery	0.560	5441.31	1203.89
Transport Equipment	0.578	19460.68	2276.49
Professional Goods	0.461	1784.72	403.80
Other Industries	0.481	-194.74	305.01
All Manufactures	0.495		

(a) Unit labor costs are defined as compensation/value-added

(b) Units for net trade are in millions of dollars.

TABLE 5.4 U.K. and Italian Unit Labor Costs and Trade Performance for 1980

INDUSTRY	UNIT LABOR COSTS a		X-M b	
	U.K	ITALY	U.K.	ITALY
Food Products	0.469	0.447	-2452.32	468.18
Beverages	0.303	0.360	1067.11	718.59
Tobacco	0.320	0.749	569.82	-314.65
Textiles	0.704	0.559	-559.71	-51.87
Wearing Apparel	0.729	0.582	-979.32	3786.70
Leather and Products	0.637	0.481	0.13	524.04
Footwear	0.674	0.586	-518.61	3478.14
Wood Products	0.581	0.483	-2208.82	-2075.83
Furniture, Fixtures	0.641	0.493	-101.26	2043.22
Paper and Products	0.594	0.499	-2755.50	-1056.91
Printing, Publishing	0.517	0.570	441.97	427.60
Industrial Chemicals	0.461	0.475	1722.71	-2537.75
Other Chemical Products	0.350	N.A.	3265.02	N.A.
Petroleum Refineries	0.082	0.032	85.90	-2890.81
Petroleum, Coal Products	0.361	N.A.	-1031.18	N.A.
Rubber Products	0.590	0.618	376.53	133.80
Plastic Products n.e.c.	0.551	0.756	-23.15	475.44
Pottery, China, etc.	0.661	N.A.	256.07	N.A.
Glass and Products	0.592	N.A.	15.80	N.A.
Nonmetal Products n.e.c.	0.392	0.471	39.82	2189.95
Iron and Steel	0.843	0.498	-1074.85	-336.01
Nonferrous Metals	0.584	0.615	-1657.47	-2326.37
Metal Products	0.615	0.543	1044.13	2318.24
Machinery n.e.c.	0.567	0.543	8324.39	6238.49
Electrical Machinery	0.590	0.614	402.01	-109.44
Transport Equipment	0.730	0.638	525.14	-912.72
Professional Goods	0.595	0.541	166.36	-891.99
Other Industries	0.538	0.547	-321.38	1764.24
All Manufactures	0.553	0.537		

(a) Unit labor costs are defined as compensation/value-added.

(b) Units for net trade are in millions of dollars.

Footnotes

[1] If unit labor costs were to be used in equation 5.5 and 5.6, one restriction would apply: that the coefficient of W be negative. But in the estimation of 5.7 and 5.8, three restrictions are necessary, causing the expected sign for unit labor costs to be positive and making the results tenuous.

[2] For more on "pooling" or panel data models, see Kmenta (1972) and Judge et al. (1980).

[3] The fixed effects model does not make any specific assumptions about the distribution of the time effects. In addition, correlation between the time effects (changes in exchange rates and differential trade restrictions) and the explanatory variables does not bias the results. The "within" estimator used in the regression analysis of the panel data with time effects (OLS on P, W, and V) is consistent as n or t becomes large. See Judge et al. (1980, pp. 328-31, 336-38).

[4] The hypothesis that V1 = V2 = ... = V14 can be tested using a joint F test comparing the restricted and unrestricted residual sum of squares. It is obvious in the present case that the hypothesis is rejected.

CHAPTER VI

ANALYSIS OF INDUSTRIES

This chapter integrates the analysis of Chapter V by examining the performance of unit labor costs for individual manufacturing industries in the United States, Japan, Germany, Italy, and Great Britain. The industries are categorized by low, medium, and high technology, based on U.S. Department of Commerce definitions and similar to the classification used in Chapter IV.[1] Each industry's level of labor productivity, labor compensation, and unit labor costs is examined as a ratio to the manufacturing average for each country. The relative unit labor costs can then be compared between countries to determine comparative advantage, and industries with a comparative advantage are expected to have a trade surplus.

Agricultural Manufacturing

Tables 5.1-5.4 show that all the countries ranked high by unit labor costs in food products. The U.S. ranking was 7 in 1967 and 5 in 1980, Japan ranked 10 in both 1967 and 1980, during which time its costs of production remained stable. The food products industry in Germany and Italy ranked 3 by unit labor costs in 1980, while Britain ranked 8.

From 1967 to 1980, the U.S. food products industry strengthened its position by increasing labor productivity and decreasing compensation relative to all manufactures. In response, the U.S. trade position improved. U.S. food products registered a trade deficit in 1967 but recorded a surplus in 1980. Given the time series evidence in Chapter V, U.S. food products' trade balance is sensitive to changes in unit labor costs. The conclusion is that the U.S. food products industry improved its trade balance by reducing its unit labor costs.

Each of the countries examined ranked high in the beverage industry category. The U.S. and Japanese industries ranked 4 by unit labor costs in 1967 and 1980, Germany ranked 4 in 1980, while Britain and Italy ranked 2. Still, U.S. beverages registered trade deficits in 1967 and 1980. Although the industry decreased its unit labor costs by increasing relative productivity, its trade position deteriorated between the two periods. The time series evidence suggests that the U.S. beverage industry's trade position was not sensitive to changes in unit labor costs. Thus, demand factors and trade restrictions were responsible for the deterioration in its trade balance.

The United States, Germany, and Britain held a comparative advantage in the tobacco industry. The U.S. tobacco industry ranked 1 by unit labor costs in 1967 and 2 in 1980, Germany ranked 1 in 1980, and Britain ranked 3. All of these high rankings due to high productivity levels, resulting in large trade surpluses for each country. In contrast, the Japanese and Italian tobacco industries are very small. Japan ranked last by unit labor costs in both 1967 and 1980, while Italy ranked last in 1980. There was no value added in the Japanese tobacco industry, and the average wage per employee was high relative to the manufacturing average.

Traditional Low Technology Industries

Tables IV-B to VIII-B show that the traditional low technology industries are characterized by low levels of labor productivity and compensation relative to the manufacturing average within each country. The United States was able to reduce its unit labor costs and improve its ranking in each of the traditional low technology industries because of reductions in labor compensation relative to all manufactures. Nevertheless, neither the United States, Japan, Germany, nor Britain ranked high by unit labor costs in textiles, wearing apparel, or leather. Italy exhibited a comparative advantage in the leather products industry, which ranked 6 in 1980.

While no country ranked high in footwear, the United States enjoyed a decided cost advantage. This was primarily because of the low level of compensation in U.S. footwear relative to all manufactures. Although the United States recorded trade deficits in all the traditional low technology industries, performance varied among industries. In textiles, the United States recorded trade deficits in 1967 and 1980, and by keeping its relative unit labor costs stable between the two years, the industry's trade deficit remained constant.

U.S. wearing apparel and leather sustained large trade deficits in both 1967 and 1980. In contrast, U.S. footwear registered only a small trade deficit in 1967 but a large one in 1980. Although U.S. wearing apparel, leather, and footwear were able to lower their relative unit labor costs from 1967 to 1980, their trade position deteriorated. Since the trade positions of these sectors did not improve with lower unit labor costs, trade restrictions and demand factors were responsible for the distortion of these industries' trade patterns.

Forest Products

Tables 5.1-5.4 show that Germany and Italy held a comparative advantage in the manufacture of wood products and furniture, while the United States and Japan displayed a comparative disadvantage. U.S. wood products ranked 27 by unit labor costs in 1967 and 24 in 1980, Japan ranked 22 in 1967 and 1980. The German wood products and furniture industry ranked 8 by unit labor costs in 1980; Britain's ranked 13 and Italy's 7.

The strong positions of Germany and Italy in wood products was due to their high labor productivity. Nevertheless, both generated large trade deficits in wood products for 1980 despite their low unit labor costs. But since there is relatively little trade in wood products, changes in its unit labor costs have little effect on trade flows. U.S. wood products sustained trade deficits in 1967 and 1980. Despite lowered unit labor costs, the wood products trade balance did not change significantly.

Italy held a comparative advantage in the furniture industry, resulting in a trade surplus. In contrast, the United States, Japan, and Britain held a comparative disadvantage. Their high unit labor costs were caused by low labor productivity relative to all manufactures. The U.S. furniture industry ranked 24 by unit labor costs in 1967 and 22 in 1980, Japan ranked 26 in 1967 and 20 in 1980, Britain's ranked 22 in 1980, and Italy's 8.

The furniture industry is characterized by low labor productivity relative to the manufacturing average. The United States, Japan, and Britain had high levels of labor compensation relative to productivity, resulting in high unit labor costs. The U.S. furniture industry suffered trade deficits in 1967 and 1980, although the industry was able to lower its relative unit labor costs between 1967 and 1980, its trade position deteriorated over the period.

Tables 5.1-5.4 show that the United States displayed a comparative advantage in the paper industry, and because of increased productivity its cost advantage over the other countries widened. The U.S. paper industry ranked 11 by unit labor costs in 1967 and 9 in 1980; Japan ranked 13 in 1967 and 11 in 1980, Germany's industry ranked 18 in 1980, Britain's 18, and Italy's 16. The U.S. paper industry registered trade deficits in both years despite its comparative advantage. Since relative unit costs were reduced during this period with no improvement in the paper industry's trade position, demand had to play the major role in determining trade flows.

Nonmetal Products

Germany and Italy held a comparative advantage in the pottery and china industry, while the United States and Japan had a comparative disadvantage. The U.S. pottery and china industry ranked 28 by unit labor costs in 1967 and 25 in 1980; the comparable figures for Japan were 26 and 27. The industry in Germany ranked 6 in 1980, in Britain 23, and in Italy 4. Although labor productivity in this sector was relatively low in all the countries, German and Italian labor productivity was high relative to its compensation. This resulted in low unit labor costs and a strong trade surplus for both countries.

The U.S. pottery and china industry recorded trade deficits in 1967 and 1980. Despite reducing relative unit labor costs between the two years, the pottery industry's trade position did not improve. Since the industry's trade position was not responsive to supply considerations, demand factors and trade restrictions were the major forces in determining trade flows.

Japan displayed a comparative advantage in the glass industry, which ranked 5 in 1967 and 8 in 1980. The high ranking was due to high productivity relative to the manufacturing average. Japan was able to translate its relative cost advantage in glass manufacturing into a strong trade surplus.

The U.S. glass industry's unit labor costs increased between 1967 and 1980, thus reducing its ranking from 12 in 1967 to 23 in 1980. The U.S. glass industry recorded trade deficits in both years, and in conformity with the comparative cost theory, its trade position deteriorated.

The United States, Japan, Germany, and Britain ranked high in other nonmetal products. U.S. nonmetals ranked 9 by unit labor costs in 1980 and 10 in 1967; for Japan the ranking was 9 in both years; Germany ranked 5 in 1980, Britain 6. U.S. nonmetal products recorded trade surpluses in 1967 and 1980. Since its relative unit labor costs remained stable during this period, the industry's trade position also remained stable.

<u>Medium Technology Industries</u>

Medium technology manufacturing has been defined as the iron and steel, nonferrous metals, metal products, energy, rubber, transport equipment, and publishing industries. A problem exists with the aggregation of categories. For example, the transport equipment classification consists of medium and high technology industries, whcin means that only broad conclusions can be drawn. Another problem is the inclusion of the energy classification, dominated by demand factors which lead to extraordinarily high values for labor productivity, thus distorting the analysis.

Iron and Steel

The U.S. iron and steel industry has experienced increasing pressure from international competition over the past twenty years (Kreinin, 1984). The main factors responsible for the decline in U.S. competitiveness were rapid escalation of labor compensation relative to the manufacturing average and slow adaptation of new technologies, leading to declines in relative productivity. Both factors increased iron and steel's relative unit labor costs, thus reducing its internal ranking and international competitiveness.

An indication that new technologies were not adopted in the iron and steel industry are estimates that less than 30 percent of U.S. steel was continuously cast in 1983, vs. 90 percent of Japanese steel. The continuous casting process turns out a single strand of molten metal for simultaneous rolling, thereby eliminating ingot casting, reheating and trimming.

Imported tonnage accounted for 22 percent of total U.S. steel sales in 1982. Although most of this was imported from Japan and Europe, an increasing amount coming from such Third World producers as Brazil, South Korea, Mexico, Taiwan, and Trinidad and Tobago. After European and Japanese producers agreed in 1982 to limit steel exports to the United States, developing countries quickly increased their exports.[2]

Tables 5.1-5.4 show that Japan and Germany held a comparative advantage in iron and steel production, while the United States and Britain had a comparative disadvantage. The U.S. ranked 19 in 1967 and last in 1980; the figures for Japan 8 and 6. Germany ranked 6 in 1980, Britain ranked last, and Italy 9.

The Japaness iron and steel industry was able to strengthen its position because of increases in labor productivity while maintaining its wage structure. The U.S. industry, in contrast fell drastically in ranking by unit labor costs. Despite a slight increase in labor productivity, it experienced large increases in labor compensation relative to all manufactures. U.S. iron and steel registered trade deficits in 1967 and 1980. Since its relative unit labor costs increased significantly, its trade position also deteriorated rapidly.

Nonferrous Metals

An important factor affecting this sector is increasing government ownership of nonferrous metals industries. Over the past decade, the major Third World copper producers -- Chile, Zambia, and Zaire -- have nationalized production. It is estimated that 55 percent of the world's output is now produced by government corporations compared to 33 percent ten years ago. The government enterprises are not motivated by profit but instead are concerned with domestic employment, foreign exchange, and the demands of international lending agencies. They often ignore economic conditions in the copper markets and keep producing in order to maintain employment and foreign exchange. In the process they depress metals prices and export unemployment.

The private aluminum industry has also been hurt by high levels of production from government-owned smelters in Venezuela and Bahrain. By 1985, Alcoa estimates that government smelters will account for 50 percent of the industry's output compared to 15 percent in 1960.

Japan held a comparative advantage in the manufacture of nonferrous metals, while Germany and Italy had a comparative disadvantage. U.S. nonferrous metals ranked 8 in 1967 and 13 in 1980; Japan's ranking was 7 in both years. Germany ranked last in 1980, Britain 14, and Italy 20.

Tables V-B and X-B show that Japan widened its advantage in this sector by increasing relative labor productivity and decreasing labor compensation. In the U.S. industry, relative unit labor costs remained stable between 1967 and 1980. U.S. nonferrous metals recorded consistent trade deficits in 1967 and 1980; since unit labor costs did not change, the industry's trade position also remained stable.

<u>Metal Products</u>

The metal products category is predominantly composed of medium technology industries, except for ordnance, which because of high levels of R&D, has been classified as high technology. However, ordnance products constitute a small share of the overall category and should not bias the results.

Although none of the countries ranked high in metal products, the United States and Italy had the lowest relative unit labor costs, thus yielding a comparative advantage. Rankings for the U.S. industry were 18 in 1967 and 21 in 1980. Comparable rankings for Japan were 20 and 18. Germany ranked 22 in 1980, Britain 20, and Italy 12.

Tables IV-B and IX-B show that the U.S. metal products industry slightly decreased its unit labor costs by increasing labor productivity and decreasing compensation relative to all manufactures. The U.S. industry registered trade surpluses for 1967 and 1980. Since its relative unit labor costs did not significantly change over the period, its trade position also remained stable.

Rubber Products

Although no country ranked high in rubber products, the United States, Germany, and Italy displayed a comparative disadvantage. The U.S. industry ranked 13 by unit labor costs in 1967 and 26 in 1980; in Japan, 14 and 15 for these years. Germany ranked 20 in 1980, Britain 16, and Italy 21.

Table 5.1 shows that the U.S. rubber industry experienced a significant reduction in ranking by unit labor costs between 1967 and 1980. The causes were the large decreases in productivity per employee and rises in compensation relative to all manufactures. This drop in ranking was reflected in the industry's trade position. Although there were trade deficits in 1967 and 1980, these had increased by 1980. The higher unit labor costs of the rubber industry were responsible for its trade balance deterioration.

Transport Equipment

The transport category is aggregated, consisting of both medium and high technology industries. Since the individual industries in this group are heterogeneous, consistent conclusions about individual ones are impossible, but broad conclusions about the category can still be drawn.

The motor vehicle industry has requested trade restrictions to stem the tide of imports from Japan and Europe. In response, the Japanese have extended their "voluntary" limit on U.S. exports through March 1985. The new passenger-car limit, starting April 1, 1984, is 1.85 million vehicles compared to 1.68 million annually the previous three years, which signifies that the U.S. industry will continue to enjoy strong nontariff protection. This resulted in U.S. automotives experiencing high average compensation per employee, poor quality standards, and inefficient plant. However, a slow improvement in international competitiveness may be under way (Kreinin, 1984).

Tables 5.1-5.4 show that Japan held a comparative advantage in the manufacture of transport equipment. The U.S. industry ranked 22 in 1967 and 27 in 1980. Japan's rankings were 12 and 14 respectively. Germany ranked 17 in 1980, Britain 27, and Italy 22. Although the U.S. transport industry improved its relative labor productivity, compensation per employee increased even faster. This resulted in higher unit labor costs and a lower ranking; it registered a trade surplus in 1967 and a trade deficit in 1980, consistent with the comparative cost theory.

Publishing

The United States and Britain displayed a comparative advantage in the printing industries. The U.S. rankings were 15 by unit labor costs in 1967 and 11 in 1967. Comparable Japanese ranking were 19 and 17. The figure for Germany was 19 in 1980, for Britain 9, and for Italy 16. The U.S. printing industry was able to improve its ranking with cuts in labor compensation. The time series evidence suggests that its trade balance was sensitive to changes in unit labor costs. Thus in conformity with comparative cost theory, the U.S. printing industry was able to increase its trade surplus between 1967 and 1980.

Energy

The energy industries consists of petroleum refining and petroleum and coal products. All the countries studied appeared to exhibit a comparative advantage in this sector, but the category is overwhelmingly dominated by demand factors which distort the analysis.

The U.S. petroleum refining industry ranked 2 by unit labor costs in 1967 and 1 in 1980. Japan ranked 1 in both years, Britain and Italy ranked 1 in 1980 and the German petroleum refining and other petroleum and coal products industries ranked 2 by unit labor costs in that year. The United States, Japan, and Germany each recorded trade deficits in the petroleum refining industry for 1980, despite its high ranking. Thus, demand was the primary determinant of trade flows.

The United States, Japan, and Britain ranked high in petroleum and coal products. The U.S. ranking by unit labor costs was 6 in both years. Japan ranked 6 in 1967 and 3 in 1980. Britain ranked 5 in 1980. U.S. petroleum and coal products registered a trade deficit in 1967 but a trade surplus in 1980. In conformity with the comparative cost theory, the U.S. industry reduced its relative unit labor costs and improved its trade position.

High Technology Industries

In the high technology manufacturing category are industrial chemicals, other chemicals, plastics, machinery, electrical machinery, and professional goods. A severe problem with this classification is the aggregation in most of the industries, especially industrial chemicals, machinery, and electrical machinery. They are composed of both medium and high technology industries, which distorts the unit labor costs of the overall category.

Industrial Chemicals

Although the category is highly aggregated, except for industrial organic chemicals (medium technology), the sector employs high technology. Thus, general conclusions can be reached.

Tables 5.1 and 5.2 show that while the United States and Japan have had a comparative advantage in industrial chemicals, Japan's advantage appears to be disappearing. To obtain stronger conclusions, disaggregated data must be observed for Japan, but unfortunately these have not been published. The U.S. industrial chemical industry ranked 3 by unit labor costs in 1967 and 8 in 1980, Japan ranked 2 in 1967 and 5 in 1980. The German figures, which includes all chemical industries, was a ranking of 14 in 1980 and its wage structure has remained stable since 1967.

According to Tables IV-B and IX-B, both the U.S. and Japanese industries increased their relative unit labor costs from 1967 to 1980. This has stemmed from decreases in labor productivity and increases in compensation relative to all manufacturing. Nevertheless, the high technology segment of industrial chemicals, examined in Table 4.1, maintained its costs structure. U.S. industrial chemicals registered trade surpluses in 1967 and 1980, widening the surplus in the latter year.

<u>Other Chemicals</u>

Other chemicals consists of the categories drugs, soap, paints, and miscellaneous chemicals. Aside from the drug industry, this category employs medium technology, but since drugs are the most important segment, the whole category is included here as a high technology industry.

Tables 5.1, 5.2, and 5.4 show that the United States, Japan, and Britain achieved a high ranking in other chemical industries. The U.S. ranking by unit labor costs was 5 in 1967 and 3 in 1980. Japan ranked 3 in 1967 and 2 in 1980. Britain ranked 4 in 1980. Although Japan's other chemicals kept unit labor costs constant between 1967 and 1980, the U.S. industry decreased unit labor costs substantially. This drop was owing to large increases in labor productivity and decreases in compensation relative to the manufacturing average. U.S. other chemicals registered trade surpluses in 1967 and 1980. By reducing unit labor costs, the industry's trade position improved between the two years in conformity with the comparative cost theory.

Plastics

The plastics industry is characterized by low labor productivity relative to all manufactures within each country. While no country ranked high in plastics, the United States held a comparative advantage and Italy a comparative disadvantage. U.S. plastics ranked 14 in 1967 and 1980; Japan ranked 15 in 1967 and 12 in 1980. Germany ranked 15, Britain 11, and Italy last in 1980.

Tables IV-B and IX-B show that U.S. plastics decreased unit labor costs between 1967 and 1980 by decreasing compensation per employee relative to the manufacturing average. Since the U.S. industry also registered trade surpluses in both years, the improvement in its trade position conforms with the comparative cost theory.

Machinery

The aggregated machinery category consists of both medium and high technology industries. The former farm and garden, metalworking, and refrigeration machinery. The latter are engines and turbines, construction, and office and computing machinery. However, even the last segment is not homogeneous, containing medium technology calculating and accounting machines and typewriters as well as high-speed computers. Thus, consistent conclusions are impossible to reach about the individual industries.

Although neither the United States nor Japan held a clear comparative advantage in the machinery industry, Germany had a clear comparative disadvantage. This was due to Germany's low level of productivity and high level of compensation relative to all manufactures. U.S. machinery ranked 17 by unit labor costs in both 1967 and 1980; Japan ranked 16 in 1980 and 17 in 1967. Germany ranked 21 in 1980, Britain and Italy 12.

The U.S. machinery industry decreased its unit labor costs between 1967 and 1980. This was achieved by increases in labor productivity and decreases in compensation in comparison to all manufactures. The industry registered a small trade surplus in 1967 and a large one in 1980. By reducing unit labor costs, the machinery industry's trade position improved over the period in conformity with the comparative cost theory.

Electrical Machinery

The highly aggregated electrical machinery category consists of medium and high technology industries. The former are household appliances, electrical lighting, and radio and TV receiving equipment. The latter are electrical distributing and communication equipment and electronic components. The dichotomy within this sector makes strong conclusions impossible.

None of the countries ranked high in electrical machinery, although the United States had the lowest unit labor costs, thus yielding a comparative advantage. U.S. electrical machinery ranked 20 by unit labor costs in 1967 and 16 in 1980; Japan ranked 11 in 1967 and 13 in 1980. Germany ranked 16 in 1980, Britain 15, and Italy 19.

In U.S. electrical machinery, unit labor costs decreased between 1967 and 1980 owing to increased labor productivity and decreased compensation relative to all manufactures. Nevertheless, the trade surplus in 1967 had changed to a deficit by 1980. Although the U.S. industry lowered relative unit labor costs between the two years, its trade position deteriorated. Since supply factors improved, demand factors were responsible.

Professional Goods

The professional goods category consists primarily of engineering and scientific devices and medical instruments. With few exceptions, the entire category is classified as high technology.

Tables 5.1-5.3 show that the United States and Germany held a comparative advantage in the manufacture of professional goods while Japan had a comparative disadvantage. U.S. professional goods ranked 10 by unit labor costs in 1967 and 7 in 1980. The respective Japanese rankings were 24 and 23. Germany ranked 7 in 1980, Britain 19, and Italy 11.

The strong U.S. position stems from high levels of relative labor productivity, whereas Germany's is derived from low relative compensation levels. Japan, in contrast, displayed very low levels of labor productivity relative to compensation. The U.S. professional goods industry decreased unit labor costs between 1967 and 1980 with large increases in labor productivity and moderate decreases in compensation relative to all manufactures. The U.S. industry recorded trade surpluses in both years and, by moving up in ranking, was able to improve its trade position over the period, in conformity with the comparative cost theory.

Summary

The analyses of individual industries indicates that in 1967 and 1980, the United States held a comparative advantage in the manufacture of food products, tobacco, paper, printing, industrial chemicals, plastics, and professional goods. It held a comparative disadvantage in iron and steel, rubber, transport equipment, wood products, and glass. The industries which experienced a reduction in international competitiveness between 1967 and 1980 were iron and steel, transport equipment, glass, and rubber.

In 1967 and 1980, Japan held a comparative advantage in glass, iron and steel, nonferrous metals, transport equipment, and industrial chemicals; a comparative disadvantage in tobacco, food products, traditionally low technology products, and professional goods. Japan's comparative advantage remained relatively stable between 1967 and 1980.

In 1980, Germany held a comparative advantage in tobacco, food products, wood products, pottery, and professional goods; a comparative disadvantage in paper, nonferrous products, metal products, rubber, industrial chemicals, and machinery.

In 1980, Italy held a comparative advantage in leather, forest products, and pottery. It displayed a comparative disadvantage in tobacco, nonferrous metals, rubber, plastics, and electrical machinery.

In 1980, Britain held a comparative advantage in industrial chemicals, plastics, tobacco, printing, and other nonmetal products. Its comparative disadvantage lay in wearing apparel, furniture, pottery and china, iron and steel, and transport equipment.

Knowledge of a country's comparative advantage at a particular time and of the changes over time are useful to a policy maker. In order for an industry whose ranking is low and which is suffering from a trade deficit to improve its position, it must decrease unit labor costs by reducing labor compensation, increasing productivity, or both.

Although all industries do not respond quickly to changes in supply, these do explain a large portion of trade flows and must be considered in the formulation of international policy decisions.

Footnotes

[1]For a detailed breakdown of industry categories see Davis (1982), Kelly (1977), and Boretsky (1982), all from the U.S. Department of Commerce.

[2]Background material for the medium and high technology industries was obtained from Forbes, January 1984.

CHAPTER VII

CONCLUSION

The purpose of this dissertation was to investigate the comparative cost advantage of manufacturing industries in the United States, Japan, and Europe between 1967 and 1980. Since it was not possible to derive accurately all the costs of production, the internal ranking of industries by comparative advantage was approximated using the inverse of unit labor cost and its components, labor productivity and labor compensation.

Although most relevant studies have measured an industry's unit labor costs across countries at one time, they were limited in scope and subject to distortions stemming from deviations in the long-run equilibrium exchange rate. The distortions can be corrected for in an approach, developed by Viner and Kreinin, which examines an industry's unit labor costs relative to the national manufacturing average. This allows all commodities produced by a country to be ranked internally by their domestic unit labor costs. Each country would export the commodities in which its comparative cost advantage is the greatest and import those ranking the lowest (highest production costs), with the exchange rate separating the two. Thus, comparative cost advantages "are embedded in the total economy" and become an effective tool on which to base policy decisions (Kreinin, 1984, p. 42).

Increases in an industry's unit labor costs relative to the manufacturing average reduce its internal ranking and international competitiveness. Since comparative advantage is important to the determination of trade flows, and in light of the large U.S. current account deficits registered recently, industries subject to acute import competition can alleviate their situation by decreasing unit labor costs. Therefore, increasing labor productivity, decreasing labor compensation, or both, become important to improving internal ranking and strengthening an industry's trade position without relying on trade restrictions.

The theoretical foundations of the classical comparative cost model were developed beginning with the Ricardian hypothesis. The assumptions of the latter were relaxed with the introduction of money wages, a multicommodity framework, transportation costs, and incomplete specialization to construct a more realistic model. It was demonstrated that the sharp distinction drawn between the Ricardian and Heckscher-Ohlin theories disappeared with the relaxation of the assumptions. The differences between countries in comparative labor productivities that were asserted by assumption in the Ricardian hypothesis were deduced from differences in relative factor endowments in the Heckscher-Ohlin model. Therefore, these two theories do not provide conflicting viewpoints, but instead are interdependent and are both important to understanding international trade flows.

MacDougall, Balassa, Stern, and Stryker's empirical results confirmed the comparative cost theory. MacDougall found a strong inverse relationship between 1937 relative U.S. and U.K. wage costs per unit of output and relative exports and a positive relationship between relative output per worker and relative exports. Balassa and Stern's results indicated that the 1950 relative U.S. and U.K. export performance followed established lines of comparative advantage as suggested by labor productivity. The introduction of differences in capital costs per unit of output did not have any significant effect on export performance. Stryker's time series evidence suggested that changes in U.S. and Canadian exports were correlated with changes in labor productivity and that the latter is a useful proxy for total factor productivity.

In contrast, Bhagwati, Stern, and Kreinin concluded that their empirical evidence did not support the simple Ricardian hypothesis, and that other factors were important in determining the pattern of trade. Although Bhagwati's tests produced a poor fit between 1950 relative labor productivity and price ratios and the relationship between comparative unit labor costs and export price ratios, the variables were measured inconsistently. Thus, as Daly stated, failures to establish a correlation between export price ratios and labor productivity ratios stem from the lack of conceptual and statistical compatibility in the data rather than provide evidence against the Ricardian hypothesis.

The statistical results in this dissertation generated from the cross-sectional and time series data confirmed the importance of unit labor costs as a determinant of international trade patterns. With the exception of Japan, which generated a positive sign for unit labor costs in 1967 and 1980, the coefficients generated by the cross-sectional models were significant and of the correct sign. The coefficient regressions from these equations were low, which was not unexpected considering the multitude of factors affecting international trade.

For the time series model, correct signs for labor compensation and productivity were produced for most of the industries when using the relative version of the comparative cost theory. Finally, the panel data model removed the biases of changes in differential trade restrictions and exchange rates and generated positive results based on all available data for the U.S. economy over the period 1967 to 1981. Thus, the empirical evidence reveals that unit labor costs are an important determinant of international trade flows and must be considered in the development of policy for industries suffering from import competition.

The results for 1967 and 1980 indicated that the United States held a comparative advantage, as approximated by unit labor costs, in the following industries: agricultural manufacturing, paper, nonferrous metals, publishing, industrial chemicals, plastics, office and computing equipment, and professional goods. It held a comparative disadvantage in traditional low technology products, wood products, furniture, pottery, glass, rubber, iron and steel, and most transport equipment.

The three major industries in the U.S. economy which experienced a reduction in international competition between 1967 and 1980 were iron and steel, transport, and rubber. It was seen that these significantly increased their unit labor costs relative to other manufactures, causing them to fall sharply in the internal ranking. This was reflected in the large trade deficits they incurred. In contrast, the iron and steel, transport and rubber industries in Japan and Germany were able to maintain their internal ranking. Thus, the increases in international competition for these industries resulted from changes in unit labor costs within the United States and not from the extraordinary performance of foreign competitors.

In contrast, the aircraft, agricultural chemicals, and professional goods industries decreased their unit labor costs, which improved their trade position. But all industries did not conform to comparative cost theory. The trade position of some industries was not effected by supply but instead dominated by demand factors, trade restrictions, and transportation costs. Nevertheless, supply considerations did explain a large portion of the trade flows.

In 1967 and 1980, Japan held a comparative advantage in glass, iron and steel, nonferrous metals, transport equipment, and industrial chemicals; a comparative disadvantage in tobacco, food products, traditionally low technology products, and professional goods. Japan's comparative advantage remained relatively stable between 1967 and 1980.

In 1980, Germany held a comparative advantage in tobacco, food products, wood products, pottery, and professional goods; a comparative disadvantage in paper, nonferrous products, metal products, rubber, industrial chemicals, and machinery. Italy held a comparative advantage in leather, forest products, and pottery. It displayed a comparative disadvantage in tobacco, nonferrous metals, rubber, plastics, and electrical machinery. Great Britain held a comparative advantage in industrial chemicals, plastics, tobacco, printing, and other nonmetal products. Its comparative disadvantage lay in wearing apparel, furniture, pottery and china, iron and steel, and transport equipment.

This evidence establishes the importance of considering unit labor costs in the formation of policy for industries experiencing international competition. Knowledge of a country's comparative advantage at a particular time and the rate of its change are useful to policy makers. An industry with low ranking which is suffering from a trade deficit can strengthen its position through decreased unit labor costs: by reducing labor compensation, increasing productivity, or both. Thus, internal responses to international competition are vital, without reliance on trade restrictions, to solving an industry's trade problems.

APPENDIX A

TABLE I-A

Concordance Between the Three-Digit International Standard Industrial Classification (top number) and the U.S. Standard Industrial Classification

311/2	313	314	321	322	323	324
201	2082	21	22	2311	3111	3131
202	2083		239	232	3151	314
203	2084			233	3161	
204	2085			234	317	
205	2086			235	3199	
206				236		
207				2371		
2087						
209						

331	332	341	342	351	352	353
24	25	26	27	281	283	2911
				282	284	
				286	2851	
				287	289	

354	355	356	361	362	369	371
295	3011	3079	326	3211	3241	331
299	3021			322	325	332
	3031			3231	327	
	3041				3281	
	3069				329	

372	381	382	383	384	385	390
333	34	35	36	37	38	39
3341						
335						
336						
339						

TABLE II-A

Concordance Between the 1980 Three-Digit International Standard Industrial Classification (top number) and the Standard International Trade Classification

311/2
012
014
035
037
046
047
048
056
058
061.2
062
071.2
072
073
091
098

313	314	321	322	323	324
11	122	26	84	61	851
		65		831	

331	332	341	342	351	352
24	821	251	892	51	53
63		64		52	541
				562	55
				58	572
				591	598
				592	

353	354	355	356	361	362
334	32	233	893	666	664
	335	62			665
	341				

369	371	372	381	382	383	384
661	67	68	69	71	76	78
662				72	77	79
663				73		
667				74		
				75		

385	390
87	894
88	895
	896
	897
	898
	899

TABLE III-A

Concordance Between the 1967 Three-Digit International Standard Industrial Classification (top number) and the Standard International Trade Classification

311/2
012
013
032
046
047
048
052
053
055
062
071.3
072.2
072.3
073
091
099

313	314	321	322	323	324
11	122	266	84	61	851
		267		831	
		65			

331	332	341	342	351	352
243	821	251	892	51	53
63		64		521	541
				561	55
				581	571
					599

353/4	355	356	361	362	369
321	231.2	893	666	664	661
332	231.3			665	662
341	231.4				663
	62				

371	372	381	382	383	384	385
67	68	69	71	72	73	86
		812				

390
891
894
895
896
897
899

TABLE IV-A

OLS Results from Equation 5.1

Country	A1	A2	R^2	N	D-W
U.S.					
1980	5.67	-8.42	0.25	27	1.50
	(1.49)	(2.91)			
1967	17.14	-27.70	0.18	27	1.13
	(6.18)	(11.70)			
Japan					
1980	1.956	5.186	0.008	26	1.93
	(4.534)	(12.038)			
1967	-43.80	168.45	0.21	25	1.99
	(23.55)	(69.02)			
Germany					
1980	1.72	-0.66	0.013	23	1.64
	(0.64)	(1.22)			
Britain					
1980	3.2694	-0.0035	0.19	27	2.05
	(0.0480)	(0.0015)			
Italy					
1980	4.19	-1.41	0.0005	23	2.54
	(7.75)	(13.89)			

TABLE V-A

OLS Results for Equation 5.2

Country	B1	B2	R^2	N	D-W
U.S.					
1980	-1.68 (0.62)	-1.96 (0.80)	0.19	27	1.92
1967	-2.17 (0.72)	-2.80 (0.94)	0.26	27	1.55
Japan					
1980	1.63 (1.39)	1.29 (1.30)	0.04	26	1.29
1967	5.41 (1.22)	3.57 (1.06)	0.33	25	2.13
Germany					
1980	-0.036 (0.264)	-0.219 (0.294)	0.03	23	1.07
Britain					
1980	6.70 (3.70)	-1.07 (0.57)	0.12	27	1.72
Italy					
1980	-0.86 (1.15)	-1.99 (1.82)	0.05	23	2.93

TABLE VI-A

OLS Results for Equation 5.3

Country	C1	C2	R^2	N	D-W
U.S.					
1980	31.36	-38.94	0.15	27	1.89
	(9.59)	(18.73)			
1967	47.54	-51.44	0.16	26	2.15
	(12.65)	(24.05)			
Japan					
1980	0.027	0.173	0.03	26	1.55
	(0.072)	(0.191)			
1967	-0.062	0.483	0.20	25	1.83
	(0.068)	(0.200)			
Germany					
1980	8.51	12.48	0.15	23	1.79
	(3.42)	(6.46)			
Britain					
1980	0.2432	-0.00025	0.27	27	1.93
	(0.0480)	(8.31*10-8)			
Italy					
1980	14.82	-7.64	0.004	23	1.88
	(14.89)	(26.69)			

TABLE VII-A

OLS Results for Equation 5.4

Country	D1	D2	R^2	N	D-W
U.S.					
1980	-1.23 (2.23)	-2.60 (2.87)	0.03	27	0.43
1967	-9.45 (0.50)	-0.93 (0.66)	0.08	26	2.15
Japan					
1980	-2.15 (0.86)	0.73 (0.80)	0.03	26	1.13
1967	-0.34 (0.84)	2.06 (0.73)	0.26	25	1.57
Germany					
1980	2.82 (0.13)	0.24 (0.15)	0.11	23	1.73
Britain					
1980	4.08 (2.91)	-1.04 (0.46)	0.17	27	1.82
Italy					
1980	0.88 (0.82)	-1.72 (1.29)	0.08	23	2.16

TABLE VIII-A

OLS Results for Equation 5.5

Industry	A1	A2	A3	R^2	D-W
Food Products	-4149.71	-339.19	1270.63	0.86	0.78
	(996.34)	(267.61)	(756.31)		
Beverages	226.42	-67.53	82.95	0.98	2.57
	(78.99)	(19.23)	(55.29)		
Tobacco	-222.51	7.16	20.17	0.99	1.19
	(24.11)	(3.27)	(13.80)		
Textiles	-641.90	-136.69	202.70	0.38	1.23
	(217.01)	(252.84)	(457.33)		
Wearing Apparel	3580.20	-408.05	-236.83	0.99	1.84
	(510.70)	(245.87)	(499.43)		
Leather and Products	413.16	-20.03	-62.81	0.91	1.54
	(175.36)	(67.28)	(134.31)		
Footwear	2177.28	134.72	-691.61	0.95	0.99
	(301.67)	(99.75)	(206.47)		
Wood Products	-80.71	-248.17	378.07	0.50	1.56
	(325.86)	(87.83)	(157.88)		
Furniture, Fixtures	468.96	61.14	-192.84	0.94	1.36
	(105.93)	(75.70)	(139.60)		
Paper and Products	-38.78	65.45	-191.20	0.44	1.40
	(272.49)	(67.76)	(149.00)		
Printing, Publishing	240.45	109.83	-210.72	0.87	1.06
	(134.03)	(35.18)	(78.09)		
Industrial Chemicals	-3483.81	1.37	455.38	0.87	0.97
	(929.97)	(104.58)	(445.74)		
Other Chemical Products	-266.14	85.33	-190.29	0.90	1.31
	(205.99)	(73.19)	(268.14)		

Petroleum Refineries	3498.82	-9.74	-386.74	0.86	1.51
	(1693.00)	(22.53)	(184.00)		
Petroleum, Coal Products	- 235.21	0.32	26.64	0.97	1.14
	(22.78)	(3.27)	(8.48)		
Rubber Products	473.44	24.41	-121.96	0.76	0.91
	(222.53)	(50.96)	(84.20)		
Plastic Products, n.e.c.	-522.65	-45.35	164.04	0.89	0.91
	(85.41)	(38.79)	(78.96)		
Pottery, China, etc.	223.38	-28.83	-3.07	0.997	2.16
	(16.11)	(11.16)	(19.05)		
Glass and Products	112.80	-10.40	12.82	0.06	0.98
	(134.97)	(47.08)	(79.49)		
Nonmetal Products	-108.75	-48.85	106.81	0.18	1.13
	(77.69)	(30.82)	(66.18)		
Iron and Steel	2998.99	-179.45	-78.93	0.89	1.94
	(837.11)	(181.76)	(247.01)		
Nonferrous Metals	-443.28	-15.66	-64.82	0.31	1.97
	(659.78)	(113.52)	(221.97)		
Metal Products	-341.52	-66.27	218.33	0.70	1.24
	(327.66)	(195.47)	(358.31)		
Machinery n.e.c.	-10564.53	-1130.88	3522.94	0.95	0.91
	(2985.61)	(999.07)	(1988.64)		
Electrical Machinery	-200.78	-411.58	732.75	0.33	1.46
	(870.77)	(301.03)	(590.86)		
Transport Equipment	3068.32	-605.89	791.54	0.35	1.33
	(1393.00)	(407.95)	(617.71)		
Professional Goods	-934.97	-93.33	372.69	0.91	1.49
	(264.60)	(96.98)	(222.35)		
Other Industries	902.34	-387.23	519.13	0.92	0.87
	(640.24)	(218.42)	(484.34)		

TABLE IX-A

OLS Results for Equation 5.6

Industry	B1	B2	B3	R^2	D-W
Food Products	0.043 (0.529)	-1.836 (0.832)	2.532 (0.937)	0.88	2.27
Beverages	-3.344 (1.139)	-2.737 (1.299)	3.975 (1.361)	0.94	2.29
Tobacco	-2.703 (3.038)	3.534 (1.864)	-3.590 (1.782)	0.35	1.13
Textiles	-2.485 (2.022)	0.474 (4.365)	0.430 (4.562)	0.68	0.89
Wearing Apparel	-1.301 (0.865)	-2.562 (2.995)	2.897 (3.452)	0.06	0.72
Leather and Products	-2.162 (0.563)	0.714 (1.995)	-0.463 (2.313)	0.25	1.27
Footwear	-5.482 (0.734)	6.159 (2.092)	-6.829 (2.391)	0.71	0.65
Wood Products	-0.785 (0.534)	-1.009 (0.857)	1.424 (0.904)	0.40	1.36
Furniture, Fixtures	-5.025 (2.278)	8.185 (5.655)	-8.423 (6.026)	0.23	0.77
Paper and Products	-1.503 (0.378)	0.981 (0.622)	-0.816 (0.680)	0.48	1.27
Printing, Publishing	-0.579 (0.633)	7.093 (1.926)	-8.467 (2.195)	0.71	1.48
Industrial Chemicals	1.547 (0.646)	-0.044 (0.634)	-0.158 (0.691)	0.26	0.75
Other Chemical Products	2.318 (1.940)	0.121 (1.606)	-0.628 (1.650)	0.76	1.30

Petroleum Refineries	0.941 (0.838)	0.344 (0.748)	-1.381 (1.154)	0.44	0.56
Petroleum, Coal Products	15.187 (5.453)	-3.910 (1.790)	1.867 (1.306)	0.63	1.87
Rubber Products	1.823 (1.558)	-1.203 (1.896)	0.477 (1.785)	0.39	0.89
Plastic Products, n.e.c.	-0.169 (0.898)	-0.365 (1.457)	0.701 (1.538)	0.27	0.81
Pottery, China, etc.	-1.038 (0.659)	-2.319 (2.082)	2.486 (2.232)	0.09	0.77
Glass and Products	2.443 (2.822)	-2.642 (3.281)	2.382 (3.006)	0.05	0.68
Nonmetal Products	0.535 (1.187)	0.112 (1.706)	-0.295 (1.710)	0.26	0.90
Iron and Steel	0.908 (1.631)	-0.820 (2.167)	0.248 (1.980)	0.27	1.51
Nonferrous Metals	-3.128 (2.482)	0.168 (3.099)	0.589 (3.216)	0.12	1.08
Metal Products	1.267 (0.866)	0.570 (1.919)	-1.018 (2.018)	0.58	1.05
Machinery n.e.c.	2.387 (0.519)	-1.014 (1.459)	0.736 (1.606)	0.62	0.85
Electrical Machinery	1.079 (0.614)	-1.449 (1.798)	1.353 (1.990)	0.31	0.56
Transport Equipment	1.992 (0.835)	-2.088 (1.246)	1.752 (1.187)	0.41	0.99
Professional Goods	2.334 (0.627)	-1.270 (0.942)	0.961 (0.989)	0.74	1.27
Other Industries	-0.404 (0.783)	-0.412 (2.134)	0.397 (2.428)	0.04	0.88

TABLE X-A

OLS Results for Equation 5.7

Industry	C1	C2	C3	R^2	D-W
Food Products	5603.59 (1733.79)	697.50 (524.27)	-7112.52 (1921.69)	0.54	1.84
Beverages	324.53 (504.04)	-373.39 (302.13)	182.94 (585.72)	0.13	1.45
Tobacco	-0.22 (0.28)	0.72 (0.35)	-1.41 (0.64)	0.31	2.15*
Textiles	6.13 (4.30)	10.90 (9.81)	-18.58 (13.17)	0.17	2.03*
Wearing Apparel	0.56 (2.55)	12.81 (19.64)	-12.12 (15.54)	0.06	2.16*
Leather and Products	-92.98 (101.03)	-288.59 (376.23)	377.41 (266.18)	0.20	1.41
Footwear	0.40 (0.88)	-6.70 (4.01)	5.07 (3.86)	0.22	1.80*
Wood Products	-40.67 (296.46)	238.26 (175.14)	-166.52 (509.90)	0.29	1.58
Furniture, Fixtures	-0.16 (0.74)	-2.32 (3.58)	2.21 (3.80)	0.04	1.78*
Paper and Products	480.29 (314.67)	-7.40 (127.95)	-448.75 (333.61)	0.17	1.35
Printing, Publishing	38.34 (85.49)	294.83 (231.70)	-317.82 (166.90)	0.32	1.52
Industrial Chemicals	3.24 (6.63)	-1.58 (3.01)	0.73 (8.76)	0.05	1.91*
Other Chemical Products	-0.31 (9.55)	2.74 (2.14)	-4.59 (9.76)	0.13	1.64*

Petroleum Refineries	12.73 (6.55)	0.94 (0.46)	-10.64 (5.22)	0.29	1.40*
Petroleum, Coal Products	0.42 (0.29)	-0.05 (0.13)	-0.32 (0.27)	0.16	2.42*
Rubber Products	10.93 (161.85)	1.23 (109.03)	-16.79 (184.21)	0.01	1.07
Plastic Products	199.37 (176.20)	-106.81 (232.80)	-127.83 (353.45)	0.13	1.39
Pottery, China, etc.	52.52 (149.78)	222.11 (371.85)	-245.25 (372.37)	0.04	1.00
Glass and Products	15.53 (21.54)	1.83 (10.49)	-16.80 (13.78)	0.16	1.25
Nonmetal Products	92.72 (58.06)	-58.37 (29.94)	-33.62 (66.40)	0.34	1.18
Iron and Steel	58.52 (1231.77)	1137.40 (1181.25)	-953.88 (579.30)	0.20	1.39
Nonferrous Metals	1133.59 (806.62)	308.69 (270.24)	-1301.57 (683.24)	0.27	1.47
Metal Products	-0.41 (7.14)	4.86 (7.43)	-3.80 (11.38)	0.05	1.99*
Machinery n.e.c.	1707.37 (13323.14)	14531.67 (7505.40)	-14412.98 (12273.64)	0.25	1.43
Electrical Machinery	-1.44 (1.62)	0.86 (1.77)	0.75 (1.57)	0.08	2.16*
Transport Equipment	-0.13 (1.88)	2.75 (1.33)	-1.96 (1.03)	0.39	1.50*
Professional Goods	589.28 (774.54)	614.49 (501.88)	-1217.16 (1065.93)	0.12	1.17
Other Industries	2.01 (3.11)	3.81 (8.19)	-6.29 (6.03)	0.14	2.07*

* Sample size =1968-1981

TABLE XI-A

OLS Results for Equation 5.8

Industry	D1	D2	D3	R^2	D-W
Food Products	-1.70 (0.66)	2.84 (1.82)	-12.56 (5.31)	0.37	0.77
Beverages	-2.76 (0.53)	-3.54 (1.70)	17.63 (2.45)	0.83	1.60
Tobacco	1.62 (1.57)	1.04 (1.97)	-1.25 (1.42)	0.10	1.04
Textiles	-7.15 (0.65)	-4.55 (2.93)	-9.50 (4.38)	0.89	1.63
Wearing Apparel	-2.14 (0.49)	-0.10 (1.56)	0.02 (1.34)	0.002	1.22
Leather and Products	-2.44 (0.52)	-1.39 (1.62)	-0.92 (1.35)	0.44	1.25
Footwear	-3.70 (0.50)	2.24 (1.40)	-3.27 (1.52)	0.29	0.96
Wood Products	0.90 (0.85)	-2.73 (1.55)	9.21 (5.13)	0.22	0.99
Furniture, Fixtures	-1.59 (0.61)	3.30 (4.04)	-6.36 (4.74)	0.28	0.50
Paper and Products	-0.79 (0.13)	1.20 (0.88)	4.78 (2.24)	0.50	0.67
Printing, Publishing	0.86 (0.11)	3.41 (1.77)	-1.27 (1.32)	0.42	1.73
Industrial Chemicals	1.50 (0.56)	-0.43 (0.76)	-0.62 (0.99)	0.22	1.01
Other Chemical Products	-2.05 (0.86)	3.88 (1.43)	4.36 (3.65)	0.58	1.40
Petroleum Refineries	0.11 (0.75)	-0.09 (0.80)	-3.81 (3.37)	0.32	0.46

Petroleum, Coal Products	3.99 (1.18)	-3.60 (3.25)	-0.62 (5.58)	0.11	0.94
Rubber Products	-0.75 (0.17)	1.77 (1.08)	1.19 (1.98)	0.34	0.77
Plastic Products, n.e.c.	-0.27 (0.30)	0.35 (1.80)	-3.76 (2.77)	0.27	0.92
Pottery, China, etc.	-1.58 (0.30)	0.91 (0.64)	0.10 (0.07)	0.25	2.62
Glass and Products	0.12 (0.15)	-1.61 (1.92)	-0.22 (2.70)	0.06	0.56
Non-metal Products	-0.13 (0.09)	1.53 (1.87)	-3.90 (4.05)	0.08	1.26
Iron and Steel	-0.36 (0.45)	0.52 (2.42)	-2.30 (1.50)	0.17	1.34
Nonferrous Metals	-3.74 (1.14)	0.65 (3.05)	19.00 (8.01)	0.33	1.33
Metal Products	0.39 (0.30)	1.46 (1.96)	5.40 (3.35)	0.66	1.16
Machinery n.e.c.	-0.01 (0.25)	-3.74 (1.15)	9.35 (2.12)	0.66	1.33
Electrical Machinery	-0.17 (0.13)	-1.43 (1.13)	2.13 (1.15)	0.23	0.69
Transport Equipment	0.50 (0.18)	-0.46 (0.60)	-1.46 (0.57)	0.37	0.80
Professional Goods	0.51 (0.07)	-0.55 (0.95)	3.69 (1.86)	0.33	1.00
Other Industries	-1.14 (0.46)	-1.96 (2.11)	0.65 (1.54)	0.08	0.47

APPENDIX B

TABLE I-B

Classification of Two-, Three-, and Four-Digit SIC Manufacturing Industries Into Low, Medium, and High Technology Categories

<u>Low Technology Industries</u>

20 - 26, 31, 32, 39

<u>Medium Technology Industries</u>

27, 284, 2851, 286, 289, 29, 30, 33, 341-347, 349, 352-356, 358, 359, 363, 364, 369, 371, 372, 3743, 3751, 379

<u>High Technology Industries</u>

281-283, 287, 348, 351, 357, 361, 362, 365-367, 372, 376, 38

This classification system is based on U.S. Department of Commerce publications. There are no classification systems which can truely capture an industry's use of technological production methods. These industries are defined in a broard manner with many diverse segments so that technological labels on a specific industry can only have limited applications. The methodology of assigning technology labels to industries is found in Davis (1982), Boertsky (1982) and Kelly (1977).

TABLE II-B

U.S. 1980, Two-, Three-, and Four-Digit
SIC Comparative Cost Rankings

Industry	Value/ Employ	Comp/ Employ	Unit Value	Rank
	(1)	(2)	(3)	
Meat Products	30.84	17.34	0.562	90-93
Dairy Products	50.08	18.54	0.370	19-20
Preserved Fruits	40.81	15.45	0.379	21
Grain Mill Products	80.18	21.25	0.265	5
Bakery Products	39.27	19.15	0.488	44
Sugar, Confectionery	61.03	17.96	0.294	7
Fats and Oils	66.42	20.12	0.303	10
Beverages	68.95	22.08	0.320	14
Misc. Foods Kindred	52.70	15.63	0.297	9
Tobacco Products	105.99	23.34	0.220	3-4
Weaving Mills, Cotton	21.92	13.49	0.615	121
Weaving Mills, Manmade	25.05	14.08	0.562	90-93
Weaving, Finished, Wool	25.46	14.10	0.554	81-82
Narrow Fabric Mills	20.58	12.50	0.607	116
Knitting Mills	20.42	11.67	0.571	94-95
Textile Finishing	27.50	14.41	0.524	61
Floor Covering Mills	31.10	14.38	0.463	38
Yarn and Thread Mills	20.03	12.22	0.610	118
Miscellaneous Textiles	28.52	15.26	0.535	68
Men's and Boys' Suits	19.32	12.09	0.626	125
Men's and Boys' Furnishings	17.78	9.44	0.531	65
Women's and Misses' Out.	16.47	9.25	0.562	90-93
Women's,Children's Under.	17.22	9.35	0.543	71-73
Hats, Caps, and Millinery	16.56	9.28	0.560	88-89
Children's Outerwear	15.73	8.71	0.554	81-82
Fur Goods	35.48	17.43	0.491	45
Misc. Apparel and Accs.	17.64	10.14	0.575	98
Misc. Fabricated Textile	22.71	13.04	0.574	97

Sawmills and Planning Mills	25.07	15.57	0.621	123
Millwork, Plywood, Struc.	24.87	15.99	0.643	129
Wood Containers	17.72	10.66	0.602	112
Wood Buildings,Mobile Homes	26.72	15.88	0.594	108
Misc. Wood Products	25.53	14.22	0.557	84
Household Furniture	21.13	12.31	0.583	101-102
Office Furniture	36.46	18.46	0.506	52
Public Bldg., Related Furn.	25.58	14.96	0.585	104
Partitions and Fixtures	28.55	17.06	0.598	109-111
Misc. Furniture and Fixt.	29.47	15.94	0.541	69
Pulpmills	79.80	30.53	0.383	22
Papermills, Building Paper	59.24	27.67	0.467	39
Paperboard Mills	59.76	28.74	0.481	41
Misc. Converted Paper	44.81	18.73	0.418	25-27
Paperboard Cont. Boxes	32.22	19.24	0.597	108
Building Paper,Board Mills	33.36	20.19	0.605	114-115
Newspapers	30.94	16.29	0.527	62-63
Periodicals	71.98	21.26	0.295	8
Books	48.80	18.06	0.370	19-20
Misc. Publishing	37.82	15.87	0.420	29
Commercial Printing	28.70	17.72	0.617	123
Manifold Business Forms	44.38	18.95	0.427	31
Greeting Card Publishing	48.09	17.41	0.362	17
Blankbooks and Bookbinding	26.20	14.27	0.545	74-76
Printing Trade Services	30.87	19.26	0.624	124
Industrial Inorganic Chem.	76.62	26.94	0.352	16
Plastic Materials,Syn.	64.34	25.95	0.403	23
Drugs	78.16	23.88	0.306	11
Soaps, Cleaners, Toilet	104.40	20.97	0.201	2
Paints, Allied Products	57.13	20.90	0.366	18
Industrial Organic Chem.	101.20	29.32	0.290	6
Agricultural Chem.	102.68	22.56	0.220	3-4
Misc. Chemicals	61.54	21.40	0.348	15
Petroleum Refining	215.65	34.00	0.158	1
Paving and Roofing Mat.	52.15	22.58	0.433	32
Misc. Petroleum, Coal Prod.	69.54	22.21	0.319	13
Tires and Inner Tubes	46.74	26.10	0.558	85-86
Rubber, Plastic Footwear	17.09	11.60	0.679	133
Reclaimed Rubber	41.00	18.83	0.459	35
Rubber, Plastic Hose	28.29	24.66	0.872	139
Fabricated Rubber	28.56	18.11	0.634	127
Misc. Plastics	30.92	15.88	0.514	56-58

Leather Tanning	29.47	16.17	0.549	79-81
Boot, Shoe Cut Stock	19.63	10.74	0.547	77
Footwear, Expt. Rubber	20.35	10.42	0.512	55
Leather Gloves	10.23	7.48	0.731	138
Luggage	25.46	12.82	0.503	51
Handbags and Purses	16.98	9.99	0.589	106
Leather Goods	20.58	10.48	0.509	54
Flat Glass	48.69	29.83	0.613	119
Glass	39.73	22.34	0.562	90-93
Products of Glass	29.77	17.44	0.586	105
Cement, Hydraulic	69.72	29.05	0.417	24
Structural Clay	28.88	16.65	0.583	101-102
Pottery	27.88	16.80	0.603	113
Concrete, Gypsum, Plaster	38.03	18.82	0.495	47
Cut Stone	22.28	13.56	0.609	117
Misc. Nonmetallic Miner.	44.45	20.47	0.461	36
Blast Furnance, Steel	45.61	32.52	0.713	135
Iron, Steel Foundries	32.37	23.15	0.715	136
Primary Nonferrous Metals	75.01	31.15	0.423	30
Secondary Nonferrous	48.03	21.86	0.455	34
Nonferrous Rolling	47.00	24.52	0.522	60
Nonferrous Foundries	29.84	19.51	0.654	130-131
Misc. Primary Metal	41.53	20.70	0.498	48
Metal Cans	67.33	28.18	0.418	25-27
Cutlery, Handtools	36.06	19.64	0.545	74-76
Plumbing, Heating	34.82	17.49	0.502	50
Fabricated Struc.	33.58	19.18	0.571	94-95
Screw Machine, Bolts	33.35	19.30	0.579	100
Metal Forgings, Stamp	35.91	23.49	0.654	130-131
Metal Services	27.45	15.35	0.559	87
Ordnance	34.15	22.43	0.657	132
Misc. Fab. Metal	36.59	19.49	0.533	66
Engines, Turbines	52.33	27.96	0.534	67
Farm, Garden Machinery	45.43	23.34	0.514	56-58
Construction Mach.	47.29	24.36	0.515	59
Metalworking Mach.	39.03	22.34	0.572	96
Special Industry Mach.	35.38	21.17	0.598	109-111
General Industry Mach.	39.08	21.88	0.560	88-89
Office, Computing Mach.	47.60	22.92	0.482	42
Refrigeration	39.24	20.75	0.529	64
Misc. Machinery	29.42	18.48	0.628	126

Electric Distributing	37.84	19.45	0.514	56-58
Elect. Industrial	36.12	20.05	0.555	83
Household Appliances	38.56	17.81	0.462	37
Elec. Lighting, Wiring	35.40	17.49	0.494	46
Radio, TV Receiving	43.11	18.08	0.419	28
Communication Equip.	39.89	23.29	0.584	103
Electronic Components	33.90	18.61	0.549	78-80
Misc. Elec. Equip.	37.08	20.35	0.549	78-80
Motor Vehicles	42.73	30.27	0.708	134
Aircraft, Parts	47.58	28.45	0.598	109-111
Ship, Boat Building	26.67	21.79	0.760	138
Railroad Equipment	49.34	26.90	0.545	74-76
Motorcycles, Bicycles	31.26	16.99	0.543	71-73
Guided Missiles, Space	52.06	33.16	0.637	128
Transportation Equip.	30.94	18.72	0.605	114-115
Engineering, Scien. Inst.	40.74	20.70	0.508	53
Measuring, Controlling	35.06	20.18	0.576	99
Optical Instruments	42.29	21.17	0.501	49
Medical Instruments	36.14	17.46	0.483	43
Ophthalmic Goods	28.54	15.49	0.543	71-73
Photographic Equip.	86.96	27.32	0.314	12
Watches, Clocks	28.85	15.20	0.527	62-63
Jewelry, Silver	31.58	15.05	0.476	40
Musical Instruments	24.00	14.73	0.614	120
Toys, Sporting Goods	33.88	14.16	0.418	25-27
Pens, Office, Art Goods	35.07	15.57	0.444	33
Costume Jewelry	23.69	12.83	0.542	70
Misc. Manufactures	27.34	15.25	0.558	85-86
All Manufactures	37.48	20.37	0.543	

(1) Units of average value added per employee are in thousands of dollars.

(2) Units of average compensation per employee are in thousands of dollars.

(3) Unit labor costs are defined as compensation/value-added.

TABLE III-B

U.S. 1967, Two-, Three-, and Four-Digit
SIC Comparative Cost Rankings

Industry	Value/ Employ	Comp/ Employ	Unit Value	Rank
	(1)	(2)	(3)	
Meat Products	11.45	7.01	0.612	104-105
Dairy Products	14.96	6.96	0.465	28-29
Preserved Fruits	13.81	5.33	0.386	18
Grain Mill Products	25.78	7.59	0.294	5
Bakery Products	13.23	7.04	0.532	52
Sugar, Confectionery	21.10	7.67	0.363	13
Fats and Oils	15.02	5.84	0.389	19-20
Beverages	21.70	7.73	0.356	12
Misc. Foods Kindred	21.52	6.91	0.321	8
Tobacco Products	27.06	5.85	0.216	2
Weaving Mills, Cotton	8.01	5.04	0.630	115
Weaving Mills, Manmade	8.49	5.32	0.627	114
Weaving, Finished, Wool	10.25	5.67	0.553	66
Narrow Fabric Mills	8.18	5.08	0.621	107-108
Knitting Mills	7.96	4.72	0.593	85
Textile Finishing	9.63	6.21	0.645	124
Floor Covering Mills	13.75	5.77	0.420	24
Yarn and Thread Mills	7.94	4.65	0.586	83
Miscellaneous Textiles	10.98	6.15	0.560	68-69
Men's and Boys' Suits	7.71	5.25	0.681	134
Men's and Boys' Furnishings	6.33	3.86	0.609	101-102
Women's and Misses' Out.	7.78	4.66	0.600	89
Women's, Children's Under.	7.64	4.29	0.561	70
Hats, Caps,and Millinery	6.93	4.68	0.676	132
Children's Outerwear	6.87	4.17	0.607	97-99
Fur Goods	13.79	7.52	0.545	60-62
Misc. Apparel and Accs.	7.21	4.42	0.612	104-105
Misc. Fabricated Textile	8.43	5.01	0.594	86
Logging Camps	9.85	5.27	0.535	56
Sawmills and Planning Mills	8.28	5.27	0.637	119-120
Millwork, Plywood, Struc.	9.78	6.43	0.658	127
Wood Containers	7.62	4.74	0.622	109
Misc. Wood Products	9.08	5.33	0.587	84

Household Furniture	8.90	5.37	0.603	90
Office Furniture	13.58	7.16	0.528	50-51
Public Bldg., Related Furn.	10.34	6.52	0.631	116-118
Partitions and Fixtures	12.23	7.42	0.607	97-99
Misc. Furniture and Fixt.	10.24	6.20	0.605	91-94
Pulpmills	22.10	9.24	0.418	23
Papermills, Building Paper	16.83	8.98	0.534	54-55
Paperboard Mills	22.52	8.93	0.396	21
Misc. Converted Paper	15.18	7.06	0.465	28-29
Paperboard Cont. Boxes	11.62	7.04	0.606	95-96
Building Paper, Board Mill	15.70	7.95	0.506	40
Newspapers	12.46	7.25	0.582	78-79
Periodicals	23.62	8.79	0.372	14
Books	20.39	7.84	0.385	17
Misc. Publishing	13.42	6.91	0.515	47-48
Commercial Printing	11.93	7.71	0.647	125
Manifold Business Forms	16.00	7.61	0.476	30
Greeting Card Publishing	62.05	28.18	0.454	26
Blankbooks and Bookbinding	9.45	6.05	0.640	121-122
Printing Trade Services	12.88	9.30	0.722	138
Industrial Inorganic Chem	31.16	9.53	0.306	6
Plastic Materials, Syn.	27.57	10.72	0.389	19-20
Drugs	34.55	8.99	0.260	4
Soaps, Cleaners, Toilet	40.56	7.92	0.195	1
Paints, Allied Products	19.95	8.29	0.416	22
Industrial Organic Chem.	17.08	6.39	0.374	15
Agricultural Chem.	22.01	6.85	0.311	7
Misc. Chemicals	17.97	7.93	0.441	25
Petroleum Refining	44.47	10.4	0.234	3
Paving and Roofing Mat.	17.20	7.88	0.458	27
Misc. Petroleum, Coal Prod.	26.80	8.64	0.323	9
Tires and Inner Tubes	19.67	9.75	0.496	38
Rubber, Plastic Footwear	8.42	5.61	0.667	129-131
Reclaimed Rubber	13.76	8.41	0.611	103
Fabricated Rubber	12.29	7.46	0.607	97-99
Misc. Plastics	11.80	6.35	0.538	57
Leather Tanning	10.40	6.78	0.652	126
Industrial Leather Belting	11.67	6.44	0.552	65
Boot, Shoe Cut Stock	7.97	4.75	0.596	88
Footwear, Expt. Rubber	7.67	4.64	0.605	91-94
Leather Gloves	5.76	3.92	0.680	133
Luggage	8.69	4.93	0.568	72-73
Handbags and Purses	7.57	4.87	0.643	123
Leather Goods	7.46	4.70	0.631	116-118

Flat Glass	17.69	9.54	0.539	58
Glass	13.75	7.03	0.511	43
Products of Glass	13.49	6.95	0.515	47-48
Cement, Hydraulic	24.92	8.79	0.353	11
Structural Clay	10.15	6.35	0.626	113
Pottery	9.81	6.48	0.661	128
Concrete, Gypsum, Plaster	14.65	7.18	0.490	36
Cut Stone	8.93	5.96	0.667	129-131
Misc. Nonmetallic Miner.	14.58	7.69	0.528	50-51
Blast Furnance, Steel	16.48	9.56	0.580	77
Iron, Steel Foundries	11.31	8.12	0.718	137
Primary Nonferrous Metals	25.87	8.71	0.337	10
Secondary Nonferrous	15.77	8.05	0.510	42
Nonferrous Rolling	17.06	8.43	0.494	37
Nonferrous Foundries	11.91	7.63	0.640	121-122
Misc. Primary Metal	14.89	9.13	0.613	106
Metal Cans	18.93	9.15	0.483	32
Cutlery, Handtools	14.87	7.55	0.508	41
Plumbing, Heating	13.37	7.34	0.549	64
Fabricated Struc.	12.72	7.74	0.609	101-102
Screw Machine, Bolts	13.96	8.13	0.582	78-79
Metal Forgings, Stamp	13.42	8.55	0.637	119-120
Metal Services	10.63	6.47	0.608	100
Misc. Wire Products	11.12	6.72	0.605	91-94
Misc. Fab. Metal	13.73	7.75	0.564	71
Engines, Turbines	16.00	9.32	0.583	80-81
Farm, Garden Machinery	14.98	8.00	0.534	54-55
Construction Mach.	15.15	8.49	0.560	68-69
Metalworking Mach.	15.11	9.38	0.621	107-108
Special Industry Mach.	13.93	8.45	0.606	95-96
General Industry Mach.	14.71	8.60	0.585	82
Office, Computing Mach.	17.50	8.49	0.485	33
Refrigeration	15.22	7.61	0.500	39
Misc. Machinery	12.50	7.81	0.625	112
Electric Distributing	14.28	7.82	0.547	63
Elect. Industrial	13.51	7.70	0.570	74
Household Appliances	15.01	7.34	0.489	34-35
Elec. Lighting, Wiring	14.09	6.79	0.482	31
Radio, TV Receiving	12.19	6.27	0.514	46
Communication Equip.	13.31	9.30	0.699	135
Electronic Components	10.81	6.74	0.623	110-111
Misc. Elec. Equip.	13.94	7.60	0.545	60-62

Motor Vehicles	18.48	9.47	0.512	44
Aircraft, Parts	14.12	10.10	0.715	136
Ship, Boat Building	10.07	8.12	0.806	139
Railroad Equipment	13.92	8.67	0.623	110-111
Motorcycles, Bicycles	11.35	6.51	0.573	75
Misc. Transport Equip.	10.06	6.09	0.605	91-94
Engineering, Scien. Inst.	13.39	7.80	0.583	80-81
Measuring, Controlling	13.34	7.73	0.579	76
Optical Instruments	13.64	8.61	0.631	116-117
Medical Instruments	14.33	7.01	0.489	34-35
Ophthalmic Goods	11.19	6.20	0.554	67
Photographic Equip.	26.14	9.80	0.375	16
Watches, Clocks	11.16	6.64	0.595	87
Jewelry, Silver	12.25	6.68	0.545	60-62
Musical Instruments	9.55	6.37	0.667	129-131
Toys, Sporting Goods	10.40	5.34	0.513	45
Pens, Office, Art Goods	11.88	6.33	0.533	53
Costume Jewelry	10.23	5.39	0.526	49
Misc. Manufactures	10.95	6.23	0.568	72-73

(1) Units of average value added per employee are in thousands of dollars.

(2) Units of average compensation per employee are in thousands of dollars.

(3) Unit labor costs are defined as compensation/value-added.

TABLE IV-B

U.S. 1980 ISIC Comparative Cost Rankings

INDUSTRY	VALUE/ EMPLOY	COMP/ EMPLOY	UNIT LABOR COSTS	RANK
	(1)	(2)	(3)	
Food Products	47.14	17.76	0.377	5
Beverages	62.89	22.15	0.352	4
Tobacco	105.99	23.33	0.220	2
Textiles	23.45	12.97	0.553	19
Wearing Apparel	17.23	9.57	0.555	20
Leather and Products	21.82	12.01	0.550	18
Footwear	20.30	10.45	0.515	15
Wood Products	25.83	15.21	0.589	24
Furniture, Fixtures	24.61	13.99	0.569	22
Paper and Products	46.05	21.99	0.478	9
Printing, Publishing	35.14	17.36	0.494	11
Industrial Chemicals	58.27	26.88	0.461	8
Other Chemical Products	79.61	22.19	0.279	3
Petroleum Refineries	215.65	34.00	0.158	1
Petroleum, Coal Products	57.76	22.47	0.389	6
Rubber Products	34.47	21.51	0.624	26
Plastic Products n.e.c.	30.92	15.88	0.514	14
Pottery, China, etc.	27.88	16.80	0.603	25
Glass and Products	38.17	21.89	0.573	23
Nonmetal Products n.e.c.	40.89	19.70	0.482	10
Iron and Steel	41.51	29.62	0.714	28
Nonferrous Metals	47.00	24.01	0.511	13
Metal Products	35.82	20.25	0.565	21
Machinery n.e.c.	41.25	22.32	0.541	17
Electrical Machinery	37.26	20.11	0.540	16
Transport Equipment	43.22	28.37	0.656	27
Professional Goods	45.28	20.63	0.456	7
Other Industries	29.62	14.67	0.495	12
All Manufactures	37.48	20.37	0.543	

(1) Units of average value added per employee are in thousands of dollars.

(2) Units of average compensation per employee are in thousands of dollars.

(3) Unit labor costs are defined as compensation/value-added.

TABLE V-B

Japanese 1980 Comparative Cost Rankings

INDUSTRY	VALUE/ EMPLOY	WAGES/ EMPLOY	UNIT LABOR COSTS	RANK
	(1)	(2)	(3)	
Food Products	5.76	1.94	0.336	10
Beverages	11.30	2.53	0.224	4
Tobacco	0	4.63	0	28
Textiles	4.16	1.83	0.439	21
Wearing Apparel	2.33	1.23	0.526	27
Leather and Products	4.19	1.91	0.456	24
Footwear	4.38	2.03	0.463	25
Wood Products	4.33	1.93	0.444	22
Furniture, Fixtures	4.89	2.05	0.418	20
Paper and Products	7.42	2.67	0.359	11
Printing, Publishing	7.70	3.11	0.403	17
Industrial Chemicals	14.72	3.75	0.254	5
Other Chemical Products	17.26	3.33	0.193	2
Petroleum Refineries	51.76	4.34	0.084	1
Petroleum, Coal Products	15.67	3.20	0.204	3
Rubber Products	7.09	2.77	0.391	15
Plastic Products n.e.c.	6.23	2.30	0.370	12
Pottery, China, etc.	4.27	1.99	0.466	26
Glass and Products	10.45	3.11	0.298	8
Nonmetal Products n.e.c.	7.66	2.45	0.319	9
Iron and Steel	13.88	3.76	0.271	6
Nonferrous Metals	11.58	3.15	0.272	7
Metal Products	6.12	2.49	0.407	18
Machinery n.e.c.	7.67	3.06	0.399	16
Electrical Machinery	6.58	2.45	0.372	13
Transport Equipment	8.27	3.14	0.379	14
Professional Goods	5.36	2.38	0.445	23
Other Industries	5.16	2.13	0.414	19
All Manufactures	7.20	2.55	0.355	

(1) Units of average value added per employee are in million yen.

(2) Units of average wage per employee are in million yen.

(3) Unit labor costs are defined as compensation/value-added.

TABLE VI-B

German 1980 Comparative Cost Rankings

INDUSTRY	VALUE/ EMPLOY	COMP/ EMPLOY	UNIT LABOR COSTS	RANK
	(1)	(2)	(3)	
Food Products	97.6	28.3	0.290	3
Beverages	107.8	34.2	0.317	4
Tobacco	551.3	33.0	0.060	1
Textiles	39.8	25.5	0.641	23
Wearing Apparel	40.1	20.0	0.498	10
Leather, Footwear, etc.	42.7	22.8	0.534	13
Wood, Furniture, etc.	63.5	29.9	0.471	8
Paper and Products	54.1	31.4	0.580	18
Printing, Publishing	60.2	35.2	0.585	19
Industrial Chemicals	75.5	40.6	0.538	14
Petroleum Refineries	825.9	50.0	0.061	2
Rubber Products	55.2	32.7	0.592	20
Plastic Products n.e.c.	53.3	29.3	0.549	15
Pottery, China, etc.	56.7	25.0	0.441	6
Glass and Products	59.2	31.4	0.531	12
Nonmetal Products n.e.c.	84.7	34.3	0.405	5
Iron and Steel	67.3	34.9	0.519	11
Nonferrous Metals	42.5	35.0	0.824	24
Metal Products	52.2	32.7	0.626	22
Machinery n.e.c.	57.8	36.1	0.625	21
Electrical Machinery	60.1	33.7	0.560	16
Transport Equipment	66.3	38.3	0.578	17
Professional Goods	67.3	31.0	0.461	7
Other Industries	53.3	25.7	0.481	9
All Manufactures	67.8	33.6	0.495	

(1) Units of average value added per employee are in thousand marks.

(2) Units of average compensation per employee are in thousand marks.

(3) Unit labor costs are defined as compensation/value-added

TABLE VII-B

U.K. 1980 Comparative Cost Rankings

INDUSTRY	VALUE/ EMPLOY	COMP/ EMPLOY	UNIT LABOR COSTS	RANK
	(1)	(2)	(3)	
Food Products	11.46	5.37	0.469	8
Beverages	21.18	6.42	0.303	2
Tobacco	21.67	6.94	0.320	3
Textiles	6.68	4.70	0.704	25
Wearing Apparel	5.35	3.90	0.729	26
Leather and Products	7.50	4.78	0.637	21
Footwear	7.12	4.80	0.674	24
Wood Products	9.62	5.59	0.581	13
Furniture, Fixtures	9.32	5.97	0.641	22
Paper and Products	10.50	6.24	0.594	18
Printing, Publishing	13.40	6.93	0.517	9
Industrial Chemicals	17.12	7.89	0.461	7
Other Chemical Products	17.55	6.15	0.350	4
Petroleum Refineries	114.12	9.35	0.082	1
Petroleum, Coal Products	19.38	7.00	0.361	5
Rubber Products	10.52	6.21	0.590	16
Plastic Products n.e.c.	10.46	5.76	0.551	11
Pottery, China, etc.	7.64	5.05	0.661	23
Glass and Products	11.48	6.80	0.592	17
Nonmetal Products n.e.c.	16.44	6.45	0.392	6
Iron and Steel	7.75	6.53	0.843	28
Nonferrous Metals	11.33	6.62	0.584	14
Metal Products	9.75	6.00	0.615	20
Machinery n.e.c.	11.09	6.29	0.567	12
Electrical Machinery	9.83	5.80	0.590	15
Transport Equipment	9.05	6.61	0.730	27
Professional Goods	9.50	5.65	0.595	19
Other Industries	9.17	4.93	0.538	10
All Manufactures	10.89	6.02	0.553	

(1) Units of average value added per employee are in thousand pounds.

(2) Units of average compensation per employee are in thousand pounds.

(3) Unit labor costs are defined as compensation/value-added.

TABLE VIII-B

Italian 1980 Comparative Cost Rankings

INDUSTRY	VALUE/ EMPLOY	COMP/ EMPLOY	UNIT LABOR	RANK
	(1)	(2)	(3)	
Food Products	30.96	13.83	0.447	3
Beverages	43.39	15.64	0.360	2
Tobacco	13.15	9.85	0.749	23
Textiles	19.43	10.86	0.559	15
Wearing Apparel	15.92	9.27	0.582	17
Leather and Products	21.96	10.57	0.481	6
Footwear	15.42	9.04	0.586	18
Wood Products	22.14	10.69	0.483	7
Furniture, Fixtures	22.11	10.89	0.493	8
Paper and Products	28.90	14.43	0.499	10
Printing, Publishing	29.70	16.94	0.570	16
Industrial Chemicals	34.20	16.25	0.475	5
Petroleum Refineries	601.11	19.42	0.032	1
Rubber Products	24.52	15.14	0.618	21
Plastic Products n.e.c.	16.96	12.82	0.756	24
Pottery, China, etc.	26.86	12.65	0.471	4
Iron and Steel	29.81	14.85	0.498	9
Nonferrous Metals	22.52	13.86	0.615	20
Metal Products	23.53	12.77	0.543	12-13
Machinery n.e.c.	26.19	14.21	0.543	12-13
Electrical Machinery	21.83	13.41	0.614	19
Transport Equipment	21.06	13.44	0.638	22
Professional Goods	27.19	14.72	0.541	11
Other Industries	20.16	11.03	0.547	14
All Manufactures	24.65	13.25	0.537	

(1) Units of average value added per employee are in hundred thousand lira.

(2) Units of average compensation per employee are in hundred thousand lira.

(3) Unit labor costs are defined as compensation/value-added.

TABLE IX-B

U.S. 1967 Comparative Cost Rankings

INDUSTRY	VALUE/ EMPLOY	COMP/ EMPLOY	UNIT LABOR COSTS	RANK
	(1)	(2)	(3)	
Food Products	15.58	5.99	0.384	7
Beverages	19.95	6.87	0.344	4
Tobacco	27.07	5.07	0.187	1
Textiles	8.79	4.71	0.536	21
Wearing Apparel	7.25	4.05	0.558	25
Leather and Products	8.78	5.00	0.570	26
Footwear	7.69	4.22	0.549	23
Wood Products	8.88	5.10	0.574	27
Furniture, Fixtures	9.27	5.15	0.555	24
Paper and Products	15.27	6.95	0.455	11
Printing, Publishing	13.93	6.94	0.498	15
Industrial Chemicals	26.78	7.84	0.293	3
Other Chemical Products	22.42	8.19	0.365	5
Petroleum Refineries	44.30	8.97	0.203	2
Petroleum, Coal Products	19.43	7.14	0.368	6
Rubber Products	14.45	6.98	0.483	13
Plastic Products n.e.c.	11.79	5.71	0.485	14
Pottery, China, etc.	9.77	5.81	0.595	28
Glass and Products	14.32	6.60	0.461	12
Nonmetal Products n.e.c.	14.55	6.52	0.448	9
Iron and Steel	15.04	7.85	0.522	19
Nonferrous Metals	16.62	7.37	0.444	8
Metal Products	13.38	6.90	0.516	18
Machinery n.e.c.	14.80	7.57	0.511	17
Electrical Machinery	13.22	6.96	0.526	20
Transport Equipment	15.35	8.26	0.538	22
Professional Goods	15.83	7.15	0.452	10
Other Industries	10.76	5.39	0.501	16
All Manufactures	14.18	6.68	0.471	

(1) Units of average value added per employee are in thousands of dollars.

(2) Units of average compensation per employee are in thousands of dollars.

(3) Unit labor costs are defined as compensation/value-added.

TABLE X-B

Japanese 1967 Comparative Cost Rankings

INDUSTRY	VALUE/ EMPLOY	WAGES/ EMPLOY	UNIT LABOR COSTS	RANK
	(1)	(2)	(3)	
Food Products	1.29	0.39	0.304	10
Beverages	2.21	0.44	0.198	4
Tobacco	0	0.91	0	28
Textiles	0.99	0.37	0.371	18
Wearing Apparel	0.71	0.30	0.418	25
Leather and Products	1.24	0.47	0.383	21
Footwear	1.17	0.46	0.393	23
Wood Products	0.99	0.39	0.391	22
Furniture, Fixtures	0.97	0.42	0.427	26
Paper and Products	1.62	0.52	0.320	13
Printing, Publishing	1.73	0.65	0.375	19
Industrial Chemicals	3.77	0.71	0.187	2
Other Chemical Products	3.18	0.60	0.188	3
Petroleum Refineries	7.86	0.86	0.109	1
Petroleum, Coal Products	2.00	0.53	0.267	6
Rubber Products	1.50	0.48	0.322	14
Plastic Products n.e.c.	1.33	0.45	0.338	15
Pottery, China, etc.	0.88	0.40	0.453	27
Glass and Products	2.28	0.58	0.254	5
Nonmetal Products n.e.c.	1.57	0.47	0.301	9
Iron and Steel	2.55	0.76	0.299	8
Nonferrous Metals	2.40	0.67	0.282	7
Metal Products	1.36	0.52	0.379	20
Machinery n.e.c.	1.63	0.59	0.359	17
Electrical Machinery	1.58	0.49	0.312	11
Transport Equipment	1.96	0.62	0.316	12
Professional Goods	1.26	0.52	0.417	24
Other Industries	1.17	0.42	0.355	16
All Manufactures	1.59	0.51	0.319	

(1) Units of average value added per employee are in million yen.

(2) Units of average wage per employee are in million yen.

(3) Unit labor costs are defined as wages/value-added.

TABLE XI-B

German 1967 Comparative Cost Rankings

INDUSTRY	OUTPUT/ EMPLOY	WAGES/ EMPLOY	UNIT LABOR COSTS
	(1)	(2)	(3)
Food Products	113.6	10.8	0.095
Beverages	80.9	12.1	0.149
Tobacco	264.7	9.7	0.037
Textiles	39.8	9.2	0.232
Wearing Apparel	30.7	7.4	0.240
Leather and Footwear	34.0	8.1	0.239
Wood Products,Furniture	42.8	10.4	0.242
Paper and Products	49.7	11.0	0.222
Printing, Publishing	32.5	12.0	0.370
Industrial Chemicals	71.2	14.3	0.201
Petroleum Refineries,Coal	430.3	16.7	0.039
Rubber Products	41.3	13.0	0.316
Plastic Products n.e.c.	41.6	11.8	0.283
Pottery, China, etc.	25.3	9.9	0.390
Glass and Products	37.5	11.5	0.306
Nonmetal Products n.e.c.	50.0	12.2	0.244
Iron and Steel	50.6	12.4	0.246
Nonferrous Metals	67.3	12.4	0.184
Metal Products	39.8	11.5	0.288
Machinery n.e.c.	38.3	12.3	0.321
Electrical Machinery	36.0	11.5	0.319
Transport Equipment	48.9	13.6	0.277
Professional Goods	27.2	10.3	0.381
Other Industries	31.7	8.9	0.280
All Manufactures	49.7	11.6	0.233

(1) Value added data were not available for Germany in 1967. Instead, gross output was substituted in an attempt to obtain a ranking system. Units of average gross output per employee are in thousand marks.

(2) Units of average wage per employee are in thousand marks.

(3) Unit labor costs are defined as compensation/gross-output.

Table XII-B

Comparative Rankings of U.S., Japanese, German, U.K., and Italian Manufacturing Industries in 1980

Industry	U.S.	JAPAN	GERMANY	U.K.	ITALY
Food Products	5	10	3	8	3
Beverages	4	4	4	2	2
Tobacco	2	28	1	3	23
Textiles	19	21	23	25	15
Wearing Apparel	20	27	10	26	17
Leather and Products	18	24	13	21	6
Footwear	15	25	-	24	18
Wood Products	24	22	8	13	7
Furniture, Fixtures	22	20	-	22	8
Paper and Products	9	11	18	18	10
Printing, Publishing	11	17	19	9	16
Industrial Chemicals	8	5	14	7	5
Other Chemical Products	3	2	-	4	-
Petroleum Refineries	1	1	2	1	1
Petroleum, Coal Product	6	3	-	5	-
Rubber Products	26	15	20	16	21
Plastic Products n.e.c.	14	12	15	11	24
Pottery, China, etc.	25	26	6	23	4
Glass and Products	23	8	12	17	-
Nonmetal Products	10	9	5	6	-
Iron and Steel	28	6	11	28	9
Nonferrous Metals	13	7	24	14	20
Metal Products	21	18	22	20	12-13
Machinery n.e.c.	17	16	21	12	12-13
Electrical Machinery	16	13	16	15	19
Transport Equipment	27	14	17	27	22
Professional Goods	7	23	7	19	11
Other Industries	12	19	9	10	14

APPENDIX C

An Extension and Empirical Test of Comparative Advantage

This section extends and tests empirically Deardorff's (1980) formulation of comparative advantage. He developed a general model of comparative advantage whose conclusion is that there must exist a negative correlation between a country's autarky prices and its pattern of net exports. This is demonstrated in his theorem below.

If $P^a * T_n \leq 0$, (1)

where P^a is a vector of autarky prices and T is net exports for n industries, then

$cor(x_1, x_2) \leq 0$ as $x_1 * x_2 \leq 0$.

The assumptions of the model are (1) the production possibilities set, given its technology, is closed, convex, and bounded from above; (2) a country's preferences can be represented by a family of community indifference curves exhibiting the property of local nonsatiation; (3) producers and consumers behave competitively to maximize the value of net output and utility of consumption; and (4) no trade subsidies exist.

The significance of this model lies in the assumptions that were not made, namely that: (1) utility and production functions are not assumed to be differentiable; (2) utility functions need not be homothetic; and (3) neither functions are assumed to be identical across countries. Thus, countries can differ in tastes, technologies, and factor endowments.

Deardorff extends the model by examining the ratio of autarky to world prices,

$$\rho_j = P^a{}_j/P^w{}_j \qquad j=1,\dots n; \tag{2}$$

where P^a and P^w are autarky and world prices respectively and j is the industries. Next consider a country's net exports valued at world prices,

$$e_j = P^w{}_j{*}T_{nj}. \tag{3}$$

Then assuming balanced trade,

$$\Sigma e_j = P^w{}_j{*}T_{nj} = e. \tag{4}$$

By examining the product $\rho{*}e$, we obtain

$$\rho{*}e = \Sigma P^a{}_j/P^w{}_j * P^w{}_j{*}T_{jn} = \Sigma P^a{}_j{*}T_{nj} = P^a{*}T_n.$$

Thus, from the theorem in equation 1,

$$cor(\rho,e) \leq 0. \tag{5}$$

This is Deardorff's first corrollary.

We can now extend the model by examining a competitive market where $P^h{}_j = MC_j$. $P^h{}_j$ is the domestic price of good j. If we define a production function employing two factors, capital-K, and labor-L,

$$Q_j = f(K_j,L_j). \tag{6}$$

Then by allowing the production function to be differentiable,

$$MC_j = w_j/MP_{lj} = r_j/MP_{kj}. \tag{7}$$

Multiplying through to obtain factor prices and factor costs,

$$MP_{lj}*MC_j = w_j \quad \text{and} \quad MP_{lj}*L_j*MC_j = w_j*L_j \tag{8}$$

$$MP_{kj}*MC_j = r_j \quad \text{and} \quad MP_{kj}*K_j*MC_j = r_j*K_j. \tag{9}$$

By adding the two equations to derive total factor costs,

$$MC_j*(MP_{lj}*L_j + MP_{kj}*K_j) = w_j*L_j + r_j*K_j, \tag{10}$$

and

$$MC_j = (w_j*L_j + r_j*K_j)/(MP_{lj}*L_j + MP_{kj}*K_j). \tag{11}$$

Multiplying through by Q_j/Q_j,

$$MC_j = [(w_j*L_j + r_j*K_j)/Q_j]*[Q_j/(MP_{lj}*L_j + MP_{kj}*K_j)]. \tag{12}$$

This simplifies into equation 13, where $MC = \sum MC_j$.

$$MC = AC/(\text{function coefficient}) = P^h, \tag{13}$$

and P^h is the vector of home prices.

If the function coefficient (fc) is greater than one, then increasing returns to scale hold. Similarly if fc = 1, constant returns to scale hold, and if fc < 1, then decreasing returns.

If, as an approximation, we assume that $P^h = P^a$, then substituting equation 13 into equation 5 yields,

$$\text{cor}\{(AC^h/AC^w)*(fc^w/fc^h),e\} \leq 0. \tag{14}$$

This formulation provides a method of testing trade theories of scale economies within a comparative cost framework. Due to the unavailability of world functional coefficient data, the empirical testing of this hypothesis required the assumption that fc^w be equal to fc^h. This assumption is not unreasonable since the H-O hypothesis assumes both identical production functions across countries and constant returns to scale, while the Ricardian model assumes the latter. Thus, compared to the standard trade theories, the assumption that $fc^w = fc^h$ is more flexible. Although economies of scale must be equal in the same industry worldwide, they do not have to be equal to one and can vary among industries.

The average costs of an industry is approximated by relative unit labor costs. These are defined as an industry's unit labor costs relative to average in all other industries. In turn, unit labor costs consist of labor productivity per employee and labor compensation per employee.

Since this dissertation examines five countries, the United States, Japan, Germany, the United Kingdom, and Italy, a weighted average of these will approximate world costs. The weights are value added as a percentage of world value added, thus reflecting the relative importance of a country's unit labor cost in an industry. The weights are as follows:

$$(V_{ji} / \sum_{j=1}^{n} V_{ji}) / \sum_{i=1}^{m} (V_{ji} / \sum_{j=1}^{n} V_i), \qquad (15)$$

where V_{ji} is the value added of industry j in country i for m countries and n industries.

The sign of equation 14 can be derived from the sign of the covariance between the vectors where,

$$cor(U^h/U^w, e) = \frac{cov(U^h/U^w, e)}{[var(U^h/U^w) + var(e)]**.5} \qquad (16)$$

Since the denominator is nonnegative, the correlation and covariance must have the same sign. Although only the covariance matrix is needed for testing the Deardorff model, both will be presented in Table C1 with net exports specified both as exports minus imports and as a ratio.

The results of the covariance matrix yielded the expected sign in eight of the ten cases. For the two cases where the wrong sign occured, the correlation matrix indicated a weaker magitude compared with the alternate specification of net exports. Considering the multitude of factors determining trade flows, these results strongly support the extension of the Deardorff model.

The conclusion is that comparative advantage, based on relative unit labor costs, is an important determinate of net exports. This extension of Deardorff's model uses less restrictive assumptions than the standard trade models, provides a comparative cost framework for testing scale economies, and fits the data well. Thus, it should be considered in further studies of the determinants of international trade flows.

Table C1

Covariance and Correlation Matrices Between
Net Exports and Relative Unit Labor Costs
for 1980.

Covariance Matrix

Country	X-M	X/M
Germany	276978.8	-0.04185
Italy	-31.8994	-0.00773
U.S.	-162.164	0.02656
Japan	-315279	-0.22299
U.K.	-66.891	-0.01674

Correlation Matrix

Country	X-M	X/M
Germany	0.16276	-0.21068
Italy	-0.14355	-0.12525
U.S.	-0.27454	0.15516
Japan	-0.23181	-0.27515
U.K.	-0.26251	-0.18855

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