

The Leontief Paradox and Industry Specialization in the United States

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Introduction

The famous Leontief paradox on the U. S. trade structure has been repeatedly discussed by international economists. The original Leontief study (1954) was an application of the input-output analysis created by Leontief himself to the U.S trade structure using actual 1947 data. Since then, there have been many papers to interpret Leontief's result and to show new results with new data. Until now, two principal analytical methods have been used on this problem: Leontief's input-output analysis, and regression. In this paper, I shall analyze the U. S. trade structure by using data from the 1977 U. S. input-output tables and applying both of these methods.

Another purpose of this paper is to discuss a feature of the U. S. trade structure that has been implicit in many studies on the Leontief paradox: the diversity of relations between factor intensity in each industry and industry specialization in production (pattern of comparative advantage). The explanatory power of the Heckscher-Ohlin theory seems weak, if not erroneous, for the outputs of most individual industries deviate from the theoretical prediction. In this paper, I shall introduce the notion of the substitutability of labor supply among various types of labor, and show that it clarifies some points related to that diversity.

In Section I, the Leontief paradox will be discussed briefly, and the U. S. trade structure will be reexamined, using 1977 data. In Section II, the diversity within the U. S. trade structure will be discussed both the-

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oretically and empirically. The last section summarizes with concluding remarks.

I. The U. S. Trade Structure and the Leontief Paradox

A. THE HECKSCHER-OHLIN THEORY AND THE LEONTIEF PARADOX

The standard international trade theory is the Heckscher-Ohlin (H-O) theorem. This theory insists that a country's trade pattern and industry specialization tends to be determined by its relative factor endowments compared with other countries. In any case, a relatively capital-abundant country tends to export capital-intensive goods that require relatively more capital in the production process. On the contrary, a relatively labor-abundant country tends to export relatively labor-intensive goods.

In this context, most economists in the 1950s had taken it for granted that the U. S. was the most capital-abundant country in the world, so that, they conjectured, it should export relatively more capital-intensive goods to the world. This expectation was disproved by Leontief's comprehensive empirical study (Leontief 1954). This study, which was one of the first applications of Leontief's own input-output analysis, revealed that, according to the 1947 data, the U. S. economy was not exporting relatively capital-intensive goods but relatively labor-intensive ones. The implication of this result was that the U. S. economy was a labor-abundant country when compared with the rest of the world. Since this was in contradiction to most economists' views, it came to be known as the Leontief paradox.

One important defect in Leontief's study was that 1947 was not a typical year if one wanted to study the U. S. structure of production and trade, because the rest of the world had not recovered from the economic ravages of World War II. To counter this criticism, Leontief (1956) reexamined the U. S. trade structure using the 1951 trade data. He again found that the U. S. import replacements were more capital-intensive than the U. S. exports. Later, Baldwin (1971) also came up with the same result using 1962 trade data.

Many economists, including Leontief himself, tried to interpret this apparent paradox rationally. Leontief's answer was that the United States was really characterized as a labor-abundant country when we measured its labor supply not in terms of a physical unit (the number of

workers or man-hours) but in terms of an efficiency unit. The high labor productivity in the United States increased the effective amount of labor supply far beyond its statistical figure, and this brought about the apparent paradox, he concluded.

Several other interpretations were also presented. For example, a bias in the pattern of U. S. final demands could induce the paradox, because if the U. S. demand for goods was biased toward more capital-intensive goods than the country produced, it would not export but import capital-intensive goods from abroad, even if it produced relatively more capital-intensive goods than the rest of the world did. A bias in the endowments of natural resources was another candidate for the cause. In fact, abundance in natural resources is an important characteristic of the U. S. economy, and both Leontief (1956) and Baldwin (1971) could show that U. S. exports were slightly more capital-abundant than imports, if natural-resource-intensive industries were excluded from the test. Also, the notion of "factor intensity reversal" was invented as a possible theoretical explanation of the paradox.

We probably cannot regard the Leontief paradox as a firmly established fact, however. Stern and Maskus (1981) insisted, using 1972 data, that the Leontief paradox had vanished. Leamer (1980) presented a new interpretation of Leontief's original analysis, in which Leamer argued that the proper comparison of factor contents should not have been between exports and imports, particularly when a country's trade was not in balance. According to Leamer, Leontief should have made a comparison between net exports and domestic expenditure, since the U. S. was a net exporter in 1947 of both capital services and labor services. His reevaluation of the Leontief paradox using Leontief's original data showed the U. S. economy was not labor abundant but capital abundant. However, Leamer could not reject Baldwin's finding that the Leontief paradox held for 1962 data.

B. REEXAMINATION OF THE LEONTIEF PARADOX USING 1977 DATA

Our first task in this paper is to reexamine the Leontief paradox using 1977 data as found in U. S. input-output tables. The data used in this section was obtained from the 85-industry-level input-output tables.

Before we turn to the empirical analysis, we have to bear some points in mind. In 1977 both the U. S. current balance and the merchandise trade balance were in deficits. However, according to the 1977 input-

output tables, total U. S. exports slightly exceeded total imports. This is simply due to the difference in the definition and coverage of exports and imports. If we exclude special commodities (commodity numbers 80 through 85), such as non-comparable imports and "rest-of-the-world industry," the net export figure turns into a deficit again. Also, if we confine our examination to manufactures, the deficit in U. S. trade increases to \$17.6 billions. Thus, in 1977 the era of huge U. S. trade surpluses was already over.

When trade is not in balance, Leamer (1980) reasoned, it is not appropriate to compare the factor contents of exports with those of imports. In order to decide whether the country is relatively capital abundant or labor abundant, we have to make a comparison between domestic production and domestic consumption (domestic demand). Leamer has shown that this comparison is always appropriate irrespective of whether trade is in surplus, in deficit, or in balance. In this paper, therefore, we shall use this as a standard criterion when examining the U. S. trade structure.

Denote capital embodied in exports, imports, total domestic output, and total domestic consumption by K_x , K_m , K_p , and K_c , and labor embodied in exports, imports, total domestic output, and total domestic consumption by L_x , L_m , L_p , and L_c , respectively. Leamer's criteria may then be summarized as follows:

First, a country is revealed to be capital abundant if and only if its production is more capital intensive than its consumption:

$$K_p / L_p > K_c / L_c \quad (1)$$

Second, when a country is an exporter of both labor services and capital services, it is revealed by trade to be relatively capital abundant, if trade is more capital intensive than production:

$$(K_x - K_m) / (L_x - L_m) > K_p / L_p \quad (2)$$

Third, if a country is an importer of both factor services, the inequality condition is reversed:

$$(K_x - K_m) / (L_x - L_m) < K_p / L_p \quad (3)$$

Last, if the net export of capital services and the net export of labor services are opposite in sign, then the factor with positive net exports is shown to be the relatively abundant factor.

The results of my calculation using 1977 85-industry-level input-output data are summarized in tables 1 and 2.

Table 1
Factor Service Contents of U. S. Trade and Production
Total Industries (1977)

	Capital Service mil \$	Labor Service mil \$	Capital / Labor
Production	632544.4	968061.6	0.653
Consumption	644646.6	963127.4	0.669
Export	52881.2	77895.1	0.679
Import	64983.4	72960.9	0.891
Net Export	-12102.2	4934.2	

Data source: U. S. Department of Commerce (1984a).

Table 2
Factor Service Contents of U. S. Trade and Production
Manufacturing Industries (1977)

	Capital Service mil \$	Labor Service mil \$	Capital / Labor
Production	186007.6	336498.4	0.553
Consumption	191761.5	347222.0	0.552
Export	33186.8	54589.4	0.571
Import	36940.7	65313.1	0.566
Net Export	-5753.9	-10723.7	0.537

Data source: U. S. Department of Commerce (1984a).

First, note that all factor contents are measured in dollars. Thus, labor service content is also measured in dollars, in spite of the convention after Leontief of measuring it by worker-year unit. Accordingly, the capital labor ratio is an absolute number. It would perhaps be desirable to make an estimate, à la Leontief; in this sense, my empirical evaluation should be considered preliminary.

Table 1 shows that the U. S. imports capital services and exports labor

services. According to Leamer's last criterion, the U. S. should be a labor-intensive country. In fact, the capital/labor ratio calculated from factor service content of U. S. import (0.891) is larger than that of U. S. export (0.679). This conclusion is also confirmed by comparing its capital/labor ratio between production (0.653) and consumption (0.669), though the difference between the two is very small. This reconfirmation of the Leontief paradox is in contradiction to the conclusions of Leamer and of Stern and Maskus.

If we confine our examination to manufacturing industries, the conclusion is reversed again by a slight margin (Table 2). As for U. S. manufactures, net export is in deficit for both capital services and labor services. In this case, Leamer's third criterion, inequality (3), is to be used, and we find the U. S. manufacturing industries are relatively capital intensive as a whole, because capital intensity is larger for production (0.553) than for net export (0.537). This is confirmed by the fact that the capital intensity of production is also larger than that of consumption (0.552). However, the differential is minimal.

Why did I make two different comparisons in regard to the relative factor abundance of the U. S.? Does it make sense to confine the calculation to manufacturing industries? Why have the two tables shown apparently contradictory results?

Suppose a linearity relationship holds between the industries' output and the capital/labor ratio. That is, suppose, between any two industries, the industry with the larger capital/labor ratio is exporting a larger part of its output, provided the country is a capital-abundant one. This is the situation that was assumed by the "chain rule" proposition of Jones (1957). If this rule were correct, the calculation in tables 1 and 2 should have shown a consistent result for the industry specialization. However, the "chain rule" does not actually hold. This is why it is possible, in principle, for the two calculations to show contradictory results.

At least two interesting facts show up in the tables. First, manufacturing industries seem to have, on the average, a smaller capital/labor ratio than the rest of the industries. To see this, compare the capital/labor ratio of total industries (0.653) with that of manufacturing (0.552). Thus, manufacturing industries are, on the average, less capital intensive than the rest of the industries. However, this seems to contradict the facts that relatively labor-intensive goods have a comparative advantage in the U. S. and that the total industries show a net export surplus, but manu-

facturing industries a deficit. Secondly, a specialization seems to have occurred toward relatively more capital-intensive industry within manufacturing industries. This is another paradoxical result.

Thus, the results seem to show that the direction of actual specialization is not uniform over all industries. How can such patterns occur? My assumption is that the answer is closely related to the various degrees of factor mobility among industries. I shall discuss this problem in the next section.

II. Labor Mobility and Specialization in Production

A. THEORETICAL PROBLEMS

Though the Heckscher-Ohlin (H-O) theory still has the status of the standard international trade theory, it also has several defects when applied to empirical examinations of real world trade. Let us discuss some issues of the H-O theory in this section.

The first point to be stressed is the inflexibly strict condition of the H-O model that the number of goods (industries) be equal to the number of factors of production. As is well known, solving the model is impossible or indeterminate when this condition is not met. Since the number of industries or factors is more or less an arbitrary matter for an empirical industry classification work, this strict condition is undesirable.

This problem relates to substitutability among products or, particularly, among factors of production. (I shall use the term "substitutability" in a broader sense to imply both the substitutability on the demand side and the transformability on the supply side.) Several types of labor are usually more or less close substitutes for one another. For example, several types of simple labor are very close substitutes, however they may be classified. Clerical labor is a substitute for sales labor, though the substitutability is imperfect. Types of intellectual labor are probably less close mutual substitutes. Substitutability between intellectual labor and simple labor is very low. This more or less imperfect substitutability between factors makes it possible for us to classify factors into any detailed divisions desired, depending on our arbitrary purposes. Therefore, it is desirable that a trade theory be able to accept any number of factors (and goods), depending on research purposes, without changing its essential feature.

The second point relates to the relevance of the so-called chain rule

mentioned in the previous section. The chain rule is a proposition on the extension of the H-O theory from the original two-by-two model to the many-goods many-factors model. According to Jones (1957), his presumption was as follows: "Ordering the commodities with respect to the capital/labor ratios employed in production is to rank them in order of comparative advantage. Demand conditions merely determine the dividing line between exports and imports; it is not possible to break the chain of comparative advantage by exporting, say, the third and fifth commodities and importing the fourth when they are ranked by factor intensity" (p.85). In other words, this chain rule asserts that the order of the commodities with respect to their capital/labor ratios coincides with the order with respect to the net export ratios. However, this chain rule proposition has been rejected theoretically by Bhagwati (1972).

Besides, Leamer (1984) has shown the theoretical possibility of a relationship that is, in a sense, contrary to the chain rule. According to Leamer, "... commodities produced by similar production processes can be expected to have outputs that are negatively correlated, not positively correlated" (p.80). In other words, production specialization tends to occur more pronouncedly between industries that require more similar capital/labor ratios in their production processes. This was a logical consequence of the extended many-goods many-factors H-O model. This conclusion means there cannot be a linearity correspondence between the order of the capital/labor ratio and that of the net export ratio.

Nevertheless, Leamer's reasoning is not satisfactory from the viewpoint of empirical studies, even if it is correct in the theoretical framework of the H-O theory, and this was also Leamer's own judgment on the matter. The conclusion above means that, the more similar the industries' production processes are, the more dissimilar are the extents of their specialization and the patterns of their net export. This theoretical result seems inconsistent with reality. After all, in his book (1984), where Leamer has carried out a comprehensive empirical study on the international trade structure, he himself could form "clusters" of similar industries, and he could show net exports of industries within each cluster had more or less similar patterns. However, there remained some non-negligible diversification within clusters. That is, when most of industries within a cluster exported (imported) their goods, there were usually some industries with net import (export) or exceptionally low export (import). Therefore, the truth seems to lie somewhere between

the chain rule and extreme specialization among similar industries. This diversity of trade pattern is among the facts that have attracted considerable attention recently.

In this context, a theory was developed around 1980: the monopolistic competition theory of intra-industry trade; it was developed by Krugman (1979, 1981) and Lancaster (1980), among others. It is meant to explain the intra-industry trade that has flourished among developed countries with similar factor endowments. For example, Krugman explains bidirectional trade within each industry as follows: Suppose firms within an industry produce similar but mutually differentiated products and their production processes are under internal scale economy (decreasing cost). By the opening of trade between two countries, each firm in the two countries now confronts a larger market for its product, which in turn induces some of the firms to expand their production to exploit scale economy, and other firms to suspend their production as a result of competition. In this way the industry's firms in each country, now producing more efficiently on larger scales, come to export their differentiated goods to the other country's market in addition to their own.

This is a good theory in that it can explain several stylized facts in regard to modern international trade among developed countries. Still, I would point out that this theory's explanation of specialization is based on the behavior of individual firms. In other words, the intra-industry trade explained by this theory is not that within a roughly defined industry group but that within the most detailed level of industry classification—individual firms. Accordingly, this theory cannot really explain the specialization that we find within Leamer's "clusters."

In the previous section, one of the paradoxical results we found was in regard to the direction of specialization among U. S. industries. This is related to the discussion above and to the inter- and intra-group specialization defined below. The following discussion is to provide a possible explanation that might serve as a substitute for the monopolistic competition theory.

B. LIMITED SUBSTITUTABILITY AMONG DIFFERENT TYPES OF LABOR

Usually industries are classified into groups according to some criterion of "similarity" of industries, however the similarity may be defined. I assume that we can identify several groups of industries that consist of

“similar” ones. Here the “similarity” of two industries is defined as a relatively high mobility of factors (particularly of labor) between the two. Thus, the similarity of two industries in turn means a high substitutability (transformability) of factor supply between the two. The following is a brief description of the model developed elsewhere more rigorously (Nishimura 1990), which introduced the notion of imperfect substitutability among factor supplies into the traditional H-O theory.

Assume there are two basic factors of production: capital and labor. Capital is assumed to be homogeneous and used in all industries, so capital is perfectly mobile among industries. On the other hand, we assume labor is heterogeneous, and one specific type of labor is used in one industry. But different types of labor are assumed to be more or less substitutable (transformable) in their supply. For example, an engineer can move from a given industry to a different industry when the new one offers a higher wage. This means one type of engineering labor was transformed into another type. This substitutability is imperfect; that is, mobility of labor between two types is usually not so high as to make the wage differential vanish.

Firms in each industry use capital and its specific labor in a technologically predetermined ratio (capital/labor ratio) to produce their goods. If the rental of capital and the industry’s wage rate (of its specific type of labor) are given, the price of the industry’s product can be determined. As a result, the production level of each industry will be determined when the labor supply of each type is given. On the contrary, if prices of all goods, the capital/labor ratios of all industries, and the labor-supply frontier of the economy are all given, the factor prices (the rental of capital and the wage rate) and the production levels can be determined in all industries in our model. Here, the fact that the labor supply frontier is given means that the rate of substitution between any pair of different types of labor is determined.

Now, what is the role of the rates of substitution among different types of labor in this model? First, suppose there were no substitutability among different types of labor. In that case, the production level of each industry is uniquely determined by the predetermined supply of each specific type of labor, irrespective of goods prices. Factor prices are passively determined. This is the well-known specific-factor model of international trade. This model is characterized by predetermined fixity of production. Next, suppose there is perfect substitutability among types

of labor. In other words, labor is perfectly mobile among industries. In this case there actually is only one type of labor supply. Since labor can move freely among industries, no industry's production level can be determined as long as the number of industries is larger than that of the factors, i.e., two. This is a special case of the H-O model. Thus, the characteristic of our model is that it introduces limited specificity of factors of production into the model of specialization.

Let us now examine some theoretical implications of our model. We shall examine the theoretical results of an exogenous increase in factor supplies under the assumption of goods prices exogenously given through free trade.

The first thing we can examine is the effects of an increase in capital on each industry's production. The most general conclusion of this case can be stated as follows: an increase in capital consists of two effects. The first effect comes from the relative position of the industry's capital/labor ratio in the whole economy. If an industry is relatively more capital intensive (or has a relatively high capital/labor ratio), it will increase its output. If it is relatively more labor intensive, it will decrease its output. The important point here is that, the higher the capital intensity of an industry is, the larger will be the increase in its production. The extent of this change, or the coefficient of specialization, is proportional to the average rate of substitution among different types of labor. When the average rate of substitution is higher, the effect will be larger, that is, the specialization of production will proceed further. If this were the only effect, however, the "chain rule" would hold, as Jones had postulated. But there is another effect.

The second effect is due to the bias among the rates of substitution between the industry's specific labor and other types of labor used in closely related industries. Let us define what we mean by "closely related industries": industries are closely related to another industry when the types of labor used in those industries have relatively high rates of substitution for the type of labor used in the industry in question. That done, the second effect can be described as follows: if an industry is relatively more capital-intensive among its closely related industries, a capital increase will expand the industry's production by absorbing various types of labor from closely related industries. In other words, additional specialization in production takes place among closely related industries.

Suppose industries are classified into groups, each of which consists of industries closely related to one another. From the above discussion, we can summarize the pattern of specialization as follows: There are two types of specialization in production, inter-group specialization and intra-group specialization. An increase in capital supply brings about both inter- and intra-group specialization toward relatively capital-intensive groups and industries. However, since industries within a group are connected more firmly through higher rates of substitution than they are among groups, the intra-group specialization appears more strongly than the inter-group one. Therefore, outputs of two industries that, for example, have the same capital/labor ratio but belong to different groups will change to different extents. One conclusion of this is: if we blend industries of different groups without paying attention to that difference, the relationship between capital/labor ratios and the comparative advantage of industries would become blurred.

Similar conclusions are obtained if we analyze the effects of an increase in labor supply instead of an increase in capital. In this case, however, we have to pay attention to the difference between exogenous increases in various types of labor supply and actually realized increases in types of labor supply. The reason for this is that types of labor can be transformed into other types. Thus, though the problem is somewhat complex, we still obtain similar results.

A new result, which we did not obtain in the case of a capital increase, is obtained when supply of types of labor is exogenously increased in one group and decreased in another. Suppose there are two groups of industries and labor supply is increased uniformly in group I and decreased uniformly in group II. We may assume without loss of generality that group I is relatively more capital intensive as a whole. If the initial labor supply shift is such that the total amount of wage income does not change under the original wage rates, then we obtain the following results. First, outputs in group I increase and outputs in group II decrease on the average. In other words, an inter-group specialization toward the more capital-intensive group occurs. Second, within each group, there occurs an intra-group specialization toward relatively more labor-intensive industries. This is because the increase in demand for capital, raised by the output shift from the labor-intensive to the capital-intensive group, will heighten the scarcity of capital. In this case, inter-group specialization and intra-group specialization occur in opposite directions.

Finally, there can be another paradoxical case. So far, we assumed capital was homogeneous and perfectly mobile among industries. How do the effects change if we introduce heterogeneity of capital and, accordingly, imperfect substitutability among several types of capital? I shall mention briefly one possible result that seems to have occurred in the following empirical examination of U. S. trade structure. If capital is less mobile between groups than within each group just like labor, labor movements toward group I away from group II can result in specialization toward less capital-intensive industries within group I, but toward more capital-intensive industries within group II. This is because capital becomes scarce in group I and abundant in group II.

In summary, if the notion of similarity and dissimilarity among industries is introduced, it becomes important to distinguish between inter-group specialization and intra-group specialization. This will also be important for realistic studies of U. S. trade structure. Not only does the chain rule no longer hold, but also diversification of the relationship between capital/labor ratios and comparative advantage should teach us a lot about factors determining the trade structure.

C. SOME EMPIRICAL ANALYSES

What are the implications of the above discussion? In the literature on U. S. trade structure, one factor that seems important in connection with our discussion has been repeatedly brought up. This is Research and Development (R & D). That is, many authors confirmed that superiority in technology and knowledge determined the pattern of the U. S. comparative advantage. Their research indicates the importance of the heterogeneity of various types of knowledge needed in production processes. In our terms, this concept can be translated into that of limited substitutability among different types of labor and the uneven distribution of those types between countries.

It seems beyond doubt that the United States has an abundance of relatively knowledgeable types of labor. The abundance in the R & D factor, the labor abundance pointed out by Leontief, etc., all seem to be closely related to this abundance in knowledgeable labor. If this is the case, what will be the effects of this on the pattern of specialization?

If our assumptions are accurate, and if industries using knowledgeable labor types are relatively more labor intensive as suggested by our calculations, the abundance of knowledgeable labor and scarcity of simple

labor will induce, first, inter-group specialization toward the group that uses knowledgeable labor more intensively, and, second, intra-group specialization toward more capital-intensive industries, since inter-group specialization decreases the demand for capital. Or, if capital is not so mobile between groups of industries, the intra-group specialization might be in a different direction between groups.

Our second empirical analysis will be to examine this conjecture. First of all, then, we have to distinguish several types of labor. For this we would need a detailed table of U. S. industry-by-occupation employment data. I was unable, however, to obtain detailed census-based industry-occupation matrix data, and as a result, the following empirical analysis is but a preliminary one.

The analysis is confined to manufacturing industries. The data issued by the U. S. Department of Labor on employment in manufacturing industries by major occupational groups have seven categories of occupation: managers and officers; professional workers; technical workers; service workers; clerical workers; sales workers; and production and other workers. I have tentatively grouped those occupations into two, linking the first three categories into one group and the last four categories into a second group. We can identify the former as a relatively knowledgeable labor group and the latter as a relatively simple labor group. Using this definition, I have divided 363 U. S. manufacturing industries in the 1977 detailed input-output table (U. S. Department of Commerce 1984b) into two groups, depending on the intensity of use of knowledgeable labor. The first group (group I), which uses knowledgeable types of labor more intensively, contains 135 industries of code numbers 26.0100 through 31.0300 and 43.0100 through 63.0300, and the second group (group II) contains the remaining 228 manufacturing industries of code numbers 13.0100 through 64.1200. Group I as a whole is slightly more labor intensive than group II (CE/VAs are 0.6785 and 0.6712, respectively).

Using the simple ordinary least square method, I carried out regressions of net exports on labor intensities. Since U. S. input-output tables distinguish commodity categories and industry categories, I transformed industry data into commodity data, when necessary, and made my calculations on the basis of those commodity data.

The results of regression are summarized in Table 3. The first point to notice is that the coefficient of determination (R-squared) is very low

in every equation. But this is neither surprising nor disappointing, as our problem is the very diversification of the relationship between net export ratio and labor intensity.

Table 3
Regressions of Net Exports on Labor Intensity

Equation	Constant	CE/VA	R-squared
1 Total commodities without weights	0.158 (2.707)	-0.288 (-3.446)	0.032
2 Total commodities with weights	0.0103 (0.356)	-0.039 (-0.762)	0.002
3 Group I commodities without weights	0.222 (2.687)	-0.301 (-2.599)	0.048
4 Group II commodities without weights	0.156 (2.044)	-0.335 (-3.006)	0.038
5 Group I commodities with weights	-0.092 (-1.345)	0.142 (1.439)*	0.181
6 Group II commodities with weights	0.077 (2.043)	-0.162 (-2.937)	0.037

Data source: U. S. Department of commerce (1984b).

Note: The dependent variable is net export of each commodity over its total amount by domestic production. Group I contains 135 commodities of the code numbers 26.0100 through 31.0300 and 43.0100 through 63.0300, and Group II contains the remaining 228 commodities out of 363 manufactures of the code numbers 13.0100 through 64.1200. CE/VA denotes compensation of employees over net value added, where net value added is value added less indirect business taxes. The CE/VA of group I as a whole is slightly higher than that of group II (0.6785 vs 0.6712). Values in parentheses are t-statistics. Weights, when used, is the total amount of each commodity by domestic production.

*significance level of 7.6%.

Second, the coefficient of CE/VA (labor intensity) is significantly negative in eq. 1 but insignificant in eq. 2, though it has the same negative sign. Considering that industry outputs are in uneven amounts, the more appropriate regression is eq. 2 with weights. Thus, I do not consider U. S. manufacturing industries to have a significant comparative advantage in relatively capital-intensive industries. This seems consis-

tent with the conclusion of Table 2, since, in the latter, the difference of capital intensity between production and consumption was very small.

Third, we find an interesting feature in eqs. 5 and 6. The coefficient of CE/VA is positive in eq. 5 and negative in eq. 6 at relatively high significance levels. This means that specialization occurred in group I toward labor-intensive industries and in group II toward capital-intensive ones. If we interpret this to be a consequence of the fact that the U. S. economy is abundant in knowledgeable labor types and scarce in simple labor types, this is consistent with Leontief's conjecture and studies on the R & D factor and U. S. trade. That is, since knowledgeable labor is abundant in the U. S., capital becomes a scarce factor in group I and specialization toward labor-intensive industries occurs. On the other hand, since simple labor is scarce in the U. S., capital becomes an abundant factor in group II and specialization toward capital-intensive industries occurs.

Though this finding is of a preliminary nature, it seems to suggest the advisability of undertaking an explicit analysis of the diversity of relations between factor intensity and comparative advantage. Particularly, we have to notice the possibility that directions of specialization can be different among groups of industries.

Concluding Remarks

In this paper, I have analyzed two problems related to the Leontief paradox.

First, as regards the Leontief paradox itself, my results seem to reconfirm the paradox. That is, the U. S. economy as a whole seems to have the comparative advantage in relatively labor-intensive industries. However, the so-called chain rule does not hold, and the relations between factor intensities and patterns of specialization are significantly diversified over industries. Therefore, it seems inappropriate to judge the U. S. trade structure in the light of an assumption based simply on an extended H-O theory.

The second point is related to this diversification. I introduced the notion of substitutability among various types of labor supply, and particularly made a distinction between inter- and intra-group specialization in production. Applying this idea to an analysis of U. S. manufacturing industries showed us that such specialization actually occurred in oppo-

site directions in the cases of group I and group II. To be specific, the group made up of industries that use knowledgeable types of labor relatively more intensively has the comparative advantage in labor-intensive industries, and the group made up of industries that use simple labor more intensively has the comparative advantage in capital-intensive industries.

One lesson from this analysis is that, for the study of industry specialization, we should not treat total industries as a set but distinguish several groups of industries. Another implication is in regard to intra-industry trade. As I stated earlier, the prevailing standard theory of intra-industry trade is based on the Krugmanian model of monopolistic competition and increasing returns. However, this theory cannot explain such specialization as is found within Leamer's clusters of industries. My theory seems to provide another explanation for intra-industry trade.

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