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A MULTICOUNTRY USE OF INPUT-OUTPUT TABLES TO TEST THE HECKSCHER-OHLIN THEOREM ACCOUNTING FOR ACTUAL IMPORTS

BY

Selena Schneider

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ABSTRACT

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A Multicountry Use of Input-Output Tables to Test the Heckscher-Ohlin Theorem Accounting for Actual Imports

Dissertation Directed by Dominick Salvatore, Ph.D.

This dissertation presents a modification of the original framework implemented by Wassily Leontief to test the validity of one of the most venerable theories of international trade. Most major empirical investigations of the Heckscher-Ohlin theorem using the Leontief approach have concentrated on the limited framework.

In this dissertation, we empirically examine the determinants of the structure of foreign trade for the most developed nations (i.e., Australia, Canada, Denmark, France, Germany, Italy, Japan, the United Kingdom and the United States) over the period 1968 – 1996. The data set used represents the most extensive data set available to document the pattern of industrial specialization and factor endowment differences. Our analyses are based on the factor content version of the Heckscher-Ohlin model using first the original Leontief method for the United States and for each of the remaining countries mentioned. Then, the input-output tables are used to measure the capital-labor content of each industry. This approach allows us to detect the presence of factor intensity reversal, the only assumption that cannot be relaxed in the

Heckscher-Ohlin theory. Last, we introduce a modification in the balance equations of the general system used as a framework to test the validity of the Heckscher-Ohlin theory.

The results of this study should be enriching for international trade economists. The study does validate the use of the underlying general equilibrium model as originally intended by Wassily Leontief but never implemented due to lack of concrete quantitative information. The principal premise of the Heckscher-Ohlin model, formerly questioned, has proven to hold for all or the majority of the years of our study resulting in trade patterns that promote prosperity within a nation.

INTRODUCTION

This dissertation takes the standard Heckscher-Ohlin model of international trade and examines its validity by applying first the limited original framework used by Wassily Leontief in 1953 and 1956 followed by two derivations of this test. Leontief's methodology was imposed to overcome the unavailability of factor endowments for the nations studied and comparable input-output tables for the exporting countries to the United States. Alternative methods developed to test the validity of Heckscher-Ohlin model include a regression of trade of many commodities on their factor input requirements for a single country (for example, Robert Baldwin, 1971; William Branson and Nicholas Monoyios, 1977; Jon Harkness, 1978, 1983; Robert Stern and Keith Maskus, 1981). Other researchers tackled the Leontief paradox[1] by disaggregating labor by skill classification while maintaining the assumption that within classifications no international productivity differences exist (see Travis, 1964, Keesing 1965, 1966, Stern and Maskus, 1981, Maskus, 1985 and Bowen et al, 1987.) As the literature is illustrated none of these studies can be considered a comprehensive confirmation of Heckscher-Ohlin theory unless the Leontief paradox is eliminated within the limits of his original explanation.

In his original study, Leontief stated that his analysis was investigating only a partial picture of the international trade structure due to the scarcity of quantitative information other than for the U.S.

[1] Leontief's calculation of capital and labor requirements per million dollars of U.S. exports and competitive imports revealed that U.S. import substitutes were approximately 30% more capital intensive than U.S. exports. This meant that the U.S. was exporting labor intensive commodities and importing more capital-intensive commodities. This was the opposite of what the Heckscher-Ohlin model predicted and became known as the Leontief paradox.

Therefore, he implemented a general equilibrium model of trade involving all the available information at that time.

This study seeks to examine the empirical testing of Heckscher-Ohlin theory over the period 1968 – 1996 by modifying the original framework implemented by Wassily Leontief. The full-fledged application of the general equilibrium model will now be based upon the availability of the input-output tables of the most industrialized nations of the world (i.e., Australia, Canada, Denmark, France, Germany, Italy, Japan, the United Kingdom and the United States) and their capital and labor endowments. The term "world" refers only to this group of countries; for example, this means that the only relevant trade flows are those among the countries mentioned above. The comparability of the input-output tables is granted by the mere fact that they are coming from the same source, namely the Organization of Economic Cooperation and Development ("OECD"). Therefore, this study restricts the sample to countries that are similar in relative endowments and technology.

The testing of the Heckscher-Ohlin theorem is organized as follows: first the original Leontief method is replicated for the United States and for each of the countries mentioned above. The replication makes use of the exports and import substitutes for each country and calculates their capital and labor content over the period 1968 – 1996. This represents a classical test of the Heckscher – Ohlin hypothesis that compares the capital per man embodied in a million dollars worth of exports with the capital per man embodied in a million dollars worth of competitive imports. Moreover, Leontief's study uses data on trade and factor input requirements but not factor endowments. Furthermore, the purpose of this implementation is to ascertain the relevance of the Leontief paradox when extending the original methodology to other countries.

When the Heckscher-Ohlin theorem is expanded to more than two nations and two industries we need to establish that the economy as a whole is consistent with the first assumption introduced by the two economists – two nations, two commodities and two factors of production (labor (L) and capital (K)). In the second approach, the input-output tables are used to measure the labor and capital content of each industry. This approach allows us to simultaneously use all input-output tables in order to detect the presence of factor intensity reversal. This represents a verification of the only assumption that cannot be relaxed and upon which the Heckscher-Ohlin theory is based, namely that one commodity is labor intensive and the other commodity is capital-intensive in both nations. When considering more than two goods in a multi-country environment, this assumption must hold for the Heckscher-Ohlin theory to be valid.

The most relevant contribution of this study consists in improving the original Leontief approach by introducing a modification to the balance equations of the general system used as a framework to test the Heckscher-Ohlin theory. This represents the first implementation of the model that was introduced in Wassily Leontief's paper "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis" published in 1956. Starting from the balance equations developed by Leontief, we will apply his method using actual data for imports of the United States multiplied by the respective input-output table of the exporting nations. This in a sense represents the full-fledged application of a general equilibrium approach to the explanation of the level and composition of trade between the U.S. and the rest of the world. Having at our disposal the endowment of each of the trading countries with the primary factors of production, it would enable us to complete the report on the progress of a continuing investigation into the structural basis of the trade relationship between the U.S. and the rest of the world.

The results obtained can only depict the validity of Heckscher-Ohlin theory when applied to certain regions of the world. In the case of our second approach, the theory fails only one-fourth of the times, therefore leaving ample room for acceptance. The results obtained from our third approach can only emphasize that the theory is important, despite the alleged restrictedness of the basic model. This dissertation sought to prove that the greatly exaggerated criticism the Heckscher-Ohlin theory received over the years were indeed wrong. Our results indicate that the Heckscher-Ohlin theory provides an accurate and illuminating description of a large part of the global pattern of trade.

Consequently, the Heckscher-Ohlin theory will continue to command interest among those concerned with international trade from a wide variety of methodological and theoretical viewpoints. The Heckscher-Ohlin theorem simply conveys the lasting power of the model as an intellectual organizing framework-providing access to such powerful derivations as the factor price equalization, Stolper-Samuelson[2], Rybczynski[3] as well as the Heckscher-Ohlin theory itself. The continued interest also reflects the absence of a clear and simple alternative that gives better results.

[2] The Stolper-Samuelson theorem describes the relationship between changes in output, or goods, prices and changes in factor prices such as wages and rents within the context of the Heckscher-Ohlin model. The theorem was originally developed to illustrate how tariffs would affect the incomes of workers and capitalists within a country. The theorem states that if the price of capital-intensive goods rises then the price of capital, the factor used intensively in that industry, will rise, while the wage rate paid to labor will fall. Similarly, if the price of labor-intensive goods were to rise then the wage rate would rise while the rental rate would fall.

[3] The Rybczynski theorem demonstrates the relationship between changes in national factor endowments and changes in the outputs of the final goods within the context of the Heckscher-Ohlin model. Briefly states the theorem says that an increase in a country's endowment of a factor will cause an increase in output of the good which uses that factor intensively, and a decrease in the output of the other good.

CHAPTER 1: HECKSCHER-OHLIN -- THEORETICAL BACKGROUND AND SURVEY OF EMPIRICAL LITERATURE

AN OVERVIEW OF HECKSCHER-OHLIN THEORY

In the 1920's two Swedish economists, Eli Heckscher and his student Bertil Ohlin developed a model of international trade now known as Heckscher-Ohlin theory. The theory has and continues to serve as the most important part of traditional trade theory. The Heckscher-Ohlin theory asserts that factor endowments determine trade flows; namely, a country exports goods that use relatively intensively its relatively abundant factors and imports goods that use relatively intensively its relatively scarce factors of production. In a sense, the theory states that it is solely the physical quantities of factors available in each country that matters and not the influence of tariffs, transportation costs and international differences in tastes and efficiency. The latter ones can simply be neglected.

Heckscher-Ohlin theory can be divided into two theorems: (1) the Heckscher-Ohlin theorem, which deals with and predicts the pattern of trade, and (2) the factor-price equalization theorem[4], which deals with the effect of international trade on prices.

Heckscher-Ohlin theory states that a country with balanced trade (assumption no. 11 described below) will export the commodity that uses intensively its relatively abundant factor and will import the commodity that uses intensively its relatively scarce factor. The theory is based on a number of assumptions that were left out of the simple

[4] The factor price equalization theorem states that when the prices of the output goods are equalized between countries, as when countries move to free trade, then the prices of the factors (capital and labor) will also be equalized between countries. This indicates that free trade will equalize the wages of workers and the rentals earned on capital throughout the world.

Ricardian model. In the Ricardian model only one factor of production, labor, is needed to produce goods and services. The productivity of labor is presumed to vary across nations, which suggests a difference in technology between nations. It was actually the difference in technology that determined advantageous international trade in the model.

By contrast, Heckscher-Ohlin model begins by expanding the number of factors of production from one to two. The model assumes that labor and capital are necessary in the production of two final goods. Therefore, trade volume is expected to be positively correlated with the dispersion of relative factor endowments. A capital abundant nation is one that is well endowed with capital relative to labor with respect to the other country. This gives the nation a propensity for producing the good that uses relatively more capital in the production process, i.e., the capital-intensive good. Once trade takes place, profit-seeking entities will sell their products into markets that temporarily have higher prices. Therefore, the capital abundant nation will export the capital-intensive good since the price will be temporarily higher in the other nation (labor abundant). Likewise, the labor abundant nation will export the labor-intensive good.

In order to produce trade theory's sharpest results the model undertakes the following assumptions:

(1) two nations, two commodities and two factors of production (labor (L) and capital (K));
(2) the two nations use the same technology in production;
(3) one commodity is labor-intensive (X_1) and the other commodity is capital-intensive (X_2) in both nations;
(4) both commodities are produced under constant returns to scale;

(5) the specialization in both nations is not complete;

(6) tastes are alike in both nations;

(7) there is perfect competition in both nations;

(8) there is perfect factor mobility within each nation, but no international mobility;

(9) transportation costs, tariffs and other obstructions to the free flow of international trade do not exist;

(10) all resources are fully employed in both nations, and

(11) international trade between the two nations is balanced.

More precisely, the theory states that one nation will export commodity X_1 because X_1 is the labor-intensive commodity and L is the relatively abundant and economical factor in Nation A. Concomitantly, Nation B exports commodity X_2 since X_2 is the K intensive commodity for this nation, which represents the relatively abundant and inexpensive factor of production. Therefore, Heckscher-Ohlin theory explains comparative advantage instead of assuming it (as was the case for classical economists). Ultimately, the theory shows that the pre-trade difference in relative commodity prices between the two nations arises from differences in relative factor abundance and prices.

Based on the assumptions listed above, it is clear that countries are alike in every respect except their endowment. The 2 x 2 x 2 Heckscher-Ohlin model starts with two countries in autarky. Both countries produce two goods with two factors of production. If technologies used in the production of goods are different between the two countries, then the respective countries have different production functions, which could imply different relative autarky prices. However, it is assumed that the production

functions are very similar in both countries. Therefore, any differences in autarky prices are not due to differences in technology.

In addition, we assume that tastes are similar in both nations. If tastes are different among countries, given the same production function, then there will also be different initial autarky prices. Therefore, by assuming similar preferences between the two countries, the model eliminates the possibility of different initial prices due to differences in demand structure.

Differences in the initial autarky prices are due to differences in endowment. One nation would have relatively more capital than the other, while the other nation would have relatively more labor. The nation with more capital is called the capital abundant nation while the other is called the labor abundant nation. Following the Rybczynski theorem the capital abundant nation will then produce relatively more capital-intensive goods than will the labor abundant nation; the labor abundant nation will produce relatively more labor-intensive goods than the capital abundant nation.

Given comparable demand structures, the autarky relative price of the capital-intensive good will be lower in the capital abundant nation as compared to the price of the capital intensive good in the labor abundant nation. In the meantime, the autarky relative price of the labor-intensive good will be lower in the labor abundant nation as compared to the price of the labor intensive good in the capital abundant nation. Therefore, it is clear that in this model, the differences in the endowment between countries causes differences in the initial autarky relative prices. This represents the basis of trade in the Heckscher-Ohlin model. With trade both nations should experience new and identical equilibrium price ratios. In the end, the capital abundant nation will

export the capital-intensive good and the labor abundant nation will export the labor-intensive good.

Factor price equalization theorem is derived from the assumption that the two countries share the same production technology and that markets are perfectly competitive. The theorem states that when the prices of the output goods are equalized between countries, as when countries move to free trade, then the prices of the factors (i.e., capital and labor) will also be equalized between countries. This implies that free trade will equalize the wages of workers and the rental earned on capital throughout the world.

In a perfectly competitive market, factors are paid on the basis of the value of their marginal productivity which in turn depends upon the output prices of the goods. Therefore, when prices differ between countries so will their marginal productivities and as a result their wages and rents. However, when goods are equalized, as they are in free trade, the value of marginal products are also equalized between countries and consequently the countries must also share the same wage and rental rates.

Paul Samuelson introduced a number of elaborations of the model in the 1930s and thus the model is sometimes referred to as the Heckscher-Ohlin-Samuelson ("HOS") model. The main result of the HOS model is that differences in factor endowments are responsible for trade patterns. The HOS theorem identifies the structure of trade as a function of either (a) the differences between autarky prices and trade prices, or (b) factor supplies. Specifically, the theory states that a nation with balanced trade (via factor price equalization) will export the commodity that uses intensively its relatively abundant factor and will import the commodity that uses

intensively its relatively scarce factor. Therefore, international trade will lead to equalization in the relative and absolute returns to homogeneous factors across nations. Then, international trade is a substitute for the international mobility of factors.

Later on in the 1950s and 1960s Jaroslav Vanek made some remarkable extensions to the model; this version is referred to as the Heckscher-Ohlin-Vanek ("HOV") model. The HOV theorem states a country will export the services of its relatively abundant factors and import services of its relatively scarce factors. The theorem is based on the following assumptions: (1) there are 'm' factors of production which are perfectly immobile between countries; (2) there are 'n' commodities which are freely mobile between countries; (3) all consumers have identical homothetic preferences; (4) all countries have identical constant returns to scale production functions; (5) factor and commodity markets are perfectly competitive with no distortions, and (6) factor prices are equalized across countries.

ILLUSTRATION OF THE HECKSCHER – OHLIN THEORY

The Heckscher – Ohlin theory is illustrated in Figure 1. The left panel illustrates the production frontier of Nation 1 and Nation 2.

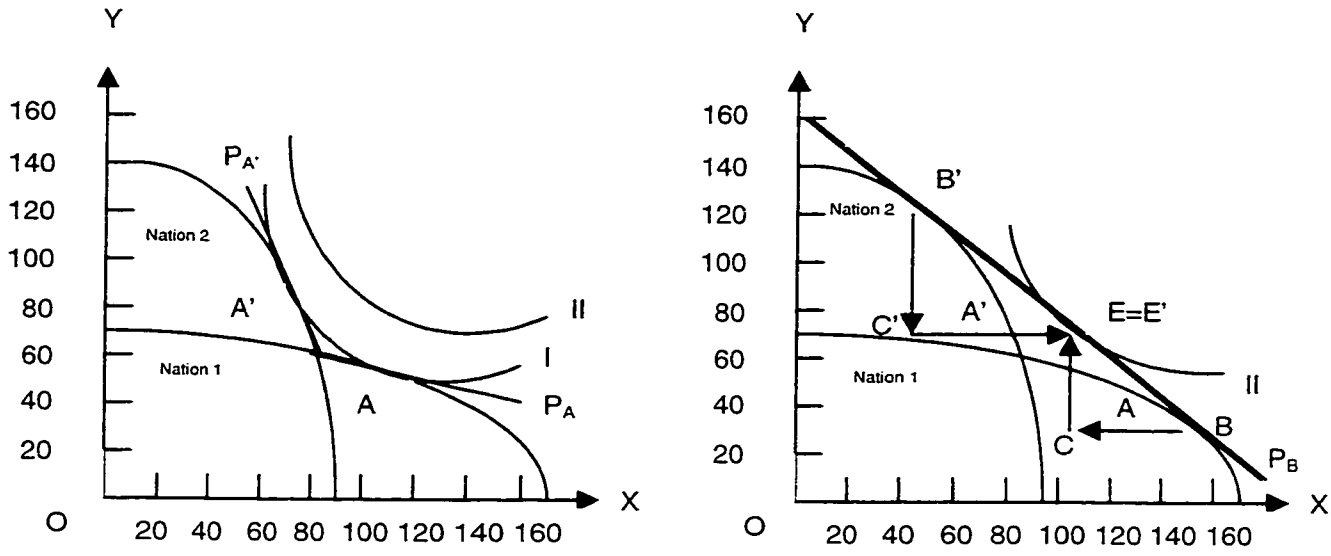


Figure 1: Illustration of The Heckscher-Ohlin Model

From Figure 1, we can depict that Nation's 1 production frontier is skewed along the X-axis because X is the L-intensive commodity. Nation 1 is the L-abundant nation, and both nations use the same technology. Moreover, since the two nations have equal tastes, they face the same indifference map. Indifference curve I (which is common for both nations) is tangent to Nation 1's production frontier at point A and to Nation 2's production frontier at point A'. We can also notice that indifference curve I is the highest indifference curve that Nation 1 and Nation 2 can reach in isolation, and points A and A' represent their equilibrium points of production and consumption.

The tangency of indifference curve I at points A and A' indicate the no-trade, or autarky position. P_A and $P_{A'}$ indicate the equilibrium relative commodity prices in Nation 1 and Nation 2, respectively. Since $P_A < P_{A'}$, Nation 1 has a comparative advantage in commodity X and Nation 2 has a comparative advantage in commodity Y.

The right panel of Figure 1 shows that when Nation 1 is exposed to trade it specializes in the production of commodity X_1 whereas Nation 2 specializes in the production of commodity X_2. Specialization takes place until Nation 1 reaches point B and Nation 2 point B', where the transformation curves of the respective nations are tangent to the common relative price line P_B. At this point, Nation 1 will export commodity X_1 in exchange for commodity X_2 and consume at point E on indifference curve II (trade triangle BCE). Concomitantly, Nation 2 will export commodity X_2 in exchange for X_1 and consume at point E', which corresponds with point E (trade triangle B'C'E').

Consequently, Nation 1's exports of commodity X_1 equal Nation 2's imports of commodity X_1 (BC=C'E'). Nation 2's exports of commodity X_2 equal Nation 1's imports of commodity X_2 (B'C'=CE).

At $\frac{P_{X1}}{P_{X2}} \succ P_B$ Nation 1 wants to export more of commodity X_1, than Nation 2 wants to import at this high relative price of X, and $\frac{P_{X1}}{P_{X2}}$ falls towards P_B. The opposite happens where $\frac{P_{Y1}}{P_{Y2}} \prec P_B$. This tendency of $\frac{P_{Y1}}{P_{Y2}}$ could also be explained in terms of commodity X_2.

Another important point worth mentioning is that point E requires more of Y but less of X_1 than point A. Nonetheless, Nation 1 gains from trade because point E is on higher indifference curve II. Point E involves more X_1 and less of X_2 than Point A' resulting in a better off position for Nation 2 since point E' is on a higher indifference curve II.

The above-mentioned pattern will remain valid until a change in the underlying demand or supply conditions in commodity and factor markets in either or both nations will intervene.

PROOF OF THE HECKSCHER-OHLIN THEOREM

Designating the output levels as X_1 and X_2, we set factor supply equal to factor demand in order to obtain a system that can be solved for outputs as a function of the endowments:

$$K = a_{K1}X_1 + a_{K2}X_2, \qquad (1)$$

$$L = a_{L1}X_1 + a_{L2}X_2, \qquad (2)$$

where a_{K1}, a_{K2}, a_{L1} and a_{L2} are production coefficients. These coefficients are the amounts of capital and labor required to produce a unit value of X_1 and X_2 respectively. The input requirements a_{ij}, where i (factor) = 1,...,m and j (commodity) = 1,...,n, per unit value of output can be transformed into input requirements a_{ij} per unit of output by multiplying by product price: $a_{ij} = a_{ij}p_j$, where p_j is the product price. The input requirements a_{ij} are called factor input intensities and can be collected in a factor intensity matrix symbolized by A below.

Writing V for the vector of endowments $\begin{bmatrix} K \\ L \end{bmatrix}$, X for the vector of outputs $\begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$ and A for the matrix A = $\begin{bmatrix} a_{K1} & a_{K2} \\ a_{L1} & a_{L2} \end{bmatrix}$ then the above equations can be written in matrix form as:

$$V = AX. \qquad (3)$$

This can be written as:

$$X = A^{-1}V \qquad (4)$$

provided that the relative input intensities are unequal: $\frac{a_{K1}}{a_{L1}} \neq \frac{a_{K2}}{a_{L2}}$. Due to the linearity of these equations we can also write the total world output vector X_W as a function of the total world endowment vector V_W:

$$V_W = AX_W \text{ or inverted as } X_W = A^{-1}V_W. \qquad (5)$$

Considering that the relative prices of goods are given in world markets and that they are the same for all countries, assumption 6 (tastes are alike in both nations) implies that each country consumes commodities in the same proportion. This means that

$$C = sX_W, \qquad (6)$$

where s represents the country's consumption share of world output and C is its consumption vector. This assumption is not unrealistic since there is a convergence in tastes.

Trade balance necessitates that the value of production equals the value of consumption, which can be expressed as:

$$p'X = p'C = sp'X_W, \qquad (7)$$

where p is the price vector $\begin{bmatrix} p_1 \\ p_2 \end{bmatrix}$ and where we have written p' for the transpose of p.

Therefore, if trade is balanced, the consumption share is the ratio of own gross national product ("GNP") to world GNP:

$$s = \frac{p'X}{p'X_w}. \tag{8}$$

The vector of net exports T represents the difference between production and consumption. Thus

$$T = X - C \tag{9}$$

Substituting for X and C from the inverted equations (4) and (6) we obtain:

$$= A^{-1}V - sA^{-1}V_W \tag{10}$$

$$= A^{-1}(V - sV_W). \tag{11}$$

Note that the final line is A^{-1} times the vector of excess factor supplies, $V - sV_w$. This excess can also be expressed as follows:

$$V - sV_W = \begin{bmatrix} K - sK_w \\ L - sL_w \end{bmatrix} = \begin{bmatrix} K_w\left(\frac{K}{K_w} - s\right) \\ L_w\left(\frac{L}{L_w} - s\right) \end{bmatrix}. \tag{12}$$

Next it will be demonstrated that if the country in question is relatively capital-abundant, that is $\frac{K}{K_w} > \frac{L}{L_w}$, then this excess factor supply vector has signs $\begin{bmatrix} + \\ - \end{bmatrix}$. This follows from the fact that the consumption share is a weighted average of the capital

$$s = \frac{p'X}{p'X_w} = \frac{p'A^{-1}V}{p'A^{-1}V_w} = \frac{w'V}{w'V_w} = \frac{\left[w_K K_w \left(\frac{K}{K_w} \right) + w_L L_w \left(\frac{L}{L_w} \right) \right]}{w_K K_w + w_L L_w}^{1} \qquad (13)$$

share and the labor share where w is the factor reward vector: $w = (A')^{-1} p$. Hence, s must fall between $\frac{K}{K_w}$ and $\frac{L}{L_w}$, and consequently $\frac{K}{K_w} > s$ implies that $\frac{K}{K_w} > \frac{L}{L_w}$.

In order to determine the signs of the net export vector of a capital-abundant country, we need to identify the effect of pre-multiplying a vector with signs (+, -) by the inverse of the matrix A:

$$A^{-1} = \begin{bmatrix} a_{K1} & a_{K2} \\ a_{L1} & a_{L2} \end{bmatrix}^{-1} = \begin{bmatrix} a_{L2} & -a_{K2} \\ -a_{L1} & a_{K1} \end{bmatrix} / |A| \qquad (14)$$

[1] $V_W = \begin{bmatrix} K_W \\ L_W \end{bmatrix}$; $where \;\; w = (A')^{-1} p = (A')^{-1} \begin{bmatrix} p_1 \\ p_2 \end{bmatrix} [w_K \quad w_L]$;

$$wV = w_K * K \left(\frac{K_W}{K_W} \right) + w_L * L \left(\frac{L_W}{L_W} \right) = w_K K_W \left(\frac{K}{K_W} \right) + w_L L_W \left(\frac{L}{L_W} \right)$$

where the determinant is

$$|A| = (a_{K1}a_{L2} - a_{L1}a_{K2}) = a_{L1}a_{L2}\left(\frac{a_{K1}}{a_{L1}} - \frac{a_{K2}}{a_{L2}}\right) \qquad (15)$$

If we assume that X_1 is the capital-intensive industry, then $|A| > 0$, and A^{-1} has the sign pattern

$$A^{-1} = \begin{bmatrix} + & - \\ - & + \end{bmatrix} \qquad (16)$$

If the country is abundant in capital, the vector of excess factor supplies has sign pattern (+, -), and trade consequently has sign pattern:

$$T = \begin{bmatrix} + & - \\ - & + \end{bmatrix}\begin{bmatrix} + \\ - \end{bmatrix} = \begin{bmatrix} + \\ - \end{bmatrix}. \qquad (17)$$

Thus, writing $T = \begin{bmatrix} T_1 \\ T_2 \end{bmatrix}$, we have shown $T_1 \geq 0$ and $T_2 \leq 0$. This means that the capital-abundant nation exports the capital-intensive commodity X_1 and imports the labor-intensive commodity X_2.

REVIEW OF THE LEONTIEF FRAMEWORK

Leontief's 1956 computation can be expressed in matrix notation. Let us adopt the following notation:

$$O = \begin{bmatrix} O_1 \\ O_2 \\ . \\ . \\ O_n \end{bmatrix}$$ is an (n x 1) column vector of outputs of *n* industries of the economy;

X is the value of total exports of all *n* industries in million of dollars;

M is the value of total competitive imports into all *n* industries in million of dollars;

$$A = \begin{bmatrix} a_{11} & . & . & a_{1n} \\ . & . & . & . \\ . & . & . & . \\ a_{n1} & . & . & a_{nn} \end{bmatrix}$$

is a square matrix (nxn) of input coefficients; that is for $i = 1,2, \ldots, n$ and $j = 1, 2, \ldots n$; a_{ij} is the amount of industry i's product used by industry j per unit of output of industry j;

$$b = \begin{bmatrix} b_1 \\ b_2 \\ . \\ . \\ b_n \end{bmatrix}$$ is a column vector (nx1) of export coefficients; that is, for $i = 1, 2, \ldots n$;

$b_i = x_i/X$, and hence equals the amount of industry *i's* exports per one million dollars of total exports of all *n* industries;

$$c = \begin{bmatrix} c_1 \\ c_2 \\ . \\ . \\ c_n \end{bmatrix}$$ is a column vector (nx1) of competitive import coefficients; that is, for $i = 1, 2, \ldots n$; $c_i = m_i/M$, and hence equals the amount of competitive imports into sector *i* per one million dollars of total competitive imports into all *n* industries;

$K = [k_1 k_2 \ldots k_n]$ is a row vector (1xn) of capital coefficients (they represent the remuneration of capital as a percentage of total output); that is, for $i = 1,2, \ldots, n$; $k_i = K_i/O_i$; more precisely, a capital coefficient represents the quantity of capital required per unit of capacity in an industry.

$L = [l_1 l_2 \ldots l_n]$ is a row vector (1xn) of labor coefficients (they represent the remuneration of labor as a percentage of total output); that is for $i = 1,2, \ldots, n$; $l_i = L_i/O_i$, and finally; more precisely, a labor coefficient represents the quantity of labor required per unit of capacity in an industry.

$R = \begin{bmatrix} r_1 \\ r_2 \\ . \\ . \\ r_n \end{bmatrix}$ is a column vector (nx1) of residual constants, each r_i represents that part of sector i's output which is allocated directly to all final uses other than exports.

In the absence of a trade equation, Leontief lets the balance equation be:

$$[I - A][O] - [b]X + [c]M = [r] \qquad (18)$$

and, therefore the capital and labor requirements can be computed by pre-multiplying equation (1) by the inverse of [I – A] to obtain:

$$O = [I - A]^{-1} \; [[b] X - [c] M + [r]] \qquad (19)$$

Subsequently, equation (2) may be pre-multiplied by the row vector of K and L to obtain:

$$KO = [K] [I - A]^{-1} \; [[b] X - [c] M + [r]] \qquad (20)$$

$$LO = [L] [I - A]^{-1} \; [[b] X - [c] M + [r]] \qquad (21)$$

The product of $[K] [I - A]^{-1} [b]$ and $[L] [I - A]^{-1} [b]$ gives capital and labor requirements per million dollars of exports and $[K] [I - A]^{-1} [c]$ and $[L] [I - A]^{-1} [c]$ gives capital and labor requirements per million dollars of competitive import replacements.

Consequently, the Leontief ratio can be calculated by computing separately the capital-labor input ratios for exports and competitive imports and then dividing the corresponding ratios to identify an index of comparative capital-labor intensity in the production of competitive imports and export goods (see equation 22).

$$Leontief\ Ratio = \frac{\left(\frac{K}{L}\right)_M}{\left(\frac{K}{L}\right)_X} \qquad (22)$$

Having reviewed Leontief's input-output computations for the determination of quantities of capital and labor required for the replacement of competitive imports and production for an equivalent amount of exports, we can resume their implementation and examine the approaches stated at the beginning of this study.

In a sense, this work will represent a continuous progress of a long lasting investigation into the structural basis of the trade relationships between the United States and the rest of the world. The term world refers only to the group of countries previously mentioned.

A comprehensive explanation of the United States' economic relationship with the rest of the world will be possible at the end of this study. Until further evidence is illustrated, a controversial position would serve no purpose.

A DESCRIPTIVE EXAMPLE OF THE LEONTIEF APPROACH

This section explains with a simple example the implementation of the Leontief approach to verify the validity of Heckscher-Ohlin theory. Let us assume that we are analyzing the United States, which is a capital abundant nation, and there are two industries (steel and agriculture). By definition, capital is relatively cheaper in the capital abundant nation before trade. The data available is illustrated in table 1:

Table 1: U.S. Input-Output Table in Million Dollars.

	Agriculture	Steel	TIP	C	G	GFCF	Δ Stock	X	TFD	M	Gross Output
Agriculture	5	2	7	2	1	0.1	0	3	6.1	-1	12.1
Steel	6	3	9	3	0.5	0.2	0	5	8.7	-2	15.7
TIP	11	5	16	5	1.5	0.3	0	8	14.8	-3	
Comp (L)	1	5									
GOS (K)	0.1	5.7									
VA	1.1	10.7									
Gross Output	12.1	15.7									27.8

where:

$A = \begin{bmatrix} 5 & 2 \\ 6 & 3 \end{bmatrix}$; actual input-output table;

TIP = total intermediate production. If we consider it by row, it represents the production of each sector of the economy (for example: agriculture) that goes as intermediate production to all the other industries (5 to agriculture and 2 to steel) for the provision of the final output. If we consider it by column, it represents the total intermediate production from all industries (steel and agriculture) that goes into the production of one sector of the economy;

C = consumption;

G = government expenditures;

GFCF = gross fixed capital formation. It represents the investment in infrastructure distinguished by industry;

Δ Stock = change in stock. It represents the change in inventory. This value can be either negative (a decrease in inventory) or positive (an increase in inventory);

X = exports;

TFD = total final demand. It represents the sum of private consumption, government expenditures, investment, change in stock and imports, less exports;

M = imports;

Gross Output = it represents the total production of each industry. The gross output is distributed among total intermediate production, consumption, government expenditures, investment, change in inventories and net exports.

$$\mathbf{GO = TIP + C + G + GFCF + \Delta\ Stock + X - M;} \qquad (23)$$

Alternatively, we can consider the gross output as given by the production of intermediate goods summed to the production required for the final demand less the amount of demand satisfied by imports:

$$\mathbf{GO = TIP + Final\ Demand - M.} \qquad (24)$$

Comp (L) = compensation of employees. It represents the remuneration of labor. This variable can be identified as L from Leontief's equations.

GOS (K) = gross operating surplus. It represents the remuneration of capital. If we consider a company, its value added is distributed among the providers of labor and capital. After the employees are paid, the residual value added is the gross operating surplus and it can be considered as the remuneration for the financing activity. This variable can be identified as K from Leontief's equations.

VA = value added. Its value is given by the sum of the compensation of employees and the gross operating surplus.

With the available data, we can determine which industry is capital or labor intensive. By comparing the capital-labor ratios of the two industries we obtain the following results is illustrated in table 2.

Table 2: Capital-Labor Ratios for the Two Sectors of the Economy.

$$Agriculture = \left[\frac{GOS}{Comp}\right] = \left[\frac{K_{agriculture}}{L_{agriculture}}\right] = \frac{0.1}{1} = 0.1 \qquad Steel = \left[\frac{GOS}{Comp}\right] = \left[\frac{K_{steel}}{L_{steel}}\right]\frac{5.7}{5} = 1.14$$

As the ratio is higher for the steel industry it represents the capital-intensive sector of the economy. Since the U.S. is a capital abundant nation, its exports are expected to be capital intensive, and so is steel.

In order to implement the Leontief approach and to compute the balance equation, we need the import and export coefficients. These coefficients represent the share of total exports or imports provided by each industry and are calculated as follows:

$$b = \frac{X_i}{\sum X_i} \qquad c = \frac{M_i}{\sum M_i} \tag{25}$$

where b is a column vector of exports coefficients (nx1) and c is a column vector of competitive imports coefficients (nx1).

The balance equation is given by equation 18[5].

[5] Leontief's paper entitled "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis" (1956)

We then follow the Leontief approach with the data in this example in order to compute the capital and labor requirements for the steel and agriculture industries for both imports and exports. The results will exhibit signs of factor intensity reversal if U.S. imports will contain more capital than labor. In this case, the Heckscher-Ohlin theory will be rejected.

The detailed explanation of this example will be useful in order to understand the procedure used in developing the first set of programs to test the validity of Heckscher-Ohlin theorem. To continue with this example we need to compute the input-output coefficients, given by the ratio of intermediate production and the total intermediate production.

$$A = \begin{bmatrix} \frac{5}{16} & \frac{2}{16} \\ \frac{6}{16} & \frac{3}{16} \end{bmatrix} = \begin{bmatrix} 0.31 & 0.12 \\ 0.38 & 0.19 \end{bmatrix}$$

As it is immediately verified, the sum of the coefficients depicted by the calculation performed above is one and it represents the total output of the economy. The capital and labor requirements for imports and exports are given by the following equations:

$$\mathbf{K_X = [k]\,[I - A]^{-1}\,[b]} \qquad (26)$$

$$\mathbf{K_M = [k]\,[I - A]^{-1}\,[c]} \qquad (27)$$

$$\mathbf{L_X = [l]\,[I - A]^{-1}\,[b]} \qquad (28)$$

$$\mathbf{L_M = [l]\,[I - A]^{-1}\,[c]} \qquad (29)$$

where k and l are row vectors of capital and labor coefficients given by the ratio of the remuneration of capital (labor) and the total output in a particular industry[6]. By substituting the values in the above equations we obtain the following results:

$$K_X = 0.4108 = [0.0082 \quad 0.3630] \begin{bmatrix} 1.5877 & 0.2442 \\ 0.7328 & 1.3435 \end{bmatrix} \begin{bmatrix} 0.375 \\ 0.625 \end{bmatrix}$$

$$K_M = 0.4195 = [0.0082 \quad 0.3630] \begin{bmatrix} 1.5877 & 0.2442 \\ 0.7328 & 1.3435 \end{bmatrix} \begin{bmatrix} 0.333 \\ 0.667 \end{bmatrix}$$

$$L_X = 0.4167 = [0.0826 \quad 0.3184] \begin{bmatrix} 1.5877 & 0.2442 \\ 0.7328 & 1.3435 \end{bmatrix} \begin{bmatrix} 0.375 \\ 0.625 \end{bmatrix}$$

$$L_M = 0.4202 = [0.0826 \quad 0.3184] \begin{bmatrix} 1.5877 & 0.2442 \\ 0.7328 & 1.3435 \end{bmatrix} \begin{bmatrix} 0.333 \\ 0.667 \end{bmatrix}$$

As can be seen, the production of US$1 million of exports required US$410,811 in capital and US$416,763 in labor. With respect to the production of import substitutes, we need US$419,586 in capital and US$420,240 in labor. In order to contrast the capital content of exports and imports, we need to compute their ratios.

$$\frac{K_X}{L_X} = \frac{0.4108}{0.4167} = 0.98571 \qquad \frac{K_M}{L_M} = \frac{0.4195}{0.4202} = 0.99844$$

As the capital-labor ratio for imports is higher than the capital-labor ratio for exports and the nation is capital abundant, we can conclude that the presence of factor intensity reversal exists. However, we should take into consideration that, in this particular case, the two ratios are very similar. Therefore, the factor intensity reversal ("FIR") argument is very weak. As an intuitive explanation of the FIR we can look at

[6] $l = \left[\frac{L_{agriculture}}{O} \quad \frac{L_{steel}}{O} \right]; \quad k = \left[\frac{K_{agriculture}}{O} \quad \frac{K_{steel}}{O} \right].$

table 1: U.S. exports more of its capital intensive good (5 versus 3 million dollars), but it also imports more of its capital intensive good (2 versus 1 million dollars). This case is suitable to describe the situation of developed countries where intra-industry trade is prevalent.

Intra-industry refers to the exchange of differentiated products of the same industry or broad product group. For the most part, intra-industry trade evolved primarily to take advantage of important economies of scale in production. This means that companies tend to produce at most few styles of the same product rather than multiple varieties. This is of extreme importance in order to keep unit costs low. This approach also allows for the specialization in a continuous operation that could lead to longer production runs. In the end, one nation imports other varieties and styles from other nations. Intra-industry trade allows consumers to benefit from a wide range of choices available at lower prices. In these cases, nations' trade consists mainly of slightly differentiated high technology commodities.

TESTS OF HECKSCHER-OHLIN THEORY:

THE LEONTIEF APPROACH

Wassily Leontief implemented the first and perhaps the most influential empirical study of trade patterns using the Heckscher-Ohlin theory in 1951. Since United States was considered a capital-abundant nation at that time, it was expected that the U.S. would export capital-intensive goods and import labor-intensive goods.

In order to test this assertion, Leontief utilized the input-output table of the United States to determine the quantity of labor and capital in a "representative bundle" of $1 million value of U.S. exports and import substitutes for the year 1947. The input-output table has a variety of uses, ranging from the assessment of the sales potential of an individual firm to the assessment of broad economic programs. It consists of the origin and destination of each intermediate product in the economy. Its major contribution is that it expresses a relationship of both direct and indirect repercussions of changes in demand.

For example, an increase in consumer demand for motorcycles will lead in the first instance to an increase in the production of motorcycles. The increase in the production of motorcycles will result in more steel production, which in turn will require more chemicals, more iron, more limestone and more coal. The production of motorcycles will also require more upholstery fabric and leather, and the increased production of these fabrics and leather will require more natural fiber and leather. These repercussions are only a few in the chain resulting from the initial change in consumer demand for motorcycles. The input-output table is used by Leontief (along with the labor

and capital coefficients matrices) to compute the indirect capital and labor requirements for unit exports and competitive imports.

Since no other nation gathered its production data in the form of an input-output table, Leontief estimated the capital-labor ratios for U.S. import substitutes rather than for actual imports. Import substitutes are commodities that a nation produces at home in addition to importing from abroad (i.e., cars, motorcycles, etc.). He reasoned that even though U.S. import substitutes would be more capital-intensive than the actual imports (capital was relatively less expensive in the United States than abroad), they should still be less capital-intensive than U.S. exports if the Heckscher-Ohlin model held.

The results obtained by Leontief were disturbing. He found that the capital per man embodied in 1947 U.S. import substitutes exceeded that in exports. These findings are illustrated in table 3.

Table 3: Capital and Labor Requirements per Million Dollars of U.S. Exports and Competitive Import Replacements, 1947 and 1951, Computed on the Basis of 1947 Structural Relationships.

	Exports	Import Substitutes	Imports/Exports
Leontief (1947 input requirements. 1947 trade data)			
Capital	$2,550,780	$3,091,339	
Labor (man-years)[3]	182,313	170,004	
Capital/Labor	$14,010	$18,180	**1.3**
Leontief (1947 input requirements, 1951 trade data)			
Capital	$2,256,800	$2,303,400	
Labor (man-years)	173,910	167,810	
Capital/Labor	$12,977	$13,726	**1.06**
Capital, excluding natural resources	$2,577,100	$2,092,700	
Labor, excluding natural resources	224,230	206,610	
Capital/Labor, excluding natural resources	$11,493	$10,120	**0.88**

Source: Leontief (1956)

[3] Labor requirements in wage-dollars for 1947 only were obtained from Computations C1 and C2:
Wage requirements per million dollars of:

	Exports	Import Replacements
C1	516,277	436,394 (452,581)
C2	545,142	475,107 (468,770)

Figures in parentheses pertain to import requirements computed with imports of raw cane sugar shifted from I.C. Number 9 to I.C. Number 27; data were not available for a similar computation for 1951.

The first four figures in table 3 illustrate the capital-labor position in the exports and import replacements industries in the U.S. for the production of one million dollars worth of final output. We can easily observe that American import replacement industries require more capital to labor than do American export industries. Indeed, Leontief's own conclusion was:

> *"America's participation in the international division of labor is based on its specialization in labor-intensive rather than capital intensive lines of production. In other words, this country resorts to foreign trade in order to economize its capital and dispose of its surplus labor, rather than vice versa".*[4]

These calculations revealed that U.S. import substitutes were approximately 30 percent more capital-intensive than U.S. exports. This meant that the U.S. was exporting labor-intensive commodities and importing more capital-intensive commodities. This, of course, was the opposite of what the Heckscher-Ohlin model predicted and became known as the Leontief Paradox. This paradoxical answer sparked a search of great breadth and intensity for a theory that could explain its findings.

In the same study, Leontief attempted to give a rational explanation of his findings rather than discard the Heckscher-Ohlin model. More precisely, in 1947, U.S. labor was approximately three times as productive as foreign labor. In this original paper, Leontief argued that "labor" should be defined in "standard" units, after adjusting for various degrees of efficiency. Based on this statement, he asserted that the average American worker is three times as efficient as elsewhere and that "spread thrice as thinly

[4] Leontief, 1954, p.25.

as the unadjusted figures suggest the American capital supply per "equivalent worker" turns out to be comparatively smaller, rather than larger, than that of many other countries[5]. If we multiply the 1947 U.S. labor force by three and compare this figure to the availability of capital in the nation, the U.S. would indeed count as a labor-abundant nation. Consequently, it was understandable that U.S. exports would be labor-intensive in relation to U.S. import substitutes. However, this explanation was not accepted and Leontief himself withdrew it. The reason behind this withdrawal was that while U.S. labor was definitely more productive than foreign labor, so was U.S. capital. Hence, both U.S. capital and labor would have to be multiplied by the same factor, leaving the relative abundance of capital in the United States more or less untouched.

Another unconvincing explanation presumed that U.S. tastes were biased so firmly in favor of capital-intensive goods as to result in higher relative prices for these goods in the United States. This narration would result in the fact that the U.S. indeed exports labor-intensive goods. But this explanation was also rejected, because it is known that tastes are similar across nations. Houthakker in his 1957 study on household consumption patterns, found that the income elasticity of demand for food, clothing, housing, and other classes of goods was distinctly alike across nations.

[5] In the original paper, Leontief argued for this threefold efficiency, but did not make any differential adjustment for the efficiency factor in export and import – competing industries. Leontief removed this implicit assumption of an identical efficiency factor for labor in both of these sectors in his later exercise by an explicit weighting of labor in each sector by its average wage.

EXPLANATIONS OF THE LEONTIEF PARADOX

One of the most plausible explanations of the Leontief paradox is that the initial data used in Leontief's study were collected too soon after the end of World War II, and were perhaps not statistically adequate samples since not all data would have been reported and accounted for properly. Leontief himself acknowledged this possibility and repeated his study in 1953 using the 1947 input-output table of the U.S. economy with 1951 trade data. This study showed that U.S. exports were only six percent more labor-intensive than U.S. import substitutes.

Another explanation is the fact that Leontief used a two-factor model, specifically labor and capital, thus ignoring differences in the relative abundance of natural resources. It is worth noting that a commodity might very well be intensive in natural resources, therefore classifying it as capital or labor-intensive would not be correct. Moreover, many production processes using natural resources require large amounts of physical capital. Therefore, the U.S. dependence on imports of specific natural resources could help clarify the large capital intensity of U.S. import-competing industries.

Robert Baldwin identified six major alternative explanations of the Leontief paradox. These maintain that the actual structure of U.S. trade can be accounted for mainly by: (1) the relative abundance of skilled labor in the U.S., (2) an efficiency advantage in favor of the U.S. in research and development ("R&D") oriented industries; (3) the scarcity of natural resources; (4) factor-intensity reversals sufficiently extensive to upset the Heckscher-Ohlin proposition; (5) a strong U.S. demand bias in favor of capital

interactive goods so that these are imported despite the fact that U.S. is a capital abundant nation; (6) high tariffs and other trade distorting measures that favor the domestic production of labor-interactive products and consequently bias the import bundle against these products.

Leontief's measure of capital accounted only for physical capital disregarding human capital. Human capital refers to the years of schooling or experience that workers have, which increases their productivity. The assumption is that since U.S. labor embodies more human capital than foreign labor, adding a human capital element to physical capital would make U.S. exports more capital-intensive relative to import substitutes.

Kravis, Keesing, Kenen and Baldwin undertook numerous empirical studies of human capital. Kravis, in his 1954 study, found that the most heavily protected U.S. industries were labor-intensive. This altered the pattern of trade and reduced the labor intensity of U.S. import substitutes. In two studies published in 1956, Kravis found that wages in U.S. exports industries in 1951 and 1947 were about fifteen percent higher than wages in U.S. import substitutes. Kravis argued that higher wages were an indication of greater productivity of human capital incorporated in U.S. exports than in U.S. import substitutes.

In 1965, Kenen added an estimate of human capital to physical capital for 1947 trade data and concluded that the paradox in Leontief's original study disappears. In his work he employed a concept of capital different from those used in the past. He used the well-known fact that average wages were higher in the export sector of the U.S. economy to argue that they contained more human capital, which he estimated by

capitalizing the wage differential between the export and import competing sectors at the prevailing rate of interest. By adding, the supplementary human capital to the existing estimates of physical capital, he concluded that exports were actually more capital intensive than the competitive imports. In a 1966 study, Keesing found that U.S. exports were more skill intensive than the exports of nine other industrial nations for the year 1957. This result indicates that the U.S. had the most highly trained labor force, therefore containing more human capital than other nations.

Vanek presupposes complementarities between capital and land[6]. He also finds that U.S. trade may conserve scarce land rather than scarce capital (see table 4). The apparent capital intensity in the U.S. import-competing production may, in fact, reflect its very heavy use of land and an extravagant use of capital to improve scarce U.S. land.

Table 4: Capital, Labor and Resource-Product (Land) Use Per Million U.S. Import-Competing Production, 1947.

Inputs	Exports	Imports
Capital ($ thousands) 1947 prices	2,085	2,244
Labor (man-years)	179	164
Resource product ($ thousands) 1947 prices	340	630

Source: Capital and labor data from Leontief, "Factor Proportions," resource product data from Vanek.

Schultz, Becker and others have drawn our attention to a comparable relationship between capital and labor.[7] Large sums are spent each year in training the U.S. labor force and these investments have out-spaced investments in tangible wealth. Combining these two findings, Kenen built a model that treats "capital" and "nature" as the aboriginal agents of production. He also assumes that every country has fixed

[6] J. Vanek, The Natural Resource Content of U.S. Foreign Trade, 1870-1955 (Cambridge, Mass: M.I.T. Press, 1963), chap. vii.

[7] T.W. Schultz, "Reflections on Investment in Man," Journal of Political Economy, LXX, Suppl. (October 1962), 1-8; and G.S. Becker, Human Capital (New York: National Bureau of Economic Research), 1965.

stocks of land and labor that must be improved by acts of investment before they can contribute to current production.

Leontief, in his well-known article on U.S. foreign trade, offers us new data on the U.S. skill mix in export and import-competing production. He suggests that these numbers, listed in table 5, bear his own supposition concerning U.S. foreign trade – that the U.S. labor is more efficient than foreign labor, so that the U.S. is indeed a labor abundant nation exporting labor-intensive goods. However, skills may suggest investment in man and if this is the case the situation changes.

Table 5: Percentage Distribution of Total Labor Input per Million Dollars of U.S. Export Production and U.S. Import-Competing Production, 1947.

Skill Group	Exports	Imports
Professional, technical, etc.	13.75	12.24
Clerical, sales, etc.	22.07	17.00
Craftsmen and foremen	15.15	11.79
Operatives	30.05	28.38
Laborers	18.98	30.59

Source: Leontief, "Factor Proportions" and Kenen, "Nature, Capital and Trade."

If skill differences are entirely due to the quantity invested in the labor force and that the wage differences credited to skill stand for the gross return on that capital, one can calculate the quantity of capital required to convert a man-year of crude labor into a man-year of skill (see table 6)[8].

[8] These estimates understate investment in the labor force; they neglect the capital required to produce an unskilled worker. For a detailed account of these computations and alternative estimates using, first, median in lieu of mean wage income and second, Leontief's data on non-agricultural labor and capital, see P.B. Kenen and E.B. Yudin, Skills, Human Capital and U.S. Foreign Trade (New York: International Economics Workshop, Columbia University, 1965.

Table 6: Annual Wage Income and Investment in Skill, All Sectors, 1959 (Dollars).

Skill Group	Mean Wage Income[9]	Excess Over Laborers	Investment in Skill[10] at 12.7% Return	Investment in Skill at 9% Return
Professional	9,414	6,011	47,336	66,790
Clerical	5,935	2,532	19,937	28,131
Craftsmen	5,982	2,579	20,311	28,658
Operatives	4,913	1,510	11,894	16,782
Laborers[11]	3,403	-	-	-

Source: Mean wage income based on Census data for principal occupations; rates of return from J. Mincer, "On-the-job Training: Costs, Returns and Some Implications," Journal of Political Economy, LXX (suppl.), October, 1962 and Kenen, "Nature, Capital and Trade."

Baldwin, in 1971, using the 1958 U.S. input-output table and U.S. trade data for 1962, found that the exclusion of natural resource intensive industries was not sufficient to eliminate the Leontief paradox unless human capital was included as well. However, the paradox remained for developing nations and for Canada. Baldwin used a different methodology in order to test the validity of Leontief's approach. He ran a regression of U.S. net exports by industry on capital-labor ratios and the shares of each industry's labor force in each of several skilled groups. Other regressions used years and cost of education.

A typical multiple regression in Baldwin's 1971 paper reported here incompletely is illustrated below:

$$X_k = -1.37\left(\frac{K}{L}\right)_k + \sum_f \beta_f p_{fk} - 421 s_k + 343 u_k \qquad R^2=0.44 \qquad (30)$$

where X_k is the U.S. adjusted net exports of commodity k in 1962, $\left(\frac{K}{L}\right)_k$ the capital-labor ratio in industry k, p_{fk} the percentage of labor force in skill group f, s_k an index of scale economies and u_k is an index of the rate of unionization.

[9] Weighted average of mean wage and salary incomes for principal occupations; total income used in lieu of wage income for farmers and self-employed managers.
[10] Computed by dividing the wage differences in the second column by the rates of return given in the column stubs; rates of return have not been corrected for finite asset life.
[11] Farmers and farm proprietors treated as laborers, regardless of Census-0.80s classification or treatment in Leontief's study of skills.

In all his studies, Baldwin found that a negative and significant relationship existed between the physical capital-labor ratio and U.S. net exports. This means that the negative sign on the capital intensity variable is suggestive of the Leontief paradox that the U.S. does not export capital-intensive goods. The results obtained from Baldwin's regression in 1971 are illustrated in table 7:

Table 7: A Sample Baldwin Regression, Dependent Variable Is (Adjusted) Net Exports by the U.S.

Independent Variable	Parameter Estimate	T-statistics
K/L	-1.37	-4.35
Percent labor in:		
Eng. And Science	7011	2.13
Other Professional	-1473	-0.69
Clerical and Sales	71	0.06
Craftsmen/Foremen	1578	1.96
Operatives	-248	-0.79
Non-farm labor	-761	-0.80
Farm labor	845	3.81
Scale Index	-421	-1.25
Unionization Index	343	1.11

Source: Baldwin (1971).

Data in table 7 shows that there is a significant positive relationship between the percentage of scientists and engineers, craftsmen, and farmers in an industry. Research and development activities, not shown here, also show up as being much more important in export output than in import competing production. Baldwin calculated the ratio of the R&D costs involved in producing a representative bundle of import competing versus export commodities, as calculated from the R&D sector in the input-output table, and obtained as a result 0.66.[12] According to Baldwin, the ratio of the number of engineers and scientists engaged in import competing versus export activities is 0.74[13].

[12] The R&D sector in the input-output table includes, however, only research and development performed for sale and thus excludes R&D performed within a company.

[13] This group includes both individuals engaged in research and development as well as those engaged in current production activities. Using data for eighteen industries and direct requirements only Kenen (1968) compared the relative importance of the two groups in "explaining" trade patterns and obtained ambitious results. As Keesing (1968 pp. 175-189) had previously shown, for exports alone, the ratio of scientists and engineers engaged in research and development to the total labor force in the industry is statistically significant whereas the proportion of scientists and engineers in non R&D activities is not. On the other hand, when an industry's net trade balance is taken as the dependent variable, the opposite result is obtained.

Baldwin also found that workers with thirteen or more years of education, as a substitute for human capital, are positively related to U.S. net exports. Nevertheless, when a range of natural resource products are excluded from the factor content calculations, the capital-labor ratio is eliminated as a statistically significant variable. Baldwin also demonstrated that additional factors of production, not only capital and labor, could be brought into the model.

At around the same time, Branson and Junz (1971) published their study on "Trends in U.S. Trade and Comparative Advantage." They estimated human capital by applying the difference between an industry wage estimate and an estimate of the economy-wide unskilled wage, discounted at ten percent. In this case they tried to analyze the following regression equation:

$$X_i = a_0 + a_1 K_i + a_2 H_i + a_3 S_i + a_i P_i + e_i \qquad (31)$$

where: X_i = net export of industry i;

K_i = physical capital per man of industry i:

H_i = human capital per man of industry i;

S_i = scale economies measure;

P_i = first trade data, as a proxy for the product cycle,

e_i = error term.

The results obtained indicate a positive and significant effect for human capital and a weak, negative effect for physical capital. In addition, Branson (1971) used gross trade data to scale the net export variable and found that U.S. exports are intensive in human capital rather than physical capital, a result that others had found earlier.

Branson and Monoyios (1971) updating Branson and Junz's 1971 work, employed a new requirement and a new set of data and came up with similar conclusions. They also experimented with variables such as skilled and unskilled labor and a shipments variable. In order to correct for heteroskedasticity, they scaled their data to the industry size. They also tried a probit model. In the end, they found that human capital is significantly positive, labor significantly negative and physical capital is negative but only marginally significant in explaining net exports. With respect to the probit model they found that the physical capital and raw labor were negative.

ANALYSIS OF THE LEONTIEF PARADOX: 1968-1996

In this thesis, we propose to test the Heckscher-Ohlin theory using three distinct approaches. The methodologies follow from the general equilibrium[7] framework originated by Leontief where all subsequent modifications were introduced using the statistical software package GAUSS.

In the first approach, the Leontief method is used to obtain the capital-labor ratios for import substitutes and exports for each of the nine nations (Australia, Canada, Denmark, France, Germany, Italy, Japan, the U.K. and the U.S.) for which the input-output tables are provided by the OECD. This is precisely the method used in the original Leontief study: we use import substitutes instead of the true value of the imports of the nations considered. In this case, the data available for all these countries are used only to replicate the Leontief approach.

The purpose of this methodology is: (1) to update the Leontief study to 1996 and to determine if the Leontief paradox is present in current trade patterns, (2) to expand the study to include other eight countries, (3) to perform the study at constant prices, and (4) to obtain benchmark results to be compared with subsequent results to be derived.

In the second approach, the input-output tables are used to measure the labor and capital content of each industry. This method is based on the study of the capital-labor ratio for each industry and on a cross-country comparison. This approach allows

[7] The income earned by the two factors of production us used to purchase the two goods. The revenue obtained is used to pay for the factor prices. The prices of outputs and factors in an equilibrium are those which equalize supply and demand in all markets simultaneously.

us to simultaneously use all input-output tables in order to detect the presence of factor intensity reversal. It is well known that the Heckscher-Ohlin theory fails in the case when one good is capital-intensive in one nation and labor-intensive in the other nation. The situation where a commodity is labor intensive when the relative price of labor is low and capital intensive when the relative price of capital is low. If prevalent, this would lead to the rejection of the Heckscher-Ohlin theorem.

For this approach, we do not need to use the imports and exports data since this empirical verification is based only on comparing the industry production processes across nations without taking into account international trade. A disadvantage of this approach is that we can only use the years for which the input-output tables are available. However, this approach is more realistic than the one used by Leontief because it involves the simultaneous use of other nations' data. Subsequently, we will compare the results obtained from the implementation of the Leontief original approach.

In the third approach, starting from the balance equation we will improve the Leontief approach by using the actual data for imports of the United States multiplied by the respective input-output table of the nations being considered. Even though Leontief had at his disposal U.S. imports data, he did not have the input-output tables of the exporting nations to the U.S. In our study, we will employ the information available to test whether or not a capital-abundant nation is exporting more capital-intensive commodities (i.e., U.S. development).

In the original study, it was claimed that even by using import substitutes, the exports should have been more capital-intensive: the findings concluded otherwise. In

this third approach, we considered only two factors of production: capital and labor, and the test is expected to be more realistic.

Since natural resource intensive industries might represent a factor of bias in the testing procedure, we have conducted the analyses in two separate ways: (1) by considering capital and labor as the only factors of production, and (2) by eliminating natural-resource intensive industries.

ASSUMPTIONS USED IN THE REPLICATION OF THE LEONTIEF APPROACH

The next paragraphs describe the assumptions employed in the replication of the Leontief study. The OECD data provided input-output tables for nine countries (i.e., Australia, Canada, Denmark, France, Germany, Italy, Japan, the U.K. and the U.S.). Using these tables, the Leontief approach is applied by making use of the exports and import substitutes for each country and by calculating their capital and labor content. Using the capital stock per worker data obtained from the Penn World Table ("PWT") we calculated the level of capital and labor available in the nations mentioned above to determine their abundancy level and then employed the necessary method to verify the existence of factor intensity reversal.

Factor intensity reversal refers to a situation where a good is labor-intensive in the labor-abundant nation and capital-intensive in the capital-abundant nation. This usually occurs when the elasticity of substitution of factors of production varies intensely for the two commodities. When factor intensity reversal is present, the Heckscher-Ohlin theorem does not hold. According to this theory, the two nations should specialize in the production of the same commodity. If this is the case, there will be no reason for international trade. Eventually, one nation will specialize in the production of the commodity that uses less intensively the abundant factor, in contrast with Heckscher-Ohlin theory. This shows why factor intensity reversal is an exception that if present invalidates Heckscher-Ohlin theory.

The Leontief's method was applied for each of the nations mentioned above. The availability of export and import data only at current prices required a deflation, at

the same base year, of the input-output tables considered. As each country re-computes its input-output table approximately every five years, we had to use several years of export data together with the same coefficients of the intermediate production. The implied assumption is that the production function does not change during this period. For example, if we consider Japan, Australia and Denmark, the frequency with which the statistical agencies are releasing data on their intermediate production is almost always five years. During this period it is reasonable to assume that neither the technique nor the system of production have changed considerably. But for countries like Italy where the availability of its input-output table is limited to one year, namely 1985, we are forced to use the twenty-seven years of export data with the same intermediate production coefficients. This assumption is fairly strong and less realistic.

In order to replicate the Leontief approach we used the available data to compute the capital-labor ratios[8] for import substitutes and exports. Despite the fact that each input-output table is expressed in the local currency of the respective country studied, the calculation of a ratio allows the comparability and the replication of the Leontief approach.

The Leontief test implemented here is based on a number of simplifying assumptions. We considered the gross operating surplus to correspond to the remuneration of capital. The value added in fact can be considered as the net value created by the production activity within the nation. This value is distributed partly to the workers in the form of wages, partly to the government in the form of taxes and the remainder to the providers of capital, as profits. As we did not find an explicit row

[8] The ratio of the quantity of capital to the quantity of labor used in a production process.

providing the amount of profit, we considered the gross operating surplus as a realistic approximation of the remuneration of capital.

In general, the remuneration of capital is difficult to compute since it is divided into the remuneration of capital in the form of a loan and as a risk investment into a corporation. This implies two different uses: (1) the capital invested into a company to be considered as debt and remunerated by the interest rate, and (2) capital risk, which is remunerated by the residual profits after the debt has been serviced. It is clear that the two components bear different risks. In the case of bankruptcy, only when the capital risk is exhausted the debt will suffer losses. For this reason it is more difficult to measure the remuneration of capital. Even though there are different types of labor (skilled and unskilled) the heterogeneity of capital is greater. We can even think of debt as a different factor of production with respect to capital risk.

The gross operating surplus may not be a perfect substitute for the remuneration of capital but certainly it includes these two components. This indicator is obtained as the difference between net revenues and cost of goods sold. It is also called "gross profit" and "earnings before interest, taxes, depreciation and amortization" ("EBITDA"). After deducting from sales the material cost of the product we obtain what can be seen as the value added less the compensation of employees. What we need in order to obtain the value added is the summation of the gross profit and the wage.

The gross profit can be separated into four components: interest costs, amortization and depreciation, corporate taxes and net profit. Interest costs represent the net remuneration of the capital invested into a company in the form of loans and bonds. Amortization and depreciation represent the cost of maintenance for the fixed

capital. Net profit is really the remuneration of the capital risk employed into a company after having compensated all other agents that deal with the company. Concerning taxes, it needs to be pointed out that we are considering the value-added components before deducting taxes. Also, for the compensation of labor, the value includes taxes; by considering gross operating surplus as a proxy for the remuneration of capital we are consistent for what concerns taxes.

It must be taken into consideration that European countries impose a value-added tax on their sale of products that may influence the magnitude of these categories. In general they are not expected to affect their relative values.

With respect to the U.S., the input-output tables do not contain the remuneration of labor and capital except for the year 1982. In order to be able to use the rest of the tables, we are extrapolating the available data for the compensation of employees and the gross operating surplus from the 1982 input-output table and we deflated the data according to the year of the other input-output tables. A similar situation occurs with France for years 1972 and 1977.

CHAPTER 2: DATA COLLECTION

This chapter describes the data gathering and provides basic information on the database used to construct the tests described in Chapter 1. The discussion includes information on the basic format of the data, units, coverage, industry classifications and international comparability.

Parts of the data, namely the input-output tables and data pertaining to imports and exports, have been collected from the OECD. The input-output tables database is part of the Structural Analysis ("STAN") activity undertaken in the Economic Analysis and Statistics Division of the OECD Directorate for Science, Technology and Industry. Despite the fact that the input-output tables have an important role in national statistics and economic analysis, they have not been developed by the Secretariat and little policy analysis has been carried out using this type of economic statistics.

The input-output tables obtained from the OECD are part of a database that was initiated in the mid-1990s to help the OECD Industry Committee in making international comparisons of constructional correction in the industry. This is by far the most detailed consistent database available on this topic. The 1992 OECD project entitled "Structural Change in Industrial Performance: A Seven Country Growth Decomposition Study" provided the initial reason for putting forth the Input-Output database which has been continuously updated in cooperation with statistical offices and various experts in member countries. The number of countries in this database is limited to ten OECD countries, although only nine countries are used in this study. The reason for omitting one nation, namely the Netherlands, is due to lack of data reported by the country's Statistical Office.

The OECD Input-Output Format

The input-output ("I/O") database consists of six elements:

- Domestic intermediate goods flows sub-matrix of the I/O tables;
- Imported intermediate goods flows sub-matrix of the I/O tables;
- Domestically-sourced investment goods flows sub-matrix of the I/O tables;
- Imported investment goods flows sub-matrix of the I/O tables;
- Sub-matrices of final demand vectors for expenditures on both domestic and foreign products; and
- The sub-matrix of value-added sectors.

National statistical agencies of Australia, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, United Kingdom and the United States were asked to provide the OECD with these matrices by converting their national tables to the format requested by the OECD. In addition, they were asked to complete the set of matrices for at least three years, with one year prior to the first oil shock in 1973 and the second in the late 1970s, and the third as late as possible in the 1980s. The database has received new updates beyond the dates mentioned except for Italy and Netherlands. Table 8 illustrates the compilation of all input-output tables for the countries mentioned above.

Table 8: OECD Input-Output database coverage.[14]

	Pre-1973	Mid/Late-1970s	Early-1980s	Mid-1980s	1990
Australia[15]	1968	1974	NA	1986	1989
Canada	1971	1976	1981	1986	1990
Denmark	1972	1977	1980	1985	1990
France	1972	1977	1980	1985	1990
Germany	NA	1978	NA	1986,1988	1990
Italy	NA	NA	1985	NA	NA
Japan	1970	1975	1980	1985	1990
Netherlands	1972	1977	1981	1986	NA
United Kingdom	1968	1979	NA	1984	1990
United States	1972	1977	1982	1985	1990

NA=input-output table not available; the numbers represent the years for which the input-output tables are available.

In general, methods of collecting data differ across countries. In the database obtained, Denmark is the only country that provided time-series data of the United Nation's System of National Accounts compatible input-output tables in both current and constant prices for 1966-1990 period. On the other hand, countries such as Italy were unable to provide the OECD with earlier tables due to their inability to render comparable data for years before the revision of their input-output tables. Equally, the last benchmark available from the United States was 1982. Due to the need for an up-to-date data point for the United States, an annual update table was used in the 1985 and 1990 data points.

Valuation

The tables provided by the OECD are expressed in current and constant national currencies at producers' or basic prices. The basic price valuation is used to describe technological relationships among industries as it excludes distortions in the producers' price system caused by the net commodity taxes on products paid by producers.

[14] Source: OECD.

[15] Australian data refer to fiscal years beginning on 1 July of the year indicated.

Unfortunately, this conversion was followed only by Denmark and Australia; the rest of the nations followed the producers' price system. Under these circumstances, producers' price net of all VAT is suggested for systematic purposes. Nevertheless, the exclusion of all VAT is difficult and Denmark and Germany chose to report non-deductible VAT in a separate row in the input-output table. For Japan, the 1990 data includes VAT in the intermediate matrix. The difference between producers' and purchasers' prices – the trade and transportation margins – have been allocated to the margin industries such as retail and wholesale trade, transportation and warehousing, and insurance.

With respect to the imports data, CIF (Cost, Insurance, Freight) values have been used which are commensurable to the basic values generally used. As for exports it is recommended that the FOB (Free on Board) values be used, but it is essential that the input-output table excludes margins or net direct taxes in order to arrive at producers' or basic values.

National currencies were used as the basic unit of measurement due to their ready availability. Using this approach encounters few problems, but the most important aspect is adjusting the flows for change in relative prices and quality changes in a sector's production. An alternative method would be to value the tables in common currency such as the U.S. dollar or the purchasing power parity. One of the problems with evaluating the table in common currency is that market exchange rates are susceptible to wide temporal fluctuations and would not reflect the amount of output not traded. The purchasing power parity would be a preferable conversion unit since they tend to reflect more accurately the relative cost of output.

Overall, countries were asked to supply their data at constant prices. Some countries have different base years and used different deflation methodologies; as a result some inter-country incompatibilities were introduced (see table 9). Different deflation methodologies were used for different industries in the same country, leading to some problems. Such problems can be overcome by concentrating on changes in the growth of specific variables, as opposed to absolute levels.

In principle, it has been settled upon the value added as the preferred variable for measuring output where real value added for a certain industry is calculated using double deflation procedure.

Table 9: Valuation Method and Base Year.[16]

Country	Pricing	Units	Base Year
Australia	Basic	Million A$	1989
Canada	Producers	Million C$	1986
Denmark	Basic	Million DKr	1980
France	Producers	Million FF	1980
Germany	Producers	Million DM	1985
Italy	Producers	Billion Lira	1985
Japan	Producers	Billion Yen	1985
United Kingdom	Producers	Million Pound	1980
United States	Producers	Million US$	1982

Industry Classification

The common classification selected by the OECD is intended to distinguish technology-intensive and/or trade-sensitive sectors – pharmaceuticals. computers, communication equipment, automobiles, aircraft, etc. – which are the focus of the Directorate of Science, Technology and Industry ("DSTI"). Countries were asked to supply data, which comply with the second revision of the International Standard Industrial Classification ("ISIC," Rev. 2)(see tables 10 and 11).

[16] Source: OECD.

Table 10: Sectoral Classification.[17]

No.	ISIC Rev. 2 codes	Description
1	1	Agriculture, forestry & fishery
2	2	Mining and quarrying
3	31	Food, beverages & tobacco
4	32	Textiles, apparel & leather
5	33	Wood products & furniture
6	34	Paper, paper products & printing
7	351+352+3522	Industrial chemicals
8	3522	Drugs & medicines
9	353+354	Petroleum & coal products
10	355+356	Rubber & plastic products
11	36	Non-metallic mineral products
12	371	Iron & steel
13	372	Non-ferrous metals
14	381	Metal products
15	382-3825	Non-electrical machinery
16	3825	Office & computing machinery
17	383-3832	Electric apparatus, nec
18	3832	Radio, TV & communication equipment
19	3841	Shipbuilding & repairing
20	3842+3844+3849	Other transport
21	3843	Motor vehicles
22	3845	Aircraft
23	385	Professional goods
24	39	Other manufacturing
25	4	Electricity, gas & water
26	5	Construction
27	61+62	Wholesale & retail trade
28	63	Restaurant & hotels
29	71	Transport & storage
30	72	Communication
31	81+82	Finance & insurance
32	83	Real Estate and business services
33	9	Community, social & personal services

Table 11: Composition of Value Added and Final Demand.

Value Added	Final Demand Sectors
Compensation of Employees	Private domestic final consumption expenditures
Operating Surplus	Government Consumption[18]
Consumption of Fixed Capital	Total gross fixed capital formation (GFCF)[19]
Indirect Taxes, net	Changes in Stocks
	Exports

For the "special industries," countries were asked to respect the following rules:

- Government enterprises that sell products via market transaction should be allocated to the sector in which they compete (state owned electricity industry should be designated to sector 25: Electricity, gas and water).

[17] Source: OECD.

[18] For the United States: Government expenditures.

[19] For the United States: Private gross fixed capital formation.

- The provision on non-market government services is usually allocated to the value added. This tabulating should be associated with sector 34: Government producers.

- Any statistical discrepancy should be allocated to sector 36.

- Special accounting industries such as scrap, used and second hand goods should be assigned to sector 35: Other producers.

Due to numerous problems encountered, certain industries had to be cumulated with others. Below is a summary of such distribution and cumulation of industries:

Table 12: Missing Industries in Country Input-Output Tables.[20]

Country	Missing Industries
Australia	Sector 16 is not available separately and is included in Sector 18 Sector 20 consists of railroad equipment only and other transport equipment nec is included in Sector 21.
Canada	Sector 35 contains the imputed rents associated with owner occupied dwellings.
Denmark	Sector 16 is not available separately and is included in Sector 15. Sectors 21 and 22 are not separately available and are included in Sector 20.
France	Sector 27 contains all the margins associated with the intermediate flows and all retail activity associated with motor vehicle sales. Sector 29 does not contain any margin activity. Sector 32 is not available separately and is included in Sector 31 (only for the years 1972 and 1977). Sector 36 includes sales of used products and scrap (only for the years 1972 and 1977).
Germany	Sector 8 is not available separately and has been included in Sector 7. Sector 18 is not available separately and has been included in Sector 17. Sector 20 does not contain any margin activity. Sector 27 contains all the margins associated with the intermediate flows and all retail activity associated with motor vehicle sales. Sector 35 includes services of private nonprofit institutions and domestic services.
Japan	Sector 34 consists of the services of public administration and of national and public institutions for education, health and R&D. Sector 35 is services of private nonprofit institutions to households. Sector 36 contains not only activities not elsewhere classified but also office supplies.
United Kingdom	Sector 18 includes electrical consumer goods and musical recordings.
United States	Post Office operations are included in sector 34 instead of sector 30. Sector 36 includes sales of used products and scrap. Sectors 1, 4, 5, 7, 8, 14, 15, 17, 18, 19, 20, 21, 22, 23, 25, 28, 29, 30, 32, and 33 had some or all of their 1985 activity estimated by using 1977 detailed sector information to scale more aggregate 1985 information in order to achieve a concordance that matched the ISIC input-output scheme.

[20] Source: OECD.

Matrices of Final Demand and Value Added

OECD requested that columns for final uses be provided in addition to consumer expenditures, government and final consumption, changes in stocks and exports. Demand for imports should be separated in order to construct compatible import flow matrices. Several problems were encountered here as well. The inconsistencies revolve around missing data. Table 13 illustrates the availability of value added and other special sectors.

Table 13: Availability of Value Added and Special Sectors[21]

	Australia	Canada	Denmark	France[22]	Germany	Italy	Japan	UK	USA[23]
Compensation of Employees	√[24]	√	√	√	√	√	√	√	√
Operating Surplus	√	√	√	√	√	√	√	√	√
Consumption of fixed capital	NA[25]	√	NA	NA	√	NA	√	N	NA
Indirect taxes, net	√	NA	√	√	√	√	√	√	√
Transfers of products	NA	N	NA	√	NA	√	NA	NA	NA
Non-deductible VAT	NA	NA	√	NA	√	NA	NA	NA	NA
Sales by final buyers	√	NA	NA	NA	NA	NA	NA	√	NA
Complementary Imports	√	√	NA	NA	NA	NA	NA	NA	NA
Business Consumption Expenditures	NA	NA	NA	NA	NA	NA	√	NA	NA

Additional Adjustments

For the most part, participating countries have provided the OECD with consistent data following the format given, but several supplementary modifications were needed to expand comparability across nations.

[21] Source: OECD.
[22] Data for 1972 and 1977 are totally missing.
[23] Data are available only for 1982.
[24] √ = Data available.
[25] NA= data not available.

Total Exports and Imports Table by Activity

The data for the total exports and imports by activity is available only for the manufacturing sectors and is derived from the OECD's product-based Foreign Trade Statistics ("FTS") database. Data have been converted from the product-based classifications ("SITC" Revs. 1, 2 and 3) to activity-based ISIC Rev. 2 categories. The conversion is not flawless since many SITC commodities can be produced by two or more ISIC industries. Estimates cover all goods coming from activities in partner countries rather than imports (intermediate inputs) into the activities in the declaring country. With respect to Germany, data up to and including 1990 refers to West Germany; from 1991, data includes the former East Germany as well.

United States Foreign Trade: General Imports – 1968-1996

Data for total imports of the United States was obtained from the FT155 Department of Commerce publication entitled General Imports: World Area by Commodity Groupings. Later, this publication became known as the FT925 under the title U.S. Merchandise Trade: Exports, General Imports, and Imports for Consumption. Data referenced in this study was extracted from table 3 of the FT155 publication. Table 3 represents the "Continent and Country of Origin by Schedule A Commodity Groupings and Method of Transportation."

The coverage of U.S. imports and exports reflect both government and non-government shipments of merchandise into and out of the U.S. Customs Territory, U.S. Foreign Trade Zones, and the U.S. Virgin Islands, without regard to whether or not a commercial transaction is involved. A number of transactions are actually excluded from

the statistics. They are as follows: (1) U.S. trade with U.S. possessions and trade between U.S. possessions and foreign countries or another U.S. possession; (2) merchandise shipped in transit through the U.S. from one foreign country to another foreign country; (3) shipments from and to the U.S. Armed Forces; (4) gold and silver; (5) issued monetary coins; (6) bunker fuel and other supplies and equipment for use on departing vessels, planes and other carriers engaged in foreign trade; (7) shipments of furniture to U.S. government agencies as well as such merchandise when returned to the U.S. and (8) other transactions believed not to be relevant.

Imports data were collected for all the countries in our study. Data reflects merchandise entered for immediate consumption plus merchandise entered into customs bonded storage warehouses and customs bonded smelting and refining warehouses. The dollar value reflected in the imports statistics is defined as the market value in the foreign country and it excludes U.S. imports duties, freight charges from the foreign country to the U.S. and insurance.

The basic imports data are compiled in terms of the commodity classifications in Tariff Schedules of the United States Annotated ("TSUSA"). These data are reorganized for presentation in foreign trade statistical reports in terms of the codes in Schedule A, Statistical Classification of Commodities Imported into the United States, which is based on the Standard International Trade Classification, Revised ("SITC"). Schedule A was compiled by the Bureau of Census to prepare for the summarization of data of about 10,000 TSUSA classifications into about 2,300 commodity groupings that are of importance to the U.S. trade and to provide comparable international statistics trade data.

The data used provides statistics on general imports by all methods of transportation that include imports by vessel, air, rail, truck, airmail, parcel post or other methods of transportation. The data used is expressed in two digits SITC code. Below is a representation of the data used:

United States – General Imports: Schedule A Commodity Groupings and Methods of Transportation

Schedule A Code	Commodity
00	Animals – Live
01	Meat and Meat Preparations
02	Dairy Products and Eggs
03	Fish and Fish Preparations
04	Cereals and Prep of Cereals, Flour, Etc.
05	Fruits and Vegetables
06	Sugar, Sugar Preparations, and Honey
07	Coffee, Cocoa, Tea, Spices, and Mfrs
08	Feeding – Stuff for Animals, Nes
09	Miscellaneous Food Preparations
11	Beverages
12	Tobacco and Tobacco Manufactures
21	Hides, Skins, Furskins – Undressed
22	Oilseeds, Oil Nuts, and Kernels
23	Rubber, Incl. Synthetic & Reclaimed
24	Wood, Lumber and Cork
25	Pulps and Waste Paper
26	Raw Textile Fibers and Their Waste
27	Crude Fertilizers and Crude Minerals
28	Metalliferous Ores and Metal Scrap
29	Animal & Vegetable Material Nes – Crude
32	Coal, Coke and Briquettes
33	Petroleum and Petroleum Products
34	Gas – Natural and Manufactured
41	Animal Oils and Fats, Nes
42	Veg Oils, Fats – Fixed, Not Hydrogenated
43	Fatty Acids, Waxes, Fats and Oils, NES
51	Chemical Elements and Compounds
52	Min Tar & Oils & Crude Chem. Etc.
53	Dyeing, Tanning & Coloring Materials
54	Medicinal and Pharmaceutical Products
55	Essent Oils, Perfume Mtrls, Soaps Etc.
56	Fertilizers – Mfrd & Fertilizers Mtrls NES
57	Explosives & Pyrotechnic Products
58	Synthetic Resins and Plastic Materials
59	Chemical Products and Materials, Nes

61	Leather, Mfg, Nes & Dressed Fur Skins
62	Rubber Manufacturers – Finished, Nes
63	Wood and Cork Manufacturers, Nes
64	Paper, Paperboard and Manufactures
65	Text Yn, Fab, Made-up Art & Rel Prod
66	Nonmetallic Mineral Manufactures, Nes
67	Iron and Steel
68	Nonferrous Metals
69	Metal Manufactures, Nes
71	Machinery, Other than Electric / Power Generating Machinery and Equipment
72	Electrical Machinery, Appr, and Appl/ Specialized Industrial Machinery
73	Transport Equipment/Metalworking Machinery
74	Industrial Machinery, NSPF, & Parts
75	Office and Automatic Data Process Machs
76	Telecommunications & Sound Reprod Eq.
77	Electrical Machinery, Appr, and Appl
78	Road Vehicles
79	Transport Equipment, NSPF
81	Plumbing, Etc Fix, Fit, Lamps and Pts.
82	Furniture
83	Travel Goods, Handbags Etc.
84	Clothing and Accessories, Etc.
85	Footwear – New, Except Orthopedic
86	Prof, Photo Etc Goods, Clocks Etc.
87	Prof, Scientific & Control Inst NSPF
88	Photo Equipment, Opt Goods & Timing Apprt
89	Miscellaneous Mfrd Articles, Nes
93	Spec Transactions Not Classed by Kind
94	Animals, Nes, Incl Zoo Animals
95	Arms of War, Armed Vehicles, Ammo, Etc.
97	Gold, Nonmonetary, Ex Ores & Concts
99	Est. Val UN 251 Forml & Informal Entries

For missing rows information was not available.

The Penn World Data

The PWT contains a widely used data set of the main macroeconomic variables for many countries. They were first published as an annex to the article by Robert Summers and Alan Heston, "The Penn World Table (Mark 5): An Expanded Set of

International Comparisons, 1950-1988," which appeared in the Quarterly Journal of Economics in May 1991, pp. 327-368.

The PWT currently comprise data for 150 countries and 30 subjects, and most variables are updated to 1992. The tables are built through a set of sophisticated extrapolations from successive benchmark studies, both through time and across space. Its distinctive feature is that its expenditure entries are denominated in a common set of prices in a common currency so that real international quantity comparisons can be made between countries and over periods of time.

The PWT is derived from the benchmark studies of the International Comparison Program ("ICP"), which covers the years 1970, 1975, 1980 and 1985. An ICP benchmark study is a pricing exercise. Prices of hundreds of identical goods and services in each participating country are collected and processed. The price comparisons that materialize are approximations of price parities for each country's currency at a number of aggregation levels, including an overall purchasing power parity. Then the price parities and purchasing power parities are used to convert the countries' national currency expenditures to a common currency unit, namely, US$.

The variable of interest for this study is the capital stock per worker, which is calculated at 1985 international prices. The capital stock per worker is the cumulated, depreciated sum of past gross domestic investment in producers' durables, nonresidential construction, and other construction. The variable is used to determine whether a nation is capital or labor abundant.

CHAPTER 3: EXPANDING THE LEONTIEF APPROACH TO NINE COUNTRIES

As previously mentioned, the theoretical background of this dissertation revolves around the Heckscher-Ohlin theorem which states that a country's exports use intensively the country's abundant factor. Consequently, a country's trade is based on its endowment and is expected to produce more cheaply those goods that are intensive in the use of a factor where that factor of production is abundant in the country relative to its trading partner. The pioneer in testing the Heckscher-Ohlin hypotheses was Wassily Leontief whose incomplete test instigated and stimulated the interest of many trade economists.

Leontief's exercise spurred the re-examination of the sufficient conditions of the Heckscher-Ohlin theorem to address the task of rescuing it from the refutation that had emerged from his tests. In the first approach the Leontief method is used to obtain the capital-labor ratios for import substitutes and exports for each of the nine nations for which the input-output tables are provided by the OECD. This is the exact application of the original Leontief study using import substitutes instead of the true value of imports of the nations considered. This information is used to extend the Leontief methodology to the group of nine countries. The purpose of this study is: (1) to update the Leontief study until 1996; (2) to expand the study to other eight countries; (3) to perform the study at constant prices, and (4) to obtain benchmark results to be compared with subsequent results.

In this chapter, a program is developed for each nation in order to obtain the capital-labor ratios for import substitutes and exports at constant prices. The following notations were implemented throughout all the programs created for this approach.

$$O = \begin{bmatrix} O_1 \\ O_2 \\ . \\ . \\ O_n \end{bmatrix}$$ is an (n x 1) column vector of outputs of *n* industries of the economy;

X is the value of total exports of all *n* industries in million of dollars;

M is the value of total competitive imports into all *n* industries in million of dollars;

$$A = \begin{bmatrix} a_{11} & . & . & a_{1n} \\ . & . & . & . \\ . & . & . & . \\ a_{n1} & . & . & a_{nn} \end{bmatrix}$$

is a square matrix (nxn) of input coefficients; that is for $i = 1,2, \ldots, n$ and $j = 1, 2, \ldots n$; a_{ij} is the amount of industry *i*'s product used by industry *j* per unit of output of industry *j*;

$$b = \begin{bmatrix} b_1 \\ b_2 \\ . \\ . \\ b_n \end{bmatrix}$$ is a column vector (nx1) of export coefficients; that is, for $i = 1, 2, \ldots n$;

$b_i = x_i/X$, and hence equals the amount of industry *i's* exports per one million dollars of total exports of all *n* industries;

$$c = \begin{bmatrix} c_1 \\ c_2 \\ . \\ . \\ c_n \end{bmatrix}$$ is a column vector (nx1) of competitive import coefficients; that is, for

$i = 1, 2, \ldots n$; $c_i = m_i/M$, and hence equals the amount of competitive imports into sector *i* per one million dollars of total competitive imports into all *n* industries;

$K = [k_1 k_2 \ldots k_n]$ is a row vector (1xn) of capital coefficients (they represent the remuneration of capital as a percentage of total output); that is, for $i = 1,2, \ldots, n$; $k_i = K_i/O_i$; more precisely, a capital coefficient represents the quantity of capital required per unit of capacity in an industry.

$L = [l_1 l_2 \ldots l_n]$ is a row vector (1xn) of labor coefficients (they represent the remuneration of labor as a percentage of total output); that is for $i = 1,2, \ldots, n$; $l_i = L_i/O$; more precisely, a labor coefficient represents the quantity of labor required per unit of capacity in an industry.

$$R = \begin{bmatrix} r_1 \\ r_2 \\ . \\ . \\ r_n \end{bmatrix}$$ is a column vector (nx1) of residual constants, each r_i represents that part of sector *i's* output which is allocated directly to all final uses other than exports.

In the absence of a trade equation, Leontief lets the balance-equation be:

$$[I - A]\,[O] - [b]X + [c]M = [r] \qquad (18)$$

and therefore the capital and labor requirements can be computed by pre-multiplying equation (1) by the inverse of [I – A] to obtain:

$$O = [I - A]^{-1}\ [[b]\,X - [c]\,M + [r]] \qquad (19)$$

Subsequently, equation (2) may be pre-multiplied by the row vector of K and L to obtain:

$$KO = [K]\,[I - A]\text{-}1\ \ [[b]\,X - [c]\,M + [r]] \qquad (20)$$

$$LO = [L]\,[I - A]\text{-}1\ \ [[b]\,X - [c]\,M + [r]] \qquad (21)$$

The product of $[K]\,[I - A]^{-1}\,[b]$ and $[L]\,[I - A]^{-1}\,[b]$ gives capital and labor requirements per million dollars of exports and $[K]\ [I - A]^{-1}\,[c]$ and $[L]\,[I - A]^{-1}\,[c]$ gives capital and labor requirements per million dollars of competitive import replacements.

Consequently, the Leontief ratio can be calculated by computing separately the capital-labor input ratios for exports and competitive imports and then dividing the corresponding ratios to identify an index of comparative capital-labor intensity in the production of competitive imports and export goods (see equation 22).

$$Leontief\ Ratio = \frac{\left(\frac{K}{L}\right)_M}{\left(\frac{K}{L}\right)_X} \qquad (22)$$

The input-output tables of a nation at current and constant prices are given at a certain base year. Since the input-output table at constant prices does not report certain information (i.e., compensation of employees, etc.) we deflated the data at current prices in order to obtain the information at constant prices. Data for the GDP deflator at current prices is obtained from the International Financial Statistics ("IFS") yearbook. In order to deflate the data, the following technique is applied. If the input-output table is based at year T_1 and the GDP deflator is at year T_2, then to calculate the GDP deflator based at T_1 we must account for the following:

$$GDP_{T1} = \frac{GDP_{T2}}{GDP_{T1}} * 100 . \qquad (32)$$

Please note that subscripts refer to base years.

In addition, the import-export data are available only at current prices. We used the GDP deflator to obtain the same data at constant prices. The imports and exports data are available from 1970 – 1996. The objective is to create a supplementary program in order to retrieve the results of the Leontief approach for all nine nations and identify if factor intensity reversal is present. Meanwhile, we reshape the matrices of imports and exports data according to ISIC classification in order for the data to be comparable with our input-output tables. Furthermore, in order to avoid any calculation errors a procedure that detects singular rows and columns in the input-output table is added in order to delete them. This calculation ensures that Leontief equation (20) and (21) can be calculated. When a row or column of matrix A is singular (the sector of the economy is insignificant), the matrix [I – A] is also singular and cannot be inverted.

An identical method is implemented eliminating natural resource intensive industries such as: agriculture, forestry & fishing; mining & quarrying; food, beverages & tobacco; wood products & furniture; petroleum & coal products; and nonmetallic mineral products. The elimination of natural resource intensive industries approach has been applied in order to verify the extent to which these industries are influencing the factor intensity reversal issue.

In order to determine whether a nation is capital or labor abundant we used the PWT. Table 14 illustrates the capital stock per worker obtained from the PWT for the most industrialized nations of the world (i.e., Australia, Canada, Denmark, France, Germany, Italy, Japan, the U.K. and the U.S.) The term "world" refers only to this group of countries. These figures are represented in U.S dollars. We then use a lower and an upper quartile to define whether a nation is capital or labor abundant. We decided that when data is less than the 40% quantile, it is an indication that the nation is labor abundant. When data is greater than the 60% quantile, it is a representation that the nation is capital abundant. All other results are denoted as zero and reflect an undetermined outcome. The computation of 40% and 60% quantiles of the PWT was decided after having evaluated few alternatives. If we enlarged the two intervals (i.e., 0-0.50 and 0.50-1) the zone of uncertainty would disappear and we would have been constrained to make a choice when there is not a clear-cut division between capital and labor abundant nations. It is in this type of circumstances where that factor intensity reversal is likely to occur and we have tried to avoid such occurrences.

Table 14: Capital Stock Per Worker

		World of Nine Countries											Capital or Labor Abundant								
Year	Penn World Average	Australia	Canada	Denmark	France	Germany	Italy	Japan	UK	US	Lower Inter-quartile	Upper Inter-quartile	Australia	Canada	Denmark	France	Germany	Italy	Japan	UK	US
1968	9059	23557	21482	17240	15372	18906	14212	7259	10619	21190	15745.6	18572.8	capital	capital	0	labor	capital	labor	labor	labor	capital
1969	9471	24555	22290	18218	16454	19949	15214	8222	11289	22256	16806.8	19602.8	capital	capital	0	labor	capital	labor	labor	labor	capital
1970	9922	25550	23113	19321	17738	21335	16256	9444	11759	23271	18054.6	20932.2	capital	capital	0	labor	capital	labor	labor	labor	capital
1971	10503	26079	23526	20442	18952	30213	17383	10921	12370	23724	19250	22909.2	capital	capital	0	labor	capital	labor	labor	labor	capital
1972	11008	26873	24009	21538	20218	32142	18384	12280	12932	24145	20482	23514.8	capital	capital	0	labor	capital	labor	labor	labor	capital
1973	11481	27519	24454	22503	21537	33846	19295	13769	13415	24718	21730.2	24063.8	capital	capital	0	labor	capital	labor	labor	labor	capital
1974	12043	27934	25092	23638	22915	35534	20399	15276	14060	25561	23059.6	24801.2	capital	capital	0	labor	capital	labor	labor	labor	capital
1975	12571	28530	25813	24650	24242	36901	21527	16400	14618	26109	24323.6	25580.4	capital	capital	0	labor	capital	labor	labor	labor	capital
1976	13028	29152	26509	25159	25189	38153	22133	17479	15014	26124	25165	25937	capital	capital	labor	0	capital	labor	labor	labor	capital
1977	13469	29629	27128	26074	26335	39482	22915	18493	15417	26242	26107.6	26316.4	capital	capital	labor	capital	capital	labor	labor	labor	0
1978	13903	30005	27674	26824	27315	40849	23706	19539	15811	26549	26604	27216.8	capital	capital	0	capital	capital	labor	labor	labor	labor
1979	14290	30644	28186	27529	28194	42237	24456	20722	16161	27068	27160.2	28054.6	capital	capital	0	capital	capital	labor	labor	labor	labor
1980	14667	31080	28910	28223	29104	43739	25391	22085	16563	27551	27685.4	28772.6	capital	capital	0	capital	capital	labor	labor	labor	labor
1981	15080	31704	30223	28641	29962	44874	26383	23345	16992	28086	28197	29697.8	capital	capital	0	capital	capital	labor	labor	labor	labor
1982	15430	32482	31894	28586	30570	45688	27034	24614	17285	28643	28597.4	30184.6	capital	capital	labor	capital	capital	labor	labor	labor	0
1983	15690	32839	32784	28721	31169	46330	27424	25785	17357	28847	28746.2	30704.6	capital	capital	labor	capital	capital	labor	labor	labor	0
1984	15891	33305	33582	28830	31547	47101	27674	26882	17473	29118	28887.6	31061.2	capital	capital	labor	capital	capital	labor	labor	labor	0
1985	16119	33875	34535	29286	31796	47695	28117	28106	17636	29925	29413.8	31421.8	capital	capital	labor	capital	capital	labor	labor	labor	0
1986	16824	34537	35835	30088	32245	48657	28668	29459	18017	30942	30258.8	31984.4	capital	capital	labor	capital	capital	labor	labor	labor	0
1987	17363	34915	37144	31201	32790	49763	29217	30891	18508	31853	31331.4	32602.6	capital	capital	labor	capital	capital	labor	labor	labor	0
1988	17821	35433	38723	32051	33487	51063	29851	32462	19168	32705	32510.6	33330.6	capital	capital	labor	capital	capital	labor	labor	labor	0
1989	17862	36641	40731	32589	34447	49539	30680	34314	20073	33567	33716.4	34420.4	capital	capital	labor	capital	capital	labor	0	labor	labor
1990	18397	37854	42745	33125	35600	50116	31640	36480	21179	34705	34884	36304	capital	capital	labor	0	capital	labor	capital	labor	labor
1991	19724	38509	43465	33536	36595	40093	32746	38883	22066	35436	35667.8	38126.2	capital	capital	labor	0	capital	labor	capital	labor	labor
1992	20741	38729	44970	33814	37460	41115	33775	41286	22509	35993	36286.4	38475.2	capital	capital	labor	0	capital	labor	capital	labor	labor

Note: 0 means undetermined

Note: When taking into account the World Capital Stock per Worker obtained from the Penn World Table, all nations are capital abundant with the exception of Japan for the period 1968-1970.

Note: We used the 40% - 60% percentile in order to calculate whether a nation is labor or capital abundant.

Source "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988," by Robert Summers and Alan Heston Article published in Quarterly Journal of Economics in May 1991, pp.327-368

A separate method, "Delta Method," is employed in order to state with certitude whether or not a nation is faced with factor intensity reversal. In order to understand its purpose let f(b) be a set of J continuous, linear or nonlinear functions of the least squares estimator;

$$\text{Let b} = \begin{bmatrix} \left(\frac{K}{L}\right)_M \\ \left(\frac{K}{L}\right)_X \end{bmatrix}, \text{ a column of ratios} \tag{33}$$

$$\text{and f(b)} = \frac{\left(\frac{K}{L}\right)_M}{\left(\frac{K}{L}\right)_X} \text{ and} \tag{34}$$

$$\text{C} = \frac{\partial f(b)}{\partial b'} \tag{35}$$

where C is the J x K matrix whose j*th* row is the vector of derivatives of the j*th* function with respect to b' or simply the estimate of one component of the true variance. According to Slutsky's theorem, which highlights a comparison between the expectation of a random variable and its probability limits, we obtain the following:

$$\text{plim } f(b) = f(\beta) \tag{36}$$

$$\text{plim } C = \frac{\partial f(\beta)}{\partial \beta'} = \Gamma. \tag{37}$$

Then if *f(b)* is a set of continuous functions of *b* such that $\Gamma = \frac{\partial f(\beta)}{\partial \beta'}$ and the theorem of asymptotic distribution of *b* with nonstochastic regressors holds, then we can evaluate gamma and obtain:

$$f(b) \xrightarrow{a} N\left[f(\beta), \Gamma\left(\frac{\sigma^2}{n} - Q^{-1}\right)\Gamma'\right] \qquad (38)$$

In practice, the estimator of the asymptotic covariance matrix would be

$$\text{Est. Asy. Var}\,[f(b)] = C\left[s^2(X'X)^{-1}\right]C'. \qquad (39)$$

By substituting the calculated variables into the above equation we obtain the following:

$$\begin{bmatrix} \frac{1}{\left(\frac{K}{L}\right)_X} & -\frac{\left(\frac{K}{L}\right)_M}{\left(\frac{K}{L}\right)_X^2} \end{bmatrix} \begin{bmatrix} \sigma^2\left(\frac{K}{L}\right)_M & \operatorname{cov}\left(\left(\frac{K}{L}\right)_M, \left(\frac{K}{L}\right)_X\right) \\ \operatorname{cov}\left(\left(\frac{K}{L}\right)_M, \left(\frac{K}{L}\right)_X\right) & \sigma^2\left(\frac{K}{L}\right)_X \end{bmatrix} \begin{bmatrix} \frac{1}{\left(\frac{K}{L}\right)_X} & -\frac{\left(\frac{K}{L}\right)_M}{\left(\frac{K}{L}\right)_X^2} \end{bmatrix} \qquad (40)$$

Given our Leontief's definition of capital/labor ratio for import substitutes and exports,

$$R = \frac{\left(\frac{K}{L}\right)_M}{\left(\frac{K}{L}\right)_X} = \frac{K_M}{L_M} * \left(\frac{K_X}{L_X}\right)^{-1} = \frac{K_M}{L_M} * \frac{L_X}{K_X} \qquad (41)$$

we then take the derivates and obtain the following:

$$\frac{\partial R}{\partial K_X} = \frac{K_M}{L_M} * \left(-\frac{L_X}{K_X^2} \right) \tag{42}$$

$$\frac{\partial R}{\partial L_X} = \frac{K_M}{L_M} * \frac{1}{K_X} \tag{43}$$

$$\frac{\partial R}{\partial K_M} = \frac{1}{L_M} * \frac{L_X}{K_X} \tag{44}$$

$$\frac{\partial R}{\partial L_M} = \left(-\frac{K_M}{L_M^2} \right) * \frac{L_X}{K_X}. \tag{45}$$

Following these calculations we must find the variance of "R" and then calculate sigma (standard error). The variance is a measure of the dispersion of a distribution. To describe a distribution, we usually use the positive square root of the variance, σ, which is the standard deviation. In the last step we must calculate the confidence interval, which will be necessary in order to identify the acceptance and rejection conditions. When a nation is capital/labor abundant we use the lower/upper limit at ten percent level to account for close proximity.

$$\text{Upper limit} = 1 + 1.645^{*}\sigma, \tag{46}$$

$$\text{Lower Limit} = 1 - 1.645^{*}\sigma. \tag{47}$$

If the nation is capital abundant and the capital/labor ratio is below the lower limit, the nation does not exhibit any signs of factor intensity reversal. If the nation is labor abundant and the capital/labor ratio is above the upper limit, the nation does not encounter any signs of factor intensity reversal. Beyond the limits mentioned, the nation, whether capital or labor abundant, reflects signs of factor intensity reversal.

AUSTRALIA – COMMENTS AND RESULTS

According to our classification of the capital stock per worker from the PWT, Australia is a capital abundant nation during the entire period of our study, 1968-1996. This classification, of course, depends on the number and type of countries taken into consideration but as our study involves all major industrialized countries, the results for Australia depict a more intensive availability of capital with respect to workers. Historically this nation has been short of employees and the target of skilled immigrants. This trend has not changed over years and Australia, along with Canada and Germany, remained a capital abundant nation over the period studied.

This section is mainly concerned with the discussion of the implementation of the Leontief approach for the years 1970-1996. The data used consists in the input-output tables for 1968, 1974, 1986 and 1989 at constant prices and the import and export data at current prices for the years 1970 through 1996. In order to deflate the imports and exports data to be used with the input-output tables at constant prices we obtained the yearly GDP deflator from the IFS. As this index was based at 1990 prices and our input-output tables are at constant 1989 prices we converted the deflator to the 1989 price index following equation (32).

Australia, being a capital abundant nation, should export capital-intensive goods and import labor-intensive commodities. After repeating the calculations for each of the input-output tables, we obtained net capital and labor requirements per million Australian

dollars of exports and competitive imports. These values were obtained for each year, at constant prices, with and without natural resource intensive sectors of the economy. Table 15 on the following page illustrates the capital and labor requirements for one million Australian dollars worth of exports and import substitutes at constant prices with and without natural resource intensive industries.

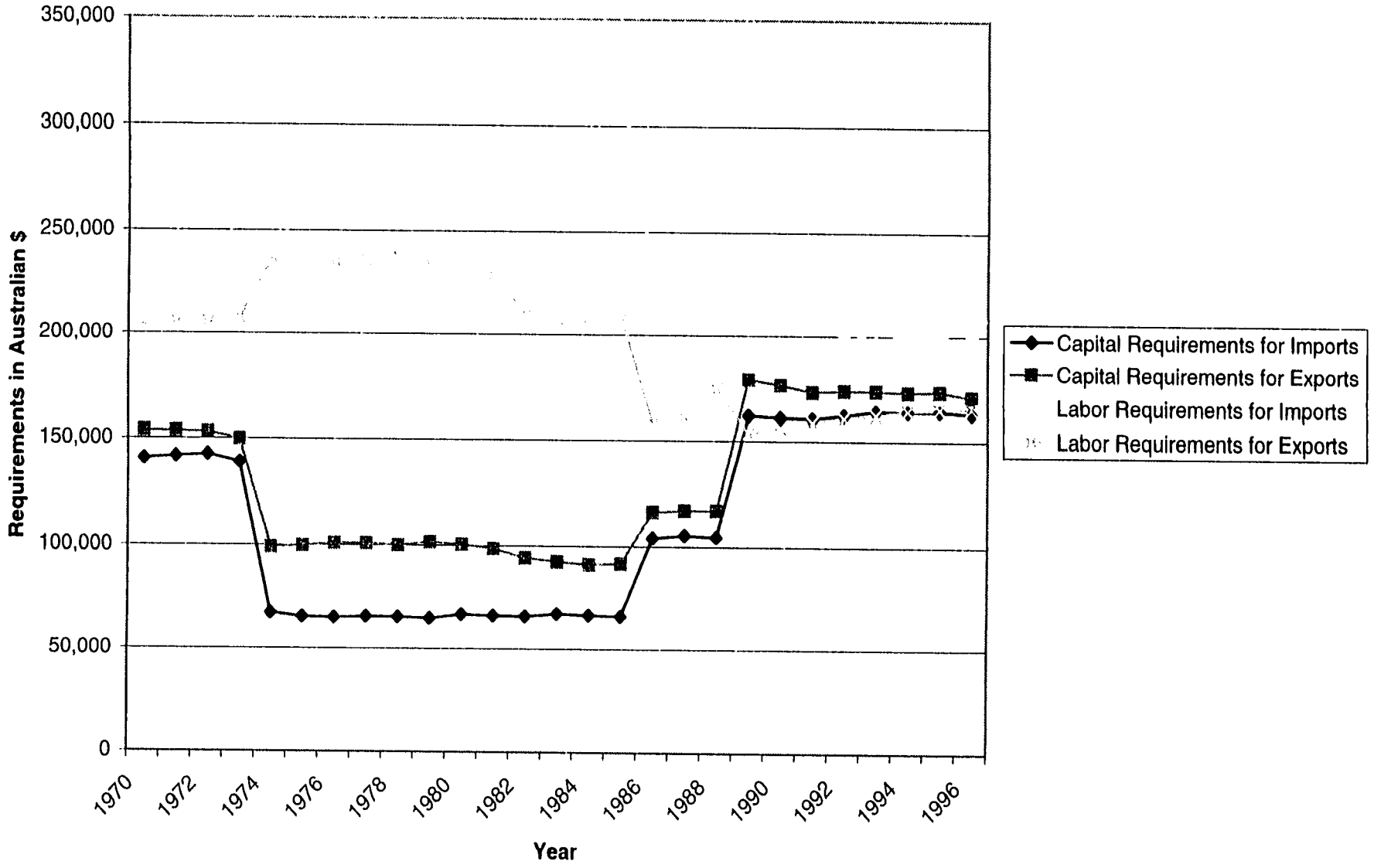
Table 15: Australia - Net Capital and Labor Requirements per Million Australian Dollars of Exports and Imports at Constant Prices

	Capital Requirements With Natural Resources		Labor Requirements			Capital Requirements Without Natural Resources		Labor Requirements	
Year	Imports	Exports	Imports	Exports	Year	Imports	Exports	Imports	Exports
1970	140,784	153,816	308,305	204,980	1970	141,608	165,466	325,871	245,103
1971	141,845	153,579	307,676	206,052	1971	143,019	166,006	326,705	248,993
1972	142,772	153,230	310,945	205,415	1972	144,085	165,194	332,035	249,452
1973	139,221	149,944	311,013	207,925	1973	139,944	158,984	330,697	259,881
1974	67,562	99,071	312,341	236,538	1974	64,318	80,525	337,082	267,283
1975	65,813	99,805	319,693	236,956	1975	63,408	83,948	347,170	271,121
1976	65,340	101,045	312,800	234,438	1976	62,524	83,080	342,202	269,438
1977	65,896	101,032	310,261	235,152	1977	62,837	83,761	342,408	268,873
1978	65,753	100,069	315,552	236,898	1978	62,776	83,482	344,333	275,630
1979	65,098	101,703	306,092	233,936	1979	62,471	84,997	337,034	273,594
1980	66,981	100,559	307,409	231,660	1980	64,522	86,136	338,224	257,865
1981	66,506	98,643	314,428	228,675	1981	64,403	85,340	345,058	256,492
1982	66,229	94,412	315,171	209,419	1982	63,778	84,895	342,918	243,379
1983	67,509	92,622	315,969	205,018	1983	64,585	85,310	344,700	240,504
1984	66,943	91,346	313,024	204,297	1984	63,543	84,435	340,373	236,469
1985	66,336	91,827	315,267	208,404	1985	62,824	84,466	340,602	239,643
1986	104,088	116,430	230,024	158,236	1986	104,451	113,772	243,272	170,581
1987	105,320	117,162	227,761	160,497	1987	105,132	112,675	239,717	171,517
1988	104,531	117,252	231,124	174,504	1988	103,399	110,614	241,352	192,346
1989	161,970	178,947	203,449	153,909	1989	161,964	182,298	213,025	168,083
1990	160,977	176,330	206,262	156,538	1990	161,017	178,945	216,955	172,560
1991	160,503	172,988	208,279	158,675	1991	160,405	175,162	219,289	177,174
1992	162,136	173,676	203,135	160,811	1992	161,854	174,258	212,368	178,417
1993	164,055	173,471	197,328	162,115	1993	163,901	174,067	204,941	179,879
1994	163,826	172,897	200,840	164,093	1994	162,880	171,992	207,189	181,575
1995	163,959	173,291	199,931	164,866	1995	163,293	173,178	206,495	180,528
1996	162,980	170,848	202,733	165,233	1996	162,231	171,530	209,750	183,539

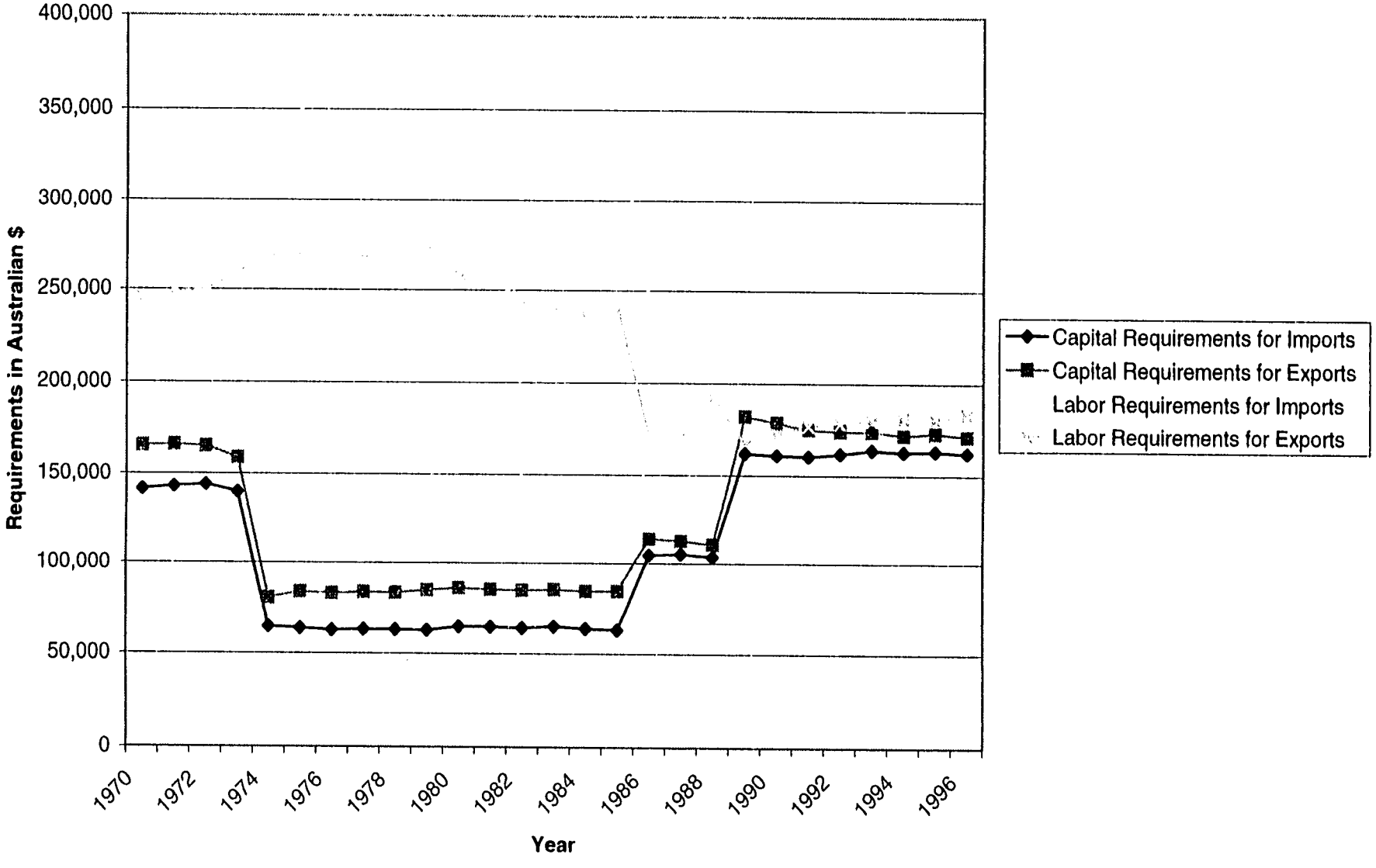
It is worth noting that we are using four input-output tables for the period studied. The evident changes in the capital and labor requirements are caused by the use of a different input-output table, in particular for 1974, 1986 and 1989. The input-output table describes the essence of the economy, intermediate and final production. Even though the structure of the economy changes continuously, this modification can be statistically accounted for only periodically. It is for this reason that after an update of the input-output table, the differences between the coefficients are so noteworthy.

In order to better illustrate these changes, a graphical representation of the evolution of the capital and labor requirements per million Australian dollars (with and without natural resource intensive industries) at constant prices is presented on the following pages (see graphs 1 and 2).

Graph 1: Australia - Capital and Labor Requirements With Natural Resources at Constant Prices Per Million Australian Dollars of Imports and Exports



Graph 2: Australia - Capital and Labor Requirements Without Natural Resources at Constant Prices Per Million Australian Dollars of Imports and Exports



It is immediately apparent that the labor requirements for import substitutes are higher than all other requirements over the period studied. As we previously mentioned, the graphs illustrate changes in the requirements for exports and import substitutes for the year in which the input-output tables are updated. In the intermediate period the results are quite stable and they do not show an upward or downward trend.

Starting in 1974, capital is substituted for labor in the Australian economy. If we consider exports, the capital requirements decrease from AU$ 149,944 in 1973 to AU$ 99,071 in 1974 and the labor requirements increase from AU$ 207,925 in 1973 to AU$ 236,538 in 1974. In contrast, after 1986 labor is substituted for capital in the national production. The capital content of exports and import substitutes increases whether the labor content decreases. During the next change, 1989, the trend is confirmed; a substitution of labor for capital. The process of industrialization is probably a factor that influenced the more intense employment of capital.

For what concerns exports, there is over the years a tendency for the capital content to increase and the labor content to decrease. In the last period studied, the exports are characterized by a higher content of capital than labor concluding the trend just mentioned.

One of the first attempts to solve the Leontief paradox was based on the elimination of natural resource intensive industries because they were considered the third factor of production. As our study takes this hypothesis into consideration, all the analysis is conducted with and without natural resource intensive industries.

In the case of Australia, the exclusion of natural resources does not affect the results. Across the various periods, the effect consists in a slight increase or decrease in the capital and/or labor requirements. Since these indicators can be interpreted as the average capital or labor content of a one million Australian dollars bundle of goods, the exclusion of natural resource intensive industries can increase the capital or labor requirements if the industries excluded used less intensively these factors of production.

In order to better understand the evolution of capital and labor requirements we need to consider the relative behavior of these variables. The capital-labor ratio is an indicator obtained for exports and import substitutes by dividing the capital by the labor requirements per million Australian dollars worth of goods.

Table 16 illustrates the change over the period 1970 to 1996 in the capital-labor ratio for import substitutes and exports at constant prices. The values are provided for the following two scenarios: (1) 33 industries input-output table, and (2) input-output table with and without natural resource intensive industries.

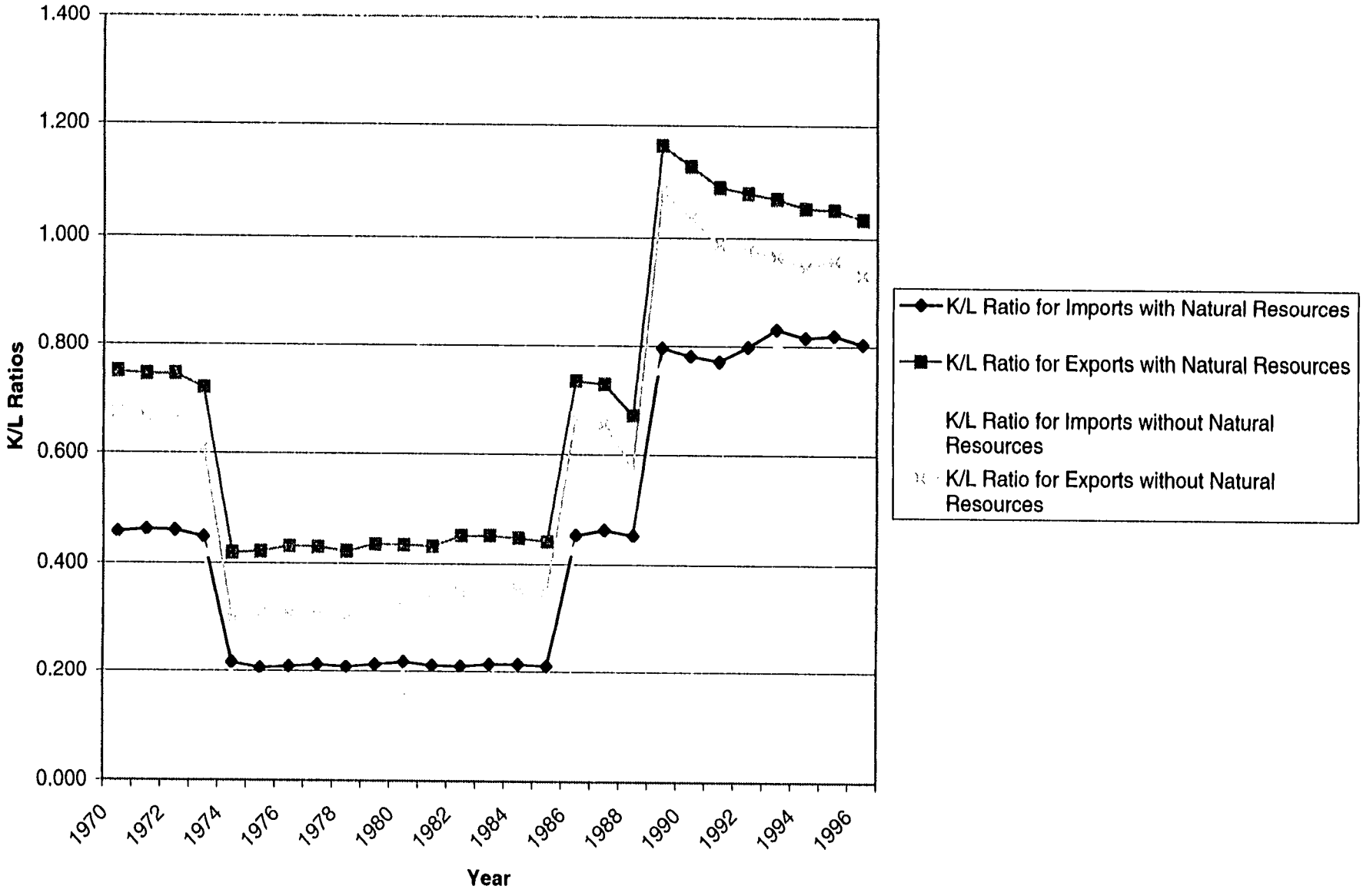
According to the PWT, Australia is a capital abundant nation during the period studied. The capital-labor ratio for import substitutes reduces from 0.47 in 1970 to 0.21 in 1974-1985. Starting from 1986 the ratio increases from 0.45 to 0.80. This means that in 1970, the production of import substitutes required more than two units of labor for each unit of capital. This ratio increased to five units of labor per each unit of capital from 1975 to 1985. The amount of labor required remained stable for the next decade and then decreased until 1996 when for each unit of labor it was necessary to invest 0.8 units of capital. By looking at the exports a similar trend can be noticed, but the relative amount of capital necessary is always greater than the amount required for import

substitutes. Exports required relatively more capital than the import substitutes during the twenty-seven year period studied. Since the capital-labor ratio for exports is always higher than import substitutes, and Australia is considered a capital abundant nation, the Leontief ratio remains always below 1, indicating the absence of factor intensity reversal.

Table 16: Australia - Capital/Labor Ratios at Current and Constant Prices

	Capital/Labor Ratio at Constant Prices					Capital/Labor Ratio at Current Prices					Leontief Ratio at Constant Prices	
	With Natural Resources		Without Natural Resources			With Natural Resources		Without Natural Resources				
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports			
1970	0.457	0.750	0.435	0.675	1970	0.467	0.766	0.437	0.675	1970	0.61	0.64
1971	0.461	0.745	0.438	0.667	1971	0.478	0.762	0.445	0.668	1971	0.62	0.66
1972	0.459	0.746	0.434	0.662	1972	0.480	0.761	0.445	0.665	1972	0.62	0.66
1973	0.448	0.721	0.423	0.612	1973	0.456	0.727	0.423	0.598	1973	0.62	0.69
1974	0.216	0.419	0.191	0.301	1974	0.219	0.422	0.187	0.296	1974	0.52	0.63
1975	0.206	0.421	0.183	0.310	1975	0.208	0.425	0.178	0.305	1975	0.49	0.59
1976	0.209	0.431	0.183	0.308	1976	0.213	0.437	0.179	0.306	1976	0.48	0.59
1977	0.212	0.430	0.184	0.312	1977	0.216	0.436	0.180	0.310	1977	0.49	0.59
1978	0.208	0.422	0.182	0.303	1978	0.211	0.429	0.179	0.301	1978	0.49	0.60
1979	0.213	0.435	0.185	0.311	1979	0.216	0.442	0.182	0.308	1979	0.49	0.60
1980	0.218	0.434	0.191	0.334	1980	0.222	0.439	0.188	0.331	1980	0.50	0.57
1981	0.212	0.431	0.187	0.333	1981	0.214	0.439	0.183	0.332	1981	0.49	0.56
1982	0.210	0.451	0.186	0.349	1982	0.212	0.466	0.182	0.351	1982	0.47	0.53
1983	0.214	0.452	0.187	0.355	1983	0.217	0.468	0.184	0.356	1983	0.47	0.53
1984	0.214	0.447	0.187	0.357	1984	0.217	0.464	0.183	0.360	1984	0.48	0.52
1985	0.210	0.441	0.184	0.352	1985	0.212	0.450	0.181	0.356	1985	0.48	0.52
1986	0.453	0.736	0.429	0.667	1986	0.450	0.742	0.426	0.681	1986	0.61	0.64
1987	0.462	0.730	0.439	0.657	1987	0.460	0.736	0.436	0.670	1987	0.63	0.67
1988	0.452	0.672	0.428	0.575	1988	0.450	0.675	0.425	0.583	1988	0.67	0.74
1989	0.796	1.163	0.760	1.085	1989	0.796	1.163	0.760	1.085	1989	0.68	0.70
1990	0.780	1.126	0.742	1.037	1990	0.780	1.126	0.742	1.037	1990	0.69	0.72
1991	0.771	1.090	0.731	0.989	1991	0.771	1.090	0.731	0.989	1991	0.71	0.74
1992	0.798	1.080	0.762	0.977	1992	0.798	1.080	0.762	0.977	1992	0.74	0.78
1993	0.831	1.070	0.800	0.968	1993	0.831	1.070	0.800	0.968	1993	0.78	0.83
1994	0.816	1.054	0.786	0.947	1994	0.816	1.054	0.786	0.947	1994	0.77	0.83
1995	0.820	1.051	0.791	0.959	1995	0.820	1.051	0.791	0.959	1995	0.78	0.82
1996	0.804	1.034	0.773	0.935	1996	0.804	1.034	0.773	0.935	1996	0.78	0.83

Graph 3: Australia - Capital/ Labor Ratios at Constant Prices



It is important to notice the effect of the change in the input-output table during the years 1974, 1986 and 1989. Ratios following the substitution of the input-output tables demonstrate radical changes. This is the result of the inability of continuously updating the input-output table. The periodic updates can only temporarily adjust the table to give a realistic representation of the economy. Graph 3 depicts these changes.

After 1974, the ratios almost halved indicating that for the same value of goods to be produced, only half of the production requirements were necessary. This reduction could have been triggered by improvements in technology or simply by changes in the techniques of production. For the next eleven years the ratios remain constant only because the input-output table is never updated and the Leontief approach cannot fully illustrate the change in the economy. After 1985, we can observe that these ratios almost recovered from the 1974-drop and the tendency to increase magnifies after 1989 when the ratios doubled to reach a value near 1 when accounting for natural resource intensive industries.

In order to interpret the evolution of the capital-labor ratios over the entire period, we can consider that from an approximate ratio of two units of labor per one unit of capital needed for the production of a representative good imported in 1970, at the end of the period studied, the ratio was almost one to one. The exports follow a similar pattern. In a sense, this shows a substitution of labor for capital, over the period studied. In fact, we witnessed an increase in the number of units of capital used for the same amount of labor employed.

In order to confirm the Heckscher-Ohlin theory with certitude, we utilize the delta method. Table 17 tests for the presence of factor intensity reversal by comparing the

Leontief ratio at the 10% confidence level interval obtained with and without natural resource intensive industries. Since Australia is a capital abundant nation, the Heckscher-Ohlin theory predicts that the ratio will be less than one. This is the case for all the years analyzed. However, when applying the delta method, we obtain benchmark values, which are significantly below the unity for each of the twenty-seven year period studied.

The lower limit given by the delta method is very sensitive to the variability of the capital-labor ratios (import substitutes and exports). As we have described over the twenty-seven year period studied, the capital-labor for import substitutes (with natural resources) declines from 0.47 to 0.20 and subsequently increases up to 0.83. The ratio for exports decreases from 0.77 to 0.43 and subsequently increases to 1.16. The same trend is revealed when eliminating natural resource intensive industries. This great variability leads the delta method to reduce the lower limit necessary to exclude factor intensity reversal.

Until 1985, the Leontief ratio is almost half the minimum value confirming the validity of the Heckscher-Ohlin theory (see table 17). This represents a strong confirmation of the theory. Starting from 1986 we can see that the ratio progressively increases, but remains below the lower limit. However, when excluding natural resource intensive industries, the variability of the capital-labor ratios increases and the lower limit is reduced. This characteristic leads the test to conclude the presence of factor intensity reversal for the period 1992-1996 when eliminating natural resource intensive industries.

Table 17: Delta Method for Australia

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Lower Limit	Upper Limit	Ratio	Conclusion	Lower Limit	Upper Limit	Ratio	Conclusion
Capital	1968	0.73	1.27	0.44	NO FIR				
Capital	1969								
Capital	1970	0.86	1.14	0.61	NO FIR	0.84	1.16	0.64	NO FIR
Capital	1971	0.87	1.13	0.62	NO FIR	0.86	1.14	0.66	NO FIR
Capital	1972	0.87	1.13	0.62	NO FIR	0.86	1.14	0.66	NO FIR
Capital	1973	0.87	1.13	0.62	NO FIR	0.87	1.13	0.69	NO FIR
Capital	1974	0.87	1.13	0.52	NO FIR	0.82	1.18	0.63	NO FIR
Capital	1975	0.88	1.12	0.49	NO FIR	0.83	1.17	0.59	NO FIR
Capital	1976	0.87	1.13	0.48	NO FIR	0.84	1.16	0.59	NO FIR
Capital	1977	0.88	1.12	0.49	NO FIR	0.84	1.16	0.59	NO FIR
Capital	1978	0.87	1.13	0.49	NO FIR	0.85	1.15	0.60	NO FIR
Capital	1979	0.88	1.12	0.49	NO FIR	0.77	1.23	0.60	NO FIR
Capital	1980	0.87	1.13	0.50	NO FIR	0.75	1.25	0.57	NO FIR
Capital	1981	0.88	1.13	0.49	NO FIR	0.84	1.25	0.56	NO FIR
Capital	1982	0.89	1.12	0.47	NO FIR	0.75	1.25	0.53	NO FIR
Capital	1983	0.89	1.11	0.47	NO FIR	0.75	1.25	0.53	NO FIR
Capital	1984	0.87	1.13	0.48	NO FIR	0.74	1.26	0.52	NO FIR
Capital	1985	0.86	1.14	0.48	NO FIR	0.74	1.26	0.52	NO FIR
Capital	1986	0.86	1.14	0.61	NO FIR	0.73	1.27	0.64	NO FIR
Capital	1987	0.87	1.13	0.62	NO FIR	0.72	1.28	0.67	NO FIR
Capital	1988	0.87	1.13	0.62	NO FIR	0.74	1.26	0.74	NO FIR
Capital	1989	0.81	1.19	0.68	NO FIR	0.71	1.29	0.70	NO FIR
Capital	1990	0.81	1.19	0.69	NO FIR	0.73	1.27	0.72	NO FIR
Capital	1991	0.82	1.18	0.71	NO FIR	0.75	1.25	0.74	NO FIR
Capital	1992	0.83	1.17	0.74	NO FIR	0.75	1.25	0.78	UNDETERMINED
Capital	1993	0.84	1.17	0.78	NO FIR	0.76	1.24	0.83	UNDETERMINED
Capital	1994	0.84	1.16	0.77	NO FIR	0.77	1.23	0.83	UNDETERMINED
Capital	1995	0.83	1.17	0.78	NO FIR	0.77	1.23	0.82	UNDETERMINED
Capital	1996	0.84	1.16	0.78	NO FIR	0.75	1.21	0.83	UNDETERMINED

Nevertheless, following the traditional Leontief approach Australia does not show the presence of factor intensity reversal over the twenty-seven year period considered. The Leontief ratio is less than 0.5 until 1986 and remains below 0.8 thereafter. As table 17 shows the Heckscher-Ohlin prediction is confirmed by the mere fact that for the entire period the capital-labor ratio for exports is always higher than the capital-labor ratio for imports. In this respect the validity of the Heckscher-Ohlin theory is confirmed.

CANADA – COMMENTS AND RESULTS

Our classification of the capital stock per worker from the PWT indicates that Canada is a capital abundant nation for the period 1968-1996 (see table 14). The capital stock per worker more than doubled from CA$21,482 in 1968 to CA$44,970 in 1992. Canada, like Australia, has had a shortage of labor, and its growing economy has attracted skilled immigrants over the years. Therefore, the unavailability of workers may have contributed to the utilization of more capital-intensive processes.

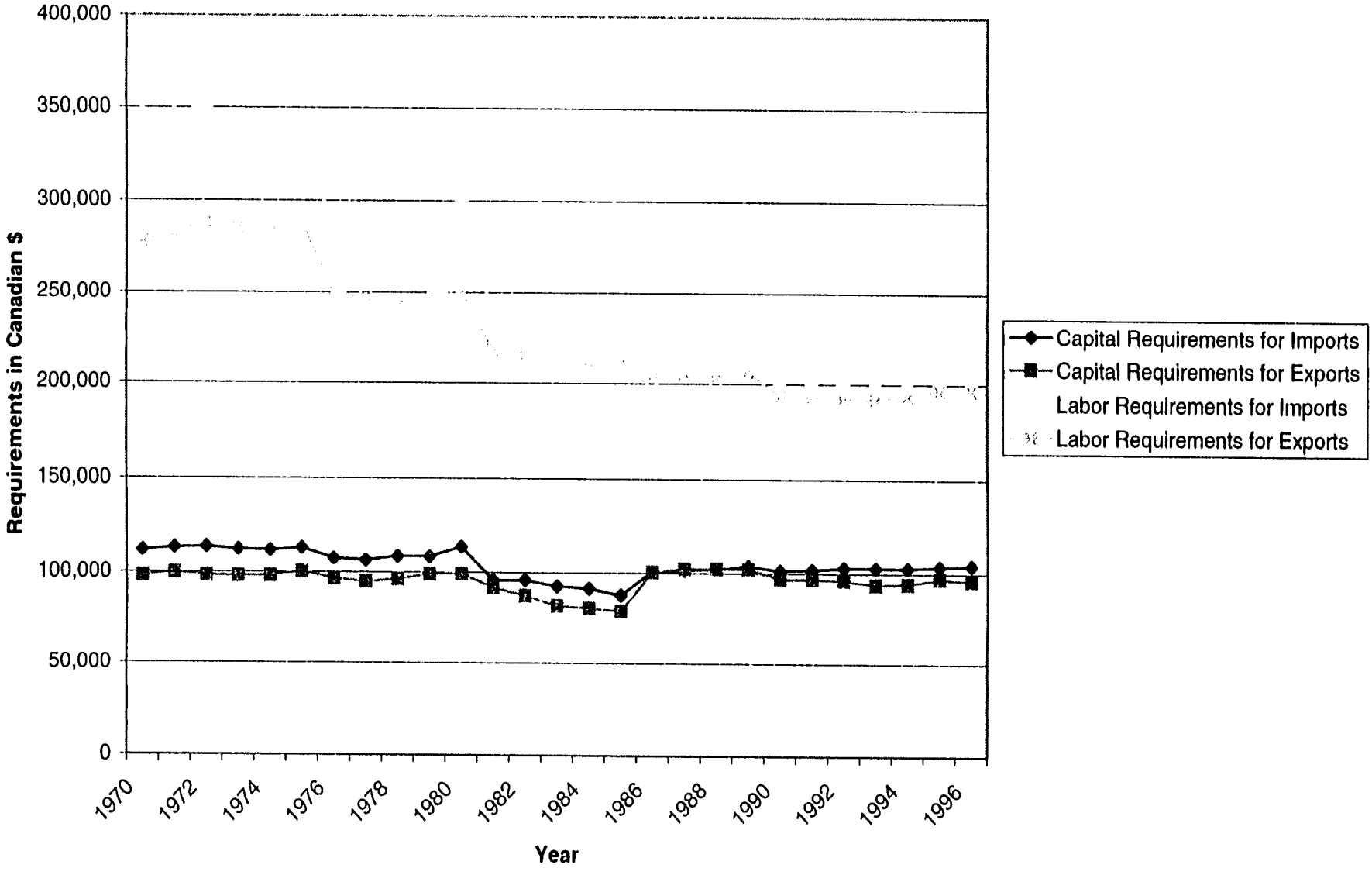
Since our clarification places Canada as a capital abundant nation, we are expecting that the nation is exporting capital-intensive goods and importing labor-intensive goods. Following Leontief's approach, we obtained the net capital and labor requirements per million Canadian dollars of exports and competitive imports with and without natural resource intensive industries. These values were obtained for each year at constant prices.

It is important to mention that we are using five different input-output tables for the period studied (1971, 1976, 1981, 1986 and 1990, all calculated at 1986 base year). Visible changes for the values of capital and labor requirements are caused by the use of different input-output tables. In order to better understand these changes, results are aggregated into a table format followed by graphical representations of capital and labor requirements at constant prices (see table 18 and graphs 4 and 5).

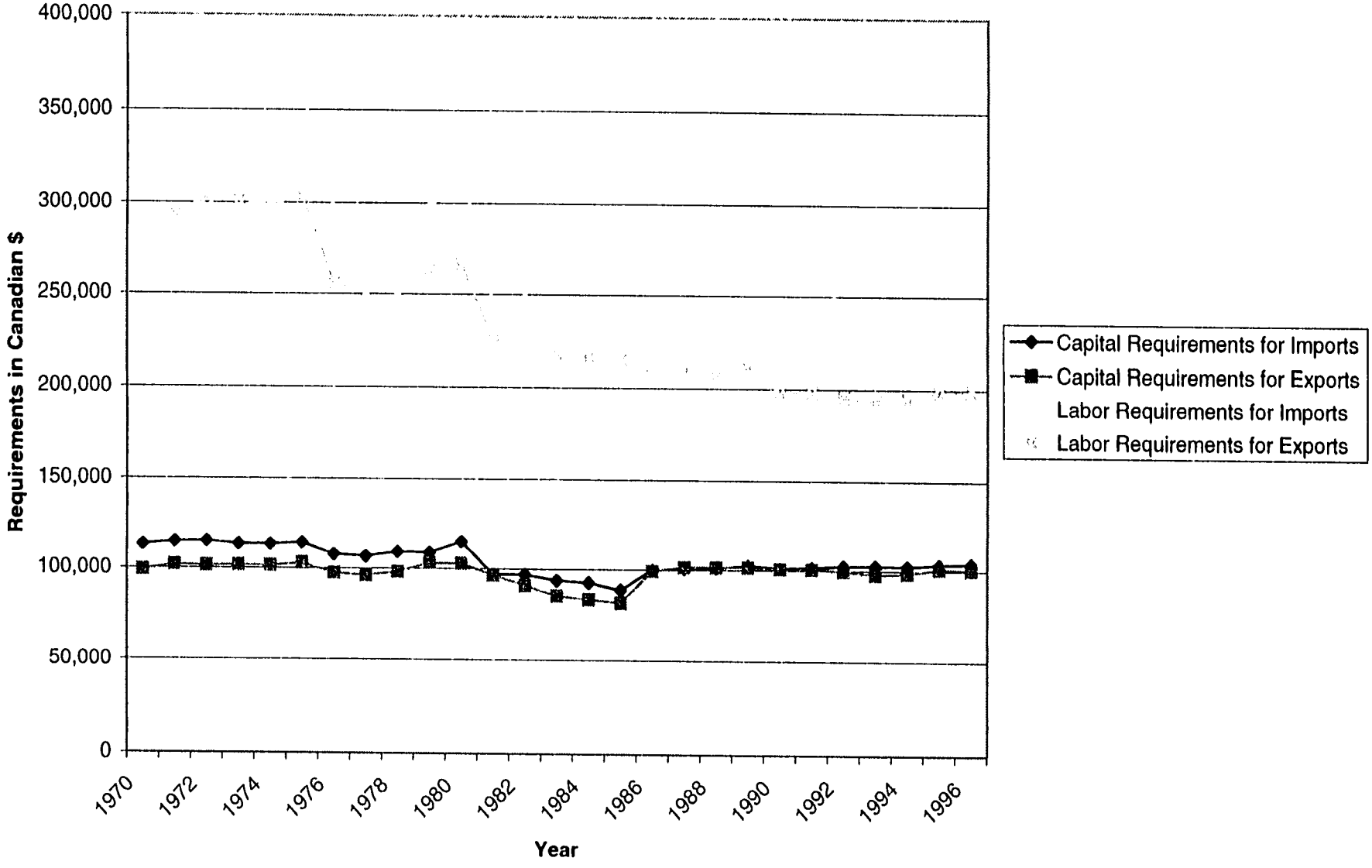
Table 18: Canada - Net Capital and Labor Requirements per Million Canadian Dollars of Exports and Imports at Constant Prices

	Capital Requirements With Natural Resources		Labor Requirements With Natural Resources		Capital Requirements Without Natural Resources		Labor Requirements Without Natural Resources	
	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports
1970	111,862	98,265	347,583	277,852	113,243	99,168	370,727	288,157
1971	113,192	99,816	347,501	282,385	114,776	101,806	369,313	293,982
1972	113,646	98,375	350,216	288,487	115,159	101,465	371,784	302,643
1973	112,357	98,094	344,262	285,521	113,607	101,694	365,830	301,623
1974	111,857	98,146	337,669	283,104	113,383	101,404	360,350	298,891
1975	113,039	100,414	337,712	288,590	114,281	102,852	358,947	303,668
1976	107,345	96,542	282,757	250,602	107,632	97,501	296,031	255,861
1977	106,385	95,058	277,297	246,928	106,650	96,115	290,597	251,090
1978	108,560	96,386	281,856	243,392	109,116	98,265	294,743	250,759
1979	108,451	99,116	285,725	249,243	108,894	103,167	297,576	263,053
1980	113,882	99,322	302,223	251,660	115,122	102,875	317,853	266,679
1981	95,761	92,008	237,176	217,557	96,829	96,609	245,176	225,439
1982	95,854	87,605	238,272	215,604	96,858	90,865	247,307	222,675
1983	92,669	82,167	235,336	212,523	93,641	85,282	243,537	217,641
1984	91,457	80,839	235,132	211,552	92,558	83,370	243,949	216,431
	87,806	79,192	229,706	210,609	88,575	81,515	237,359	215,035
1986	100,803	100,509	212,680	202,756	99,787	99,289	219,128	207,154
1987	101,612	102,503	213,351	205,484	100,567	101,498	219,875	209,910
1988	102,353	102,465	220,850	203,282	101,009	101,577	226,852	207,733
1989	103,859	102,356	220,458	206,313	102,582	101,590	226,871	211,008
1990	101,368	96,975	203,501	193,491	101,188	100,841	209,087	198,309
1991	102,040	96,919	202,883	193,098	101,519	100,644	207,703	198,158
1992	102,985	96,204	202,674	192,345	102,572	99,656	207,309	195,628
1993	103,007	93,992	201,675	191,903	102,689	97,830	206,081	193,989
1994	102,945	94,456	201,644	193,662	102,476	98,497	205,788	194,660
1995	103,745	97,203	202,931	196,610	103,426	101,026	206,980	198,434
1996	104,366	95,986	202,294	196,634	104,068	100,403	206,621	199,244

Graph 4: Canada - Capital and Labor Requirements with Natural Resources at Constant Prices Per Million Canadian Dollars for Imports and Exports



Graph 5: Canada - Capital and Labor Requirements without Natural Resources at Constant Prices Per Million Canadian Dollars for Imports and Exports



An expeditious glance at the capital and labor requirements in table 18 indicates that the labor requirements for import substitutes with and without natural resource intensive industries are always more than the double of the capital requirements over the entire period studied. Most importantly, the exclusion of natural resource intensive industries does not affect our results substantially.

The amount of labor per one million Canadian dollars of import substitutes is higher when natural intensive industries are removed over the period studied compared with the amount of labor necessary for exports. Concomitantly, the capital requirements for import substitutes are higher than those of exports over the period studied, although the difference is immaterial. The capital requirements seem to be higher for import substitutes when considering all industries of the input-output table as well as when the natural resource intensive industries are eliminated. There is only one exception over the period studied when the capital requirements are higher for exports than for import substitutes, namely in 1987-1988. Although the change is very small, it is still worth mentioning: CA$102,353 in capital requirements for import substitutes in 1988 versus CA$102,465 for exports when all industries are considered and CA$101,009 in capital requirements for import substitutes versus CA$101,577 for exports when natural resource intensive industries are being eliminated.

During the period considered, capital requirements for import substitutes remain stable from 1970 to 1980. These requirements decrease upon the update of an input-output table. Towards the end of the period studied the capital requirements do not vary significantly from those in 1970. The situation is considerably different for labor requirements; we are experiencing a decrease from a value of CA$347,583 in 1970 to CA$202,294 in 1996. This represents a reduction of more than 50%, probably caused

by an increased efficiency of labor or to a reduction (due to changes in production) in the quantity of labor necessary to produce the same quantity of goods. This trend shows an increase in the capital intensity of imports, for which less labor is necessary for the same amount of capital.

A similar trend is shown by export requirements, even though the capital showed an initial upward trend until 1989 followed by a steady decrease under the levels of 1996. Labor requirements instead reduced from CA$277,852 in 1970 to CA$196,634 in 1996. Therefore, exports and import substitutes became more capital intensive, confirming the easier availability of capital over labor in Canada during the twenty-seven year period studied.

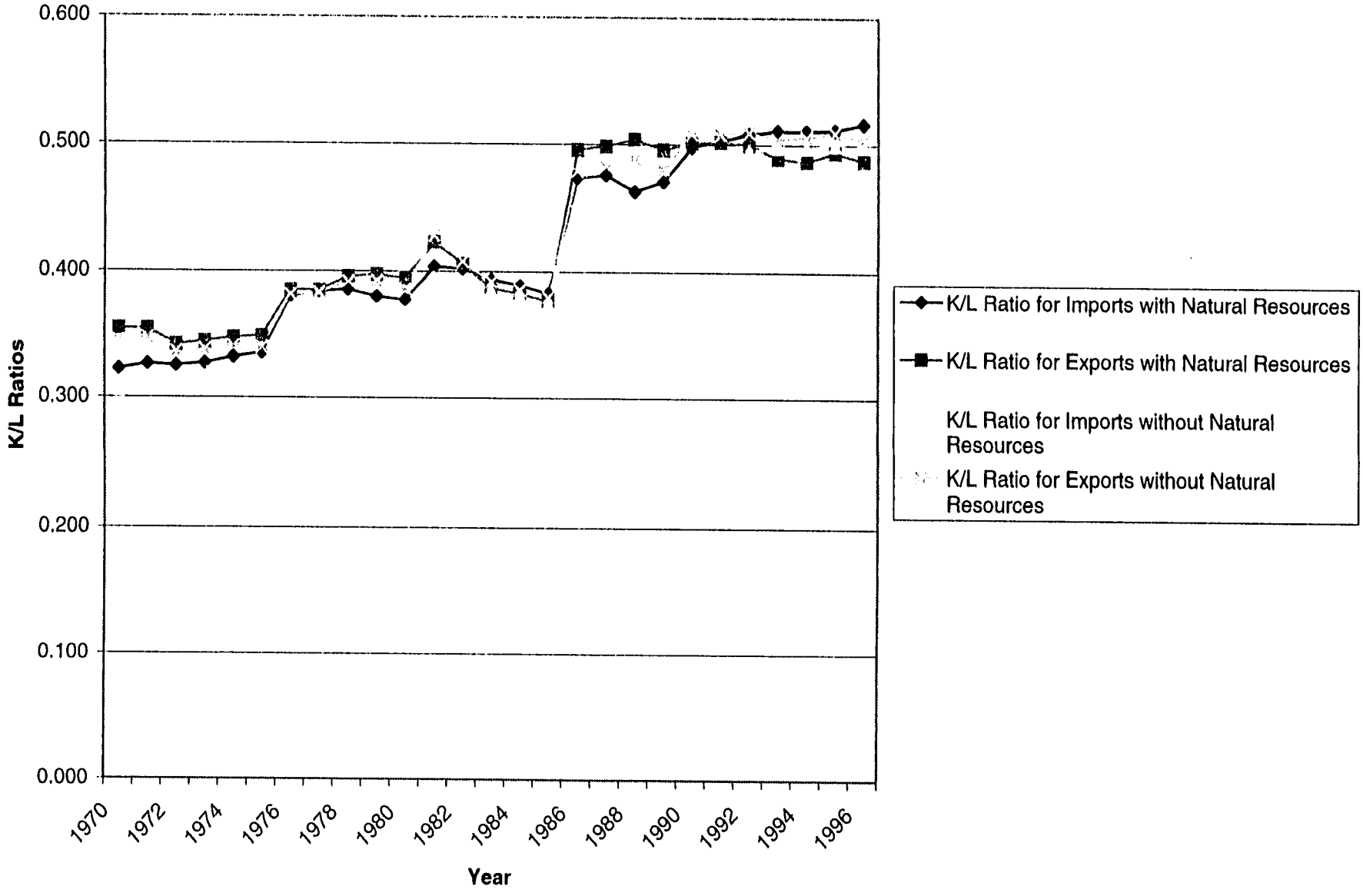
In order to have a better understanding of what is actually taking place, we need to consider the relative behavior of these variables and contrast the results obtained.

Table 19 illustrates the changes in the capital-labor ratio for import substitutes and exports at constant prices over the period studied. These values are provided taking into consideration all 33 industries of the input-output table as well as the elimination of natural resource intensive industries. Before we indulge into a critique of the table a graphical representation of the capital-labor ratio at constant prices considering all industries, as well as eliminating natural resource intensive industries is provided in graph 6.

Table 19: Canada - Capital/Labor Ratios at Current and Constant Prices

	Capital/Labor Ratio at Constant Prices					Capital/Labor Ratio at Current Prices					Leontief Ratio at Constant Prices	
	With Natural Resources		Without Natural Resources			With Natural Resources		Without Natural Resources				
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports			
1970	0.322	0.354	0.305	0.344	1970	0.394	0.386	0.374	0.378	1970	0.91	0.89
1971	0.326	0.353	0.311	0.346	1971	0.403	0.392	0.385	0.388	1971	0.92	0.90
1972	0.325	0.341	0.310	0.335	1972	0.403	0.382	0.385	0.381	1972	0.95	0.92
1973	0.326	0.344	0.311	0.337	1973	0.397	0.383	0.379	0.382	1973	0.95	0.92
1974	0.331	0.347	0.315	0.339	1974	0.400	0.387	0.382	0.383	1974	0.96	0.93
1975	0.335	0.348	0.318	0.339	1975	0.404	0.392	0.385	0.385	1975	0.96	0.94
1976	0.380	0.385	0.364	0.381	1976	0.391	0.393	0.371	0.388	1976	0.99	0.95
1977	0.384	0.385	0.367	0.383	1977	0.395	0.392	0.375	0.389	1977	1.00	0.96
1978	0.385	0.396	0.370	0.392	1978	0.399	0.406	0.380	0.402	1978	0.97	0.94
1979	0.380	0.398	0.366	0.392	1979	0.391	0.409	0.374	0.404	1979	0.95	0.93
1980	0.377	0.395	0.362	0.386	1980	0.390	0.406	0.395	0.427	1980	0.95	0.94
1981	0.404	0.423	0.395	0.429	1981	0.405	0.422	0.392	0.405	1981	0.95	0.92
1982	0.402	0.406	0.392	0.408	1982	0.404	0.405	0.384	0.388	1982	0.99	0.96
1983	0.394	0.387	0.385	0.392	1983	0.394	0.384	0.379	0.380	1983	1.02	0.98
1984	0.389	0.382	0.379	0.385	1984	0.389	0.379	0.371	0.374	1984	1.02	0.98
1985	0.382	0.376	0.373	0.379	1985	0.381	0.372	0.371	0.373	1985	1.02	0.98
1986	0.474	0.496	0.455	0.479	1986	0.474	0.496	0.455	0.479	1986	0.96	0.95
1987	0.476	0.499	0.457	0.484	1987	0.476	0.499	0.457	0.484	1987	0.95	0.95
1988	0.463	0.504	0.445	0.489	1988	0.463	0.504	0.445	0.489	1988	0.92	0.91
1989	0.471	0.496	0.452	0.481	1989	0.471	0.496	0.452	0.481	1989	0.95	0.94
1990	0.498	0.501	0.484	0.509	1990	0.498	0.500	0.484	0.507	1990	0.99	0.95
1991	0.503	0.502	0.489	0.508	1991	0.502	0.500	0.489	0.507	1991	1.00	0.96
1992	0.508	0.500	0.495	0.509	1992	0.507	0.499	0.494	0.508	1992	1.02	0.97
1993	0.511	0.490	0.498	0.504	1993	0.510	0.488	0.498	0.503	1993	1.04	0.99
1994	0.511	0.488	0.498	0.506	1994	0.510	0.486	0.497	0.505	1994	1.05	0.98
1995	0.511	0.494	0.500	0.509	1995	0.510	0.493	0.499	0.508	1995	1.03	0.98
1996	0.516	0.488	0.504	0.504	1996	0.515	0.487	0.503	0.503	1996	1.06	1.00

Graph 6: Canada - Capital/Labor Ratios at Constant Prices



The capital-labor ratio for import substitutes at constant prices, when including all thirty-three industries, is slightly lower than the capital-labor ratio for exports for the periods 1970-1982 and 1986-1990. According to our findings, Canada is a capital abundant nation during the period studied and our results indicate no signs of factor intensity reversal for the period indicated. For the period 1983-1985 and 1991-1996, the Leontief ratios are slightly above 1, which do not allow us to repudiate the presence of factor intensity reversal even upon the elimination of natural resource intensive industries. Despite this period, the Canadian data substantiates the validity of Heckscher-Ohlin theory.

In order to statistically validate or invalidate the Heckscher-Ohlin theory we have applied the delta method as shown in table 20. The consequent reduction in the capital-labor ratio for import substitutes and exports upon the elimination of natural resource intensive industries is negligible. However, in the case of exports, the capital-labor ratio slightly increases instead of decreasing during the period 1981-1985 and 1990-1996. This should lead to an improvement in the prediction of the Heckscher-Ohlin theory, since the capital content of exports is slightly higher than when including natural resource intensive industries.

Upon the implementation of the delta method the Leontief ratios indicate the presence of factor intensity reversal for most of the period studied. The results obtained refute the validity of the Heckscher-Ohlin theory in the case of Canada. Despite these results the ratios obtained using the traditional approach are always less than 1 and confirm the validity of the Heckscher-Ohlin theory.

Table 20: Delta Method for Canada

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Lower Limit	Upper Limit	Ratio	Conclusion	Lower Limit	Upper Limit	Ratio	Conclusion
Capital	1970	0.85	1.15	0.91	UNDETERMINED	0.88	1.12	0.89	UNDETERMINED
Capital	1971	0.87	1.13	0.92	UNDETERMINED	0.89	1.11	0.90	UNDETERMINED
Capital	1972	0.87	1.13	0.95	UNDETERMINED	0.90	1.10	0.92	UNDETERMINED
Capital	1973	0.89	1.11	0.95	UNDETERMINED	0.92	1.08	0.92	NO FIR
Capital	1974	0.90	1.10	0.96	UNDETERMINED	0.92	1.08	0.93	UNDETERMINED
Capital	1975	0.92	1.08	0.96	UNDETERMINED	0.93	1.07	0.94	UNDETERMINED
Capital	1976	0.91	1.10	0.99	UNDETERMINED	0.91	1.09	0.95	UNDETERMINED
Capital	1977	0.90	1.10	1.00	UNDETERMINED	0.92	1.08	0.96	UNDETERMINED
Capital	1978	0.91	1.09	0.97	UNDETERMINED	0.93	1.07	0.94	UNDETERMINED
Capital	1979	0.91	1.09	0.95	UNDETERMINED	0.93	1.07	0.93	UNDETERMINED
Capital	1980	0.91	1.09	0.95	UNDETERMINED	0.92	1.08	0.94	UNDETERMINED
Capital	1981	0.88	1.12	0.95	UNDETERMINED	0.90	1.10	0.92	UNDETERMINED
Capital	1982	0.87	1.13	0.99	UNDETERMINED	0.88	1.12	0.96	UNDETERMINED
Capital	1983	0.85	1.15	1.02	FIR	0.86	1.14	0.98	UNDETERMINED
Capital	1984	0.85	1.15	1.02	FIR	0.86	1.14	0.99	UNDETERMINED
Capital	1985	0.86	1.14	1.02	FIR	0.86	1.14	0.98	UNDETERMINED
Capital	1986	0.94	1.06	0.96	UNDETERMINED	0.95	1.05	0.95	UNDETERMINED
Capital	1987	0.94	1.06	0.96	UNDETERMINED	0.95	1.05	0.95	UNDETERMINED
Capital	1988	0.94	1.06	0.92	NO FIR	0.94	1.06	0.91	NO FIR
Capital	1989	0.94	1.06	0.95	UNDETERMINED	0.95	1.05	0.94	NO FIR
Capital	1990	0.90	1.10	0.99	UNDETERMINED	0.94	1.06	0.95	UNDETERMINED
Capital	1991	0.91	1.09	1.00	UNDETERMINED	0.94	1.06	0.96	UNDETERMINED
Capital	1992	0.90	1.10	1.02	FIR	0.94	1.06	0.97	UNDETERMINED
Capital	1993	0.88	1.12	1.04	FIR	0.94	1.06	0.99	UNDETERMINED
Capital	1994	0.88	1.12	1.05	FIR	0.95	1.05	0.98	UNDETERMINED
Capital	1995	0.89	1.11	1.03	FIR	0.94	1.06	0.98	UNDETERMINED
Capital	1996	0.88	1.12	1.06	FIR	0.94	1.06	1.00	UNDETERMINED

DENMARK – COMMENTS AND RESULTS

The classification used to identify whether a nation is capital or labor abundant concludes that Denmark is a labor abundant nation for the years 1976, 1977, 1982-1996. With respect to the remainder of the years our results are inconclusive, which indicates that the method used resulted in a borderline outcome. Consequently, the latter results do not allow for the testing of the Heckscher-Ohlin theory.

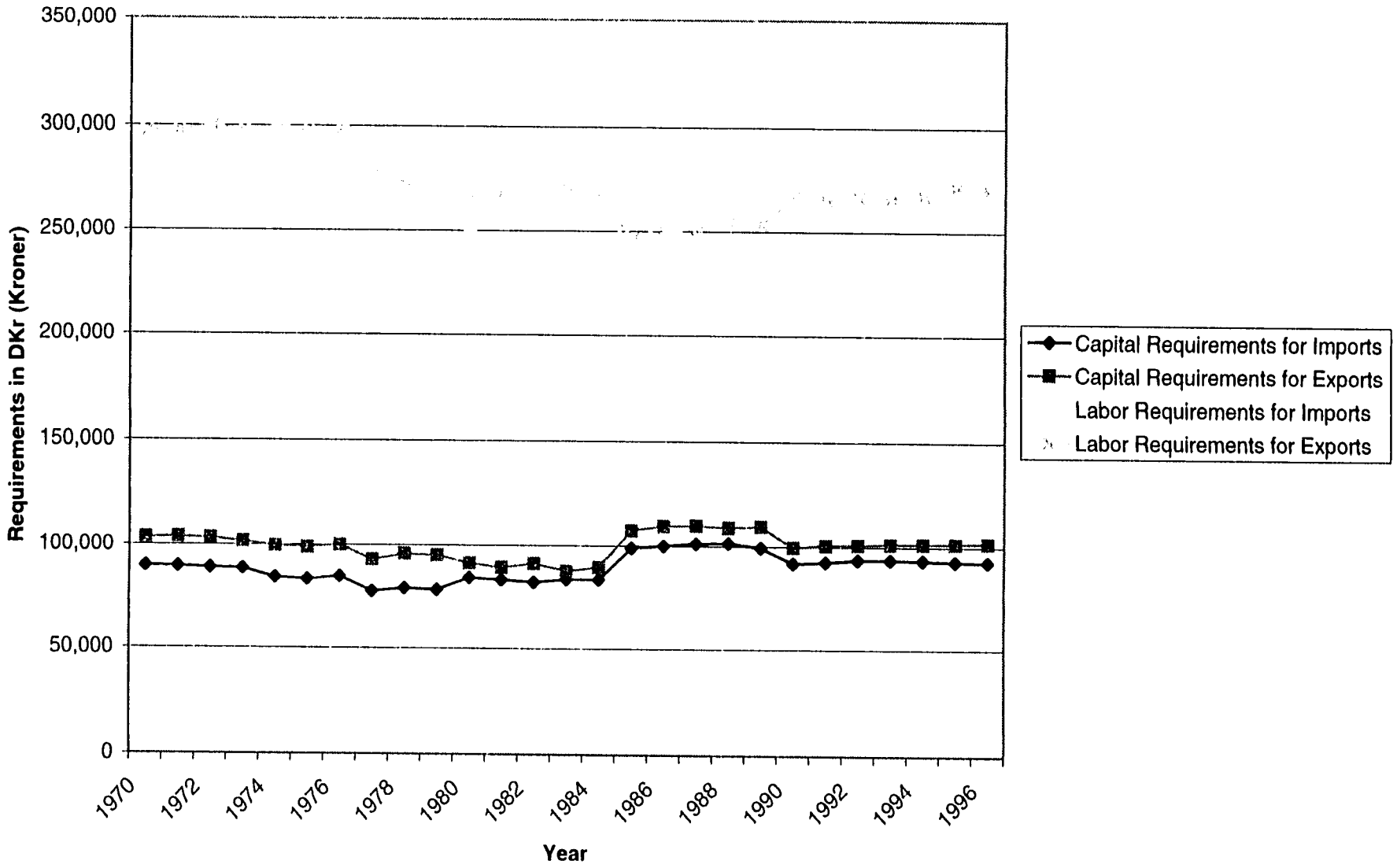
This section is dedicated to the implementation of the Leontief approach for the years 1970 – 1996. The data used consists of the input-output tables for the years 1972, 1977, 1980, 1985 and 1990 at constant prices and the import and export data at current prices for the years 1970 through 1996. In order to deflate the import and export data to be used with the input-output tables at constant prices, we obtained the yearly GDP deflator from the IFS. As this index was based at 1990 prices and our input-output tables are based at 1980 prices, we converted the deflator for the 1980 price index following equation (32).

Based on our findings of a labor abundant nation, Denmark should export its labor-intensive goods and import capital-intensive commodities. After running the programs for each of the available input-output tables we obtained the net capital and labor requirements per million Dutch Kroner ("DKr") of exports and competitive imports. These values were calculated for each year at constant prices, with and without natural resource intensive sectors of the economy. Table 21 on the following page illustrates the capital and labor requirements for one million DKr worth of exports and imports at constant prices with and without natural resources.

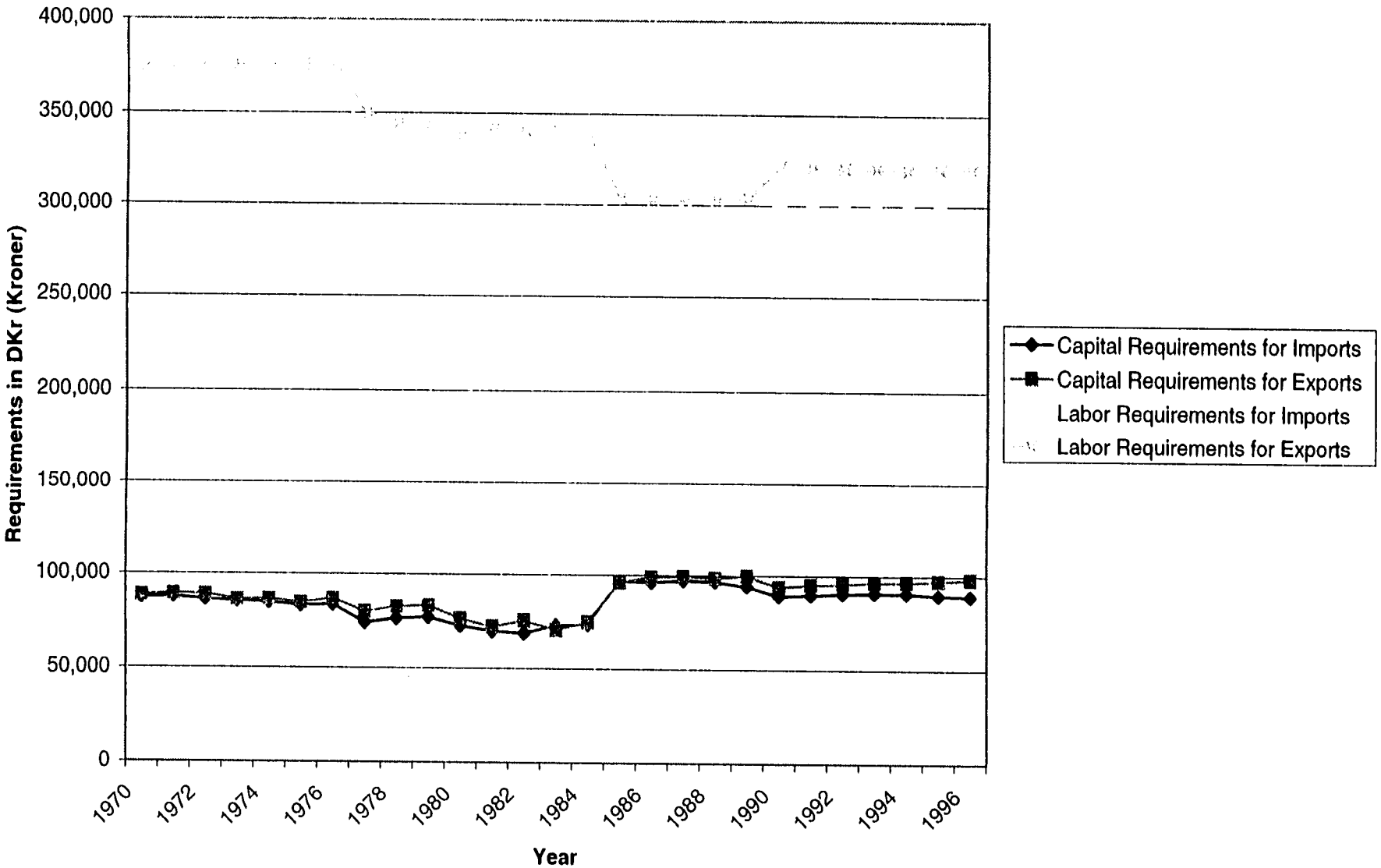
Table 21: Denmark - Net Capital and Labor Requirements per Million Dutch Kroner of Exports and Imports at Constant Prices

	Capital Requirements With Natural Resources		Labor Requirements With Natural Resources			Capital Requirements Without Natural Resources		Labor Requirements Without Natural Resources	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports
1970	89,760	103,520	318,722	297,623	1970	87,037	88,618	361,618	373,496
1971	89,539	103,904	317,100	297,691	1971	87,490	89,357	364,493	375,423
1972	88,863	103,462	317,572	299,953	1972	85,944	89,009	363,636	375,781
1973	88,476	101,772	314,090	297,907	1973	85,219	86,079	363,132	376,436
1974	83,966	99,598	298,652	297,266	1974	84,309	86,448	360,050	374,557
1975	83,069	99,017	303,687	298,012	1975	82,788	84,362	365,672	375,862
1976	84,569	100,057	304,951	298,376	1976	83,266	86,650	366,346	376,787
1977	77,233	92,993	277,081	279,643	1977	73,890	79,620	336,208	349,885
1978	78,846	95,824	280,728	273,041	1978	76,058	82,398	333,619	345,008
1979	78,028	95,179	265,213	269,972	1979	76,794	83,104	327,015	343,519
1980	84,072	91,428	253,082	266,955	1980	72,326	76,113	317,098	338,757
1981	83,007	89,297	253,419	268,218	1981	69,731	72,072	318,904	342,857
1982	81,814	91,114	255,048	267,813	1982	68,671	75,342	318,925	340,133
1983	83,287	87,625	263,136	270,615	1983	72,772	70,684	316,914	341,550
1984	83,250	89,504	265,086	267,730	1984	73,355	74,533	316,022	337,801
1985	98,945	107,589	239,854	246,136	1985	96,691	95,956	283,572	304,133
1986	100,104	109,854	258,306	249,623	1986	96,179	98,937	287,849	303,191
1987	101,229	110,050	258,958	251,421	1987	97,124	99,369	287,176	302,389
1988	101,464	109,198	260,263	254,366	1988	96,597	98,559	285,568	303,381
1989	99,356	109,864	260,336	253,788	1989	94,054	99,872	286,637	304,002
1990	91,748	99,731	274,736	267,470	1990	88,909	93,919	303,380	322,539
1991	92,469	100,749	274,170	265,616	1991	89,458	95,189	302,840	321,543
1992	93,542	100,953	274,147	266,753	1992	90,304	95,742	301,891	320,834
1993	93,589	101,346	272,900	266,289	1993	90,632	96,555	302,130	320,573
1994	93,399	101,507	275,268	267,487	1994	90,460	96,805	301,884	319,847
1995	92,877	101,617	279,925	271,447	1995	89,456	97,505	303,171	320,352
1996	92,619	101,890	278,918	270,342	1996	89,056	98,427	304,824	320,594

Graph 7: Denmark - Capital and Labor Requirements With Natural Resources at Constant Prices Per Million DKr for Imports and Exports



Graph 8: Denmark - Capital and Labor Requirements Without Natural Resources at Constant Price Per Million DKr for Imports and Exports



Changes in input-output tables are indicated by the remarkable variations in capital and labor requirements for the production of one million DKr worth of goods. These changes reflect the different levels of capital and labor used in the production of goods and services during the period studied.

The graphical illustration (see graphs 7 and 8) helps us to better visualize our assertion of a labor abundant nation. The gap between the amount of capital and labor necessary for the production of one million Dutch Kroner is fairly large. The amount of labor needed for both imports and exports is decreasing over the period studied, although the gap between labor and capital remains quite large. The capital needed for imports and exports does not change significantly over the period studied.

The elimination of natural resource intensive industries does not change the values of the requirements; moreover it reinforces it. Across the period studied there are slight increases or decreases in the capital and labor requirements.

In order to understand the evolution of capital and labor requirements we must consider the behavior of these variables. Table 22 illustrates changes in the capital-labor ratios for exports and import substitutes at constant prices over the period studied (see graph 9).

Table 22: Denmark - Capital/Labor Ratios at Current and Constant Prices

	Capital/Labor Ratio at Constant Prices					Capital/Labor Ratio at Current Prices					Leontief Ratio at Constant Prices	
	With Natural Resources		Without Natural Resources			With Natural Resources		Without Natural Resources				
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports		With and Without Natural Resource Intensive Industries	
1970	0.282	0.348	0.241	0.237	1970	0.302	0.364	0.245	0.238	1970	0.81	1.01
1971	0.282	0.349	0.240	0.238	1971	0.305	0.367	0.245	0.239	1971	0.81	1.01
1972	0.280	0.345	0.236	0.237	1972	0.301	0.363	0.241	0.239	1972	0.81	1.00
1973	0.282	0.342	0.235	0.229	1973	0.303	0.359	0.239	0.229	1973	0.82	1.03
1974	0.281	0.335	0.234	0.231	1974	0.310	0.355	0.238	0.232	1974	0.84	1.01
1975	0.274	0.332	0.226	0.224	1975	0.302	0.350	0.230	0.225	1975	0.82	1.01
1976	0.277	0.335	0.227	0.230	1976	0.305	0.355	0.231	0.231	1976	0.83	0.99
1977	0.279	0.333	0.220	0.228	1977	0.291	0.340	0.222	0.229	1977	0.84	0.97
1978	0.281	0.351	0.228	0.239	1978	0.292	0.358	0.230	0.240	1978	0.80	0.95
1979	0.294	0.353	0.235	0.242	1979	0.308	0.360	0.236	0.243	1979	0.83	0.97
1980	0.332	0.342	0.228	0.225	1980	0.332	0.342	0.228	0.225	1980	0.97	1.02
1981	0.328	0.333	0.219	0.210	1981	0.328	0.333	0.219	0.210	1981	0.98	1.04
1982	0.321	0.340	0.215	0.221	1982	0.321	0.340	0.215	0.221	1982	0.94	0.97
1983	0.317	0.324	0.230	0.207	1983	0.317	0.324	0.230	0.207	1983	0.98	1.11
1984	0.314	0.334	0.232	0.221	1984	0.314	0.334	0.232	0.221	1984	0.94	1.05
1985	0.413	0.437	0.341	0.315	1985	0.411	0.437	0.339	0.312	1985	0.94	1.08
1986	0.388	0.440	0.334	0.326	1986	0.387	0.439	0.332	0.323	1986	0.88	1.02
1987	0.391	0.438	0.338	0.329	1987	0.390	0.437	0.336	0.325	1987	0.89	1.03
1988	0.390	0.429	0.338	0.325	1988	0.388	0.429	0.336	0.321	1988	0.91	1.04
1989	0.382	0.433	0.328	0.328	1989	0.381	0.432	0.326	0.324	1989	0.88	1.00
1990	0.334	0.373	0.293	0.291	1990	0.345	0.384	0.295	0.288	1990	0.90	1.01
1991	0.337	0.379	0.295	0.296	1991	0.348	0.390	0.297	0.292	1991	0.89	1.00
1992	0.341	0.378	0.299	0.298	1992	0.351	0.389	0.300	0.294	1992	0.90	1.00
1993	0.343	0.381	0.300	0.301	1993	0.352	0.391	0.300	0.297	1993	0.90	1.00
1994	0.339	0.379	0.300	0.303	1994	0.348	0.389	0.300	0.298	1994	0.89	0.99
1995	0.332	0.374	0.295	0.304	1995	0.339	0.382	0.295	0.299	1995	0.89	0.97
1996	0.332	0.377	0.292	0.307	1996	0.339	0.385	0.292	0.301	1996	0.88	0.95

Graph 9: Denmark - Capital/Labor Ratios at Constant Prices

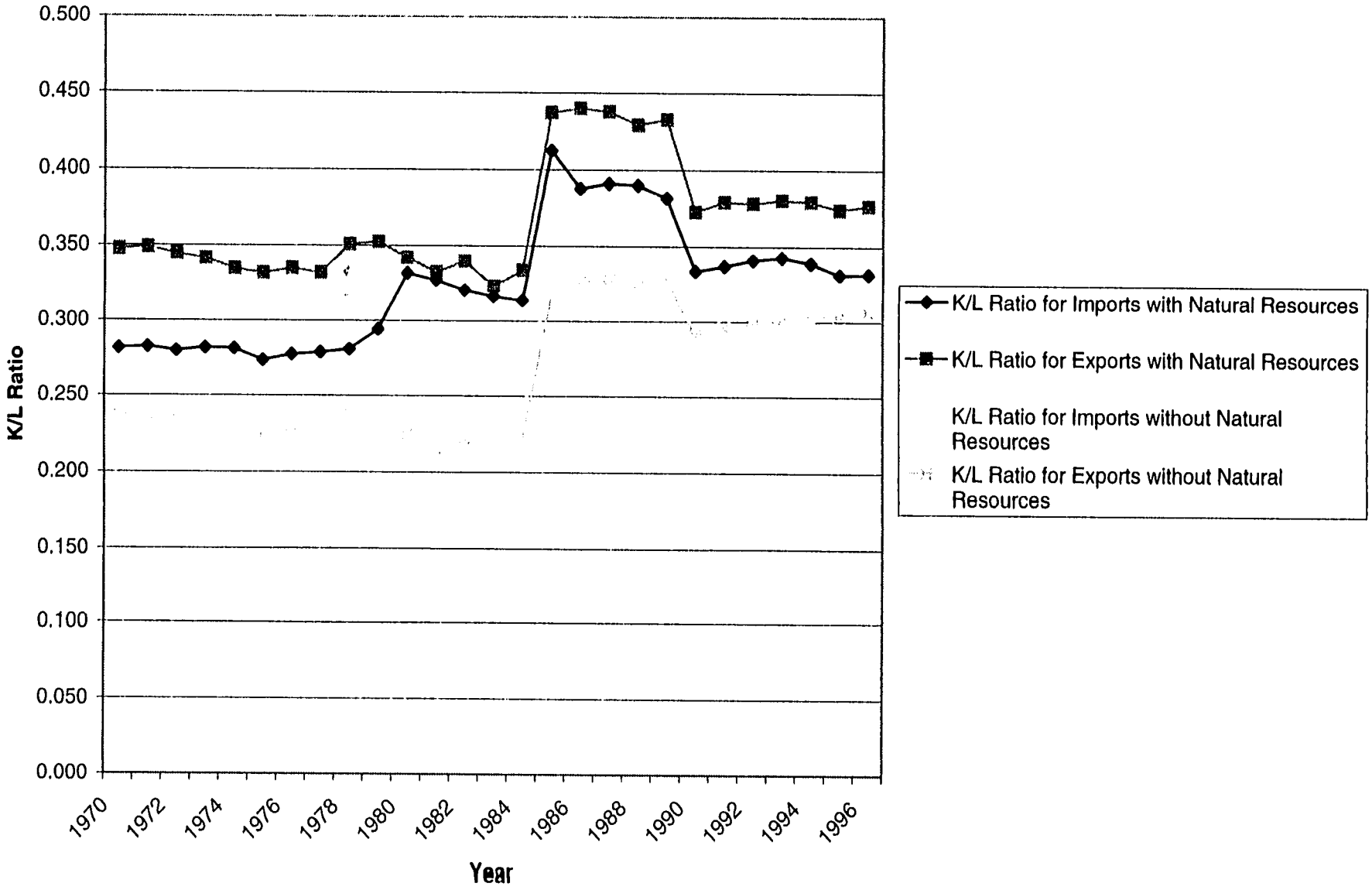


Table 22 indicates that exports are more capital intensive than import substitutes across the period studied. Since Denmark is a labor abundant nation for most of the years covered by this study, this concludes that factor intensity reversal is present during the period considered.

When natural resource intensive industries are removed, import substitutes and exports become more labor intensive. However, the difference in the values obtained is significant. The removal of natural resource intensive industries allows us to accept the Heckscher-Ohlin theory for the majority of the period studied with the exception of 1977, 1982 and 1994-1996.

Over the entire period studied, Danish exports were concentrated in the following industries: manufacturing, food, textiles, chemicals, fabricated metals, non-electrical machinery, machinery and equipment, electrical machinery, transportation equipment and shipbuilding repair. It is interesting to notice that imports were concentrated in the same industries as well as wood, paper and petroleum products.

The significance of these results is altered when the application of the delta method is implemented (see table 23). The results obtained exhibit the presence of factor intensity reversal throughout the entire period. This is another instance when even though the Heckscher-Ohlin theory is not confirmed by the delta method, the ratios are always above one upon the elimination of natural resource intensive industries which confirms the validity of the theorem.

Table 23: Delta Method for Denmark

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Upper Limit	Lower Limit	Ratio	Conclusion	Upper Limit	Lower Limit	Ratio	Conclusion
Inconclusive	1968								
Inconclusive	1969								
Inconclusive	1970								
Inconclusive	1971								
Inconclusive	1972								
Inconclusive	1973								
Inconclusive	1974								
Inconclusive	1975								
Labor	1976	1.19	0.81	0.83	FIR	1.10	0.90	0.99	FIR
Labor	1977	1.20	0.80	0.84	FIR	1.09	0.91	0.97	FIR
Inconclusive	1978								
Inconclusive	1979								
Inconclusive	1980								
Inconclusive	1981								
Labor	1982	1.37	0.61	0.94	FIR	1.15	0.85	0.97	FIR
Labor	1983	1.33	0.66	0.98	FIR	1.26	0.74	1.11	UNDETERMINED
Labor	1984	1.27	0.66	0.94	FIR	1.18	0.82	1.05	UNDETERMINED
Labor	1985	1.22	0.78	0.94	FIR	1.16	0.84	1.08	UNDETERMINED
Labor	1986	1.17	0.83	0.88	FIR	1.11	0.89	1.02	UNDETERMINED
Labor	1987	1.17	0.83	0.89	FIR	1.12	0.88	1.03	UNDETERMINED
Labor	1988	1.16	0.84	0.91	FIR	1.13	0.87	1.04	UNDETERMINED
Labor	1989	1.15	0.85	0.88	FIR	1.11	0.89	1.00	UNDETERMINED
Labor	1990	1.16	0.84	0.90	FIR	1.16	0.84	1.01	UNDETERMINED
Labor	1991	1.16	0.84	0.89	FIR	1.16	0.84	1.00	UNDETERMINED
Labor	1992	1.15	0.85	0.90	FIR	1.16	0.84	1.00	UNDETERMINED
Labor	1993	1.15	0.86	0.90	FIR	1.15	0.85	1.00	UNDETERMINED
Labor	1994	1.15	0.85	0.89	FIR	1.16	0.84	0.99	FIR
Labor	1995	1.14	0.86	0.89	FIR	1.17	0.83	0.97	FIR
Labor	1996	1.14	0.86	0.88	FIR	1.18	0.82	0.95	FIR

FRANCE – COMMENTS AND RESULTS

France is identified as a labor abundant nation during 1968 – 1975 and as a capital abundant nation during 1977-1990. With respect to the remainder of the period studied our results are inconclusive, which indicates that the method used resulted in a borderline outcome. As previously mentioned, these results do not allow us to test the validity of Heckscher-Ohlin theory for these years.

During the period 1968-1975 approximately one third of the French people worked in agriculture, forestry and fishing; another third in manufacturing and mining and the rest in commerce and professions. Agriculture occupied a fairly large segment of the economy. Therefore, our method of identifying France as a labor abundant nation is in agreement with the nation's economic conditions during that period.

During the same period, namely early 1970s, France was one of the world's leading industrial countries. French industries had grown rapidly since 1958 when France joined Belgium, Italy, West Germany, the Netherlands and Luxembourg to form the European Economic Community ("EEC"). This organization was set up in an effort to provide easy movement of raw materials and manufactured goods between the member countries by lowering trade tariffs. As a result, each of the member countries had a wider market for its manufactured goods than previously was possible. Manufacturing continued its expansion and helped the nation to reach the status of a capital abundant nation by 1977. According to our test, it kept this status until 1989.

For the remainder of the period studied, our method of classification gives us inconclusive results which unable us to reach an unerring conclusion.

The data used for France consists in the input-output tables for 1972, 1977, 1980, 1985 and 1990 at constant prices and the import and export data at current prices for the years 1970 through 1996. We have used the same method of deflating the data as previously mentioned in the other country evaluations (see equation (32)).

France has been identified as a labor abundant nation during the period 1968 through 1975. Upon the elimination of natural resource intensive industries, the Heckscher-Ohlin theory is validated. Looking at the period 1970-1975, French exports were concentrated on three product categories: chemical, basic metal and fabricated metal products. During the next twenty-five years these three categories remained the blockbuster of exports. By eliminating natural resource intensive industries, we can understand the relation between patterns of trade and Heckscher-Ohlin theory based on the country's factor endowments. During the period in which France can be considered a labor abundant nation, France was exporting labor-intensive goods. It seems that of the three industries mentioned, fabricated metal products can be considered labor intensive, at least during the early 1970s.

With the industrialization process, France became a capital abundant nation. During this period the exports of fabricated metal and chemical products increased at a rapid speed. In 1970 the exports for chemical products were 13,325,853,680 French francs and exports for fabricated metal products were 38,291,639,821 French francs, whereas after a surge that lasted twenty-five years, the level of exports in 1996 reached 282,712,191,000 French francs and 670,830,198,000 French francs respectively. This

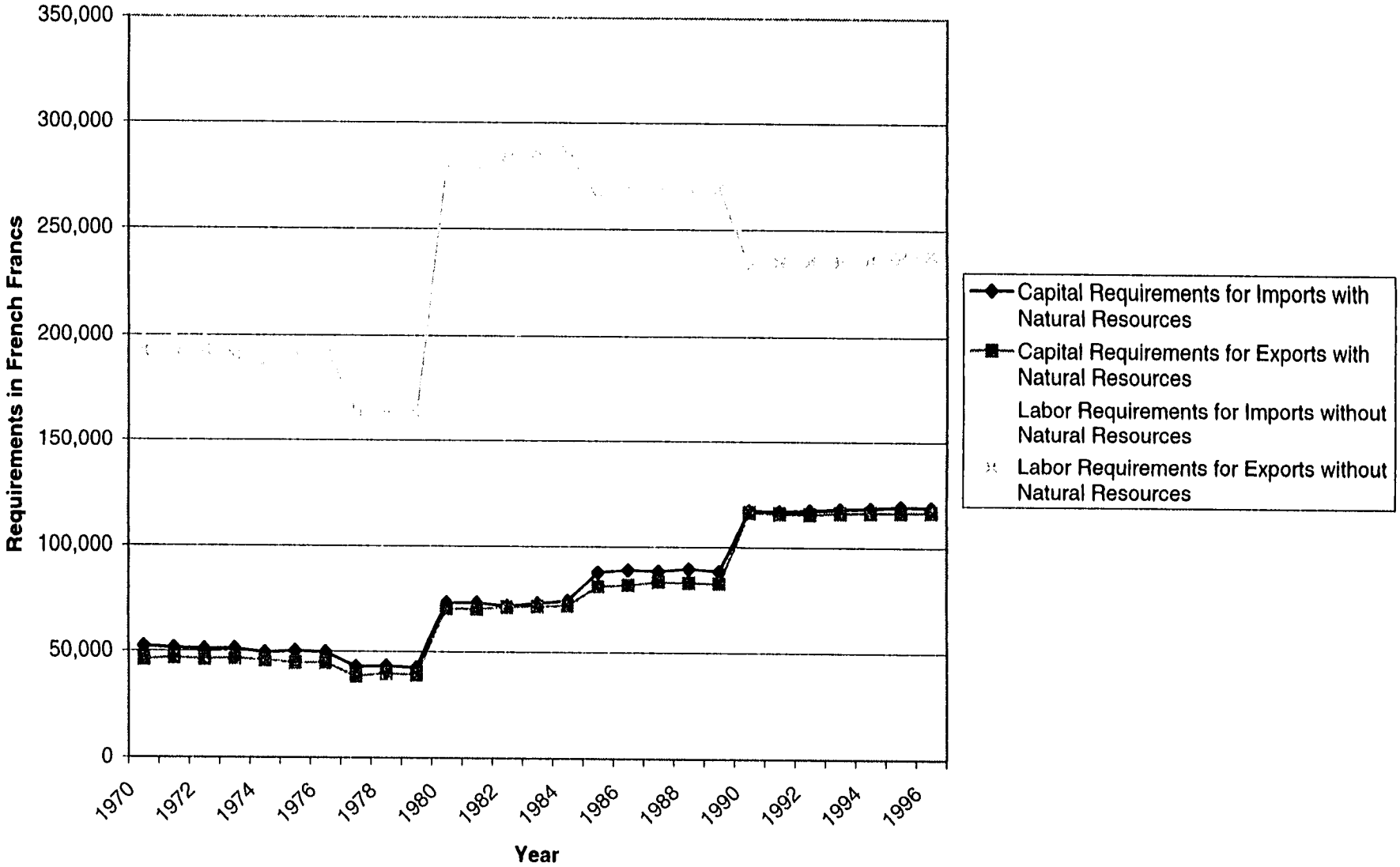
period of industrialization made fabricated metal products an intensive industry. This tendency explains the increase in the capital requirements that took place over the years due to a substitution of labor for capital.

A closer look at the net capital and labor requirements per million French francs of exports and competitive imports helps us comment on the trade evolution in France. These values were obtained with and without natural resource intensive sectors of the economy. Table 24 illustrates the capital and labor requirements at constant prices for one million French francs worth of exports and imports including as well as excluding natural resource intensive industries. A graphical representation is also provided (see graphs 10 and 11.)

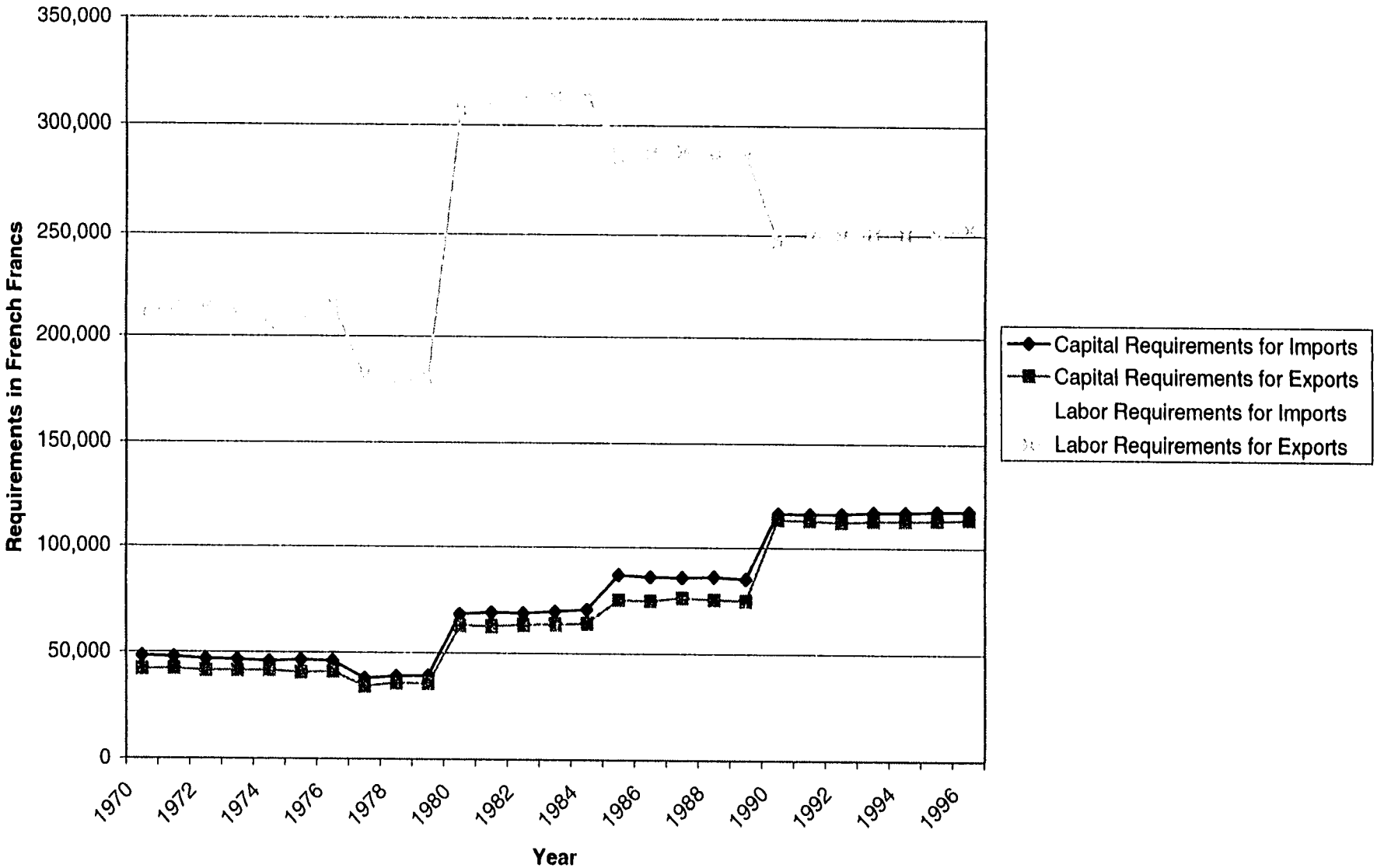
Table 24: France - Net Capital and Labor Requirements per Million French Francs of Exports and Imports at Constant Prices

	Capital Requirements With Natural Resources		Labor Requirements With Natural Resources			Capital Requirements Without Natural Resources		Labor Requirements Without Natural Resources	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports
1970	52,268	46,354	197,316	192,578	1970	48,231	42,132	219,604	211,076
1971	51,499	47,060	198,534	193,061	1971	47,823	42,398	221,438	213,641
1972	50,886	46,460	197,176	192,774	1972	46,840	41,498	219,441	213,634
1973	51,155	46,834	195,588	190,131	1973	46,660	41,495	217,637	211,584
1974	49,450	46,028	192,465	186,136	1974	45,886	41,617	213,294	205,960
1975	50,140	44,856	194,224	191,729	1975	46,505	40,654	217,345	211,553
1976	49,725	45,006	194,850	195,061	1976	46,113	41,055	217,095	215,549
1977	43,084	38,689	161,848	164,642	1977	37,913	34,265	179,965	180,755
1978	43,442	40,003	163,281	162,950	1978	38,956	35,780	179,897	178,630
1979	42,649	39,304	161,658	162,627	1979	39,162	35,682	178,529	179,375
1980	72,926	70,144	277,740	279,964	1980	67,778	62,712	306,093	307,250
1981	72,877	69,887	278,673	280,274	1981	68,595	62,376	311,129	310,705
1982	71,530	70,895	279,416	284,225	1982	68,265	63,088	314,101	312,177
1983	72,805	71,254	279,953	286,598	1983	69,237	63,306	314,700	313,262
1984	73,955	71,674	280,987	287,264	1984	70,113	63,688	314,266	313,234
1985	87,584	80,769	262,832	265,007	1985	86,773	74,790	290,816	286,189
1986	88,730	81,567	271,550	269,884	1986	85,960	74,455	293,304	288,276
1987	88,205	83,202	274,008	271,735	1987	85,628	76,030	295,324	289,041
1988	89,436	82,784	276,166	269,836	1988	86,113	75,039	294,607	286,898
1989	88,191	82,433	275,016	269,936	1989	85,020	74,586	293,390	287,228
1990	116,848	116,017	238,111	232,980	1990	116,887	113,597	253,522	247,246
1991	116,395	115,593	239,527	234,661	1991	116,529	113,198	256,147	249,199
1992	116,953	115,280	239,460	235,631	1992	116,741	112,480	255,521	249,961
1993	117,614	115,818	239,874	235,374	1993	117,420	113,082	256,668	250,805
1994	118,022	116,019	239,795	235,972	1994	117,487	113,190	255,216	250,664
1995	118,829	116,259	239,219	236,972	1995	117,964	113,415	252,795	250,936
1996	118,557	116,310	240,073	238,520	1996	118,077	113,867	254,516	253,461

Graph 10: France - Capital and Labor Requirements with Natural Resources at Constant Prices Per Million French Francs for Imports and Exports



Graph 11: France - Capital and Labor Requirements without Natural Resources at Constant Prices Per Million French Francs for Imports and Exports



It is important to note that significant changes occur in the capital and labor requirements when different input-output tables are used. In particular, more visible changes take place during the years 1977, 1980, 1985 and 1990.

It is contiguously apparent that the labor requirements for both import substitutes and exports are higher than the capital requirements during the period studied. Even more, the labor requirements are higher once natural resource intensive industries are being removed. The interesting part is that labor requirements over the period studied do not increase substantially when compared to capital requirements. If we consider exports with natural resources, the labor requirements increased from 192,577 French francs in 1970 to 238,520 French francs in 1996. Concomitantly, the imports required 197,316 French francs in 1970 and 240,072 French francs in 1996.

On the other hand, the capital content of both import substitutes and exports with and without natural resource intensive industries has more than doubled during the period studied. This increase in capital requirements could be attributed to the process of industrialization that has captured and influenced the more intense use of capital.

During 1970, in order to produce one million French francs worth of import substitutes, it was necessary to employ 52,268 French Francs in capital requirements plus 197,316 French Francs in labor requirements. This represents a total of approximately 250,000 French francs. During the same period, the total inputs required for exports totaled 238,932 French francs (46,354 in capital and 192,578 in labor). If we compare these figures with 1996 results we obtain 358,630 for import substitutes and 354,830 for exports.

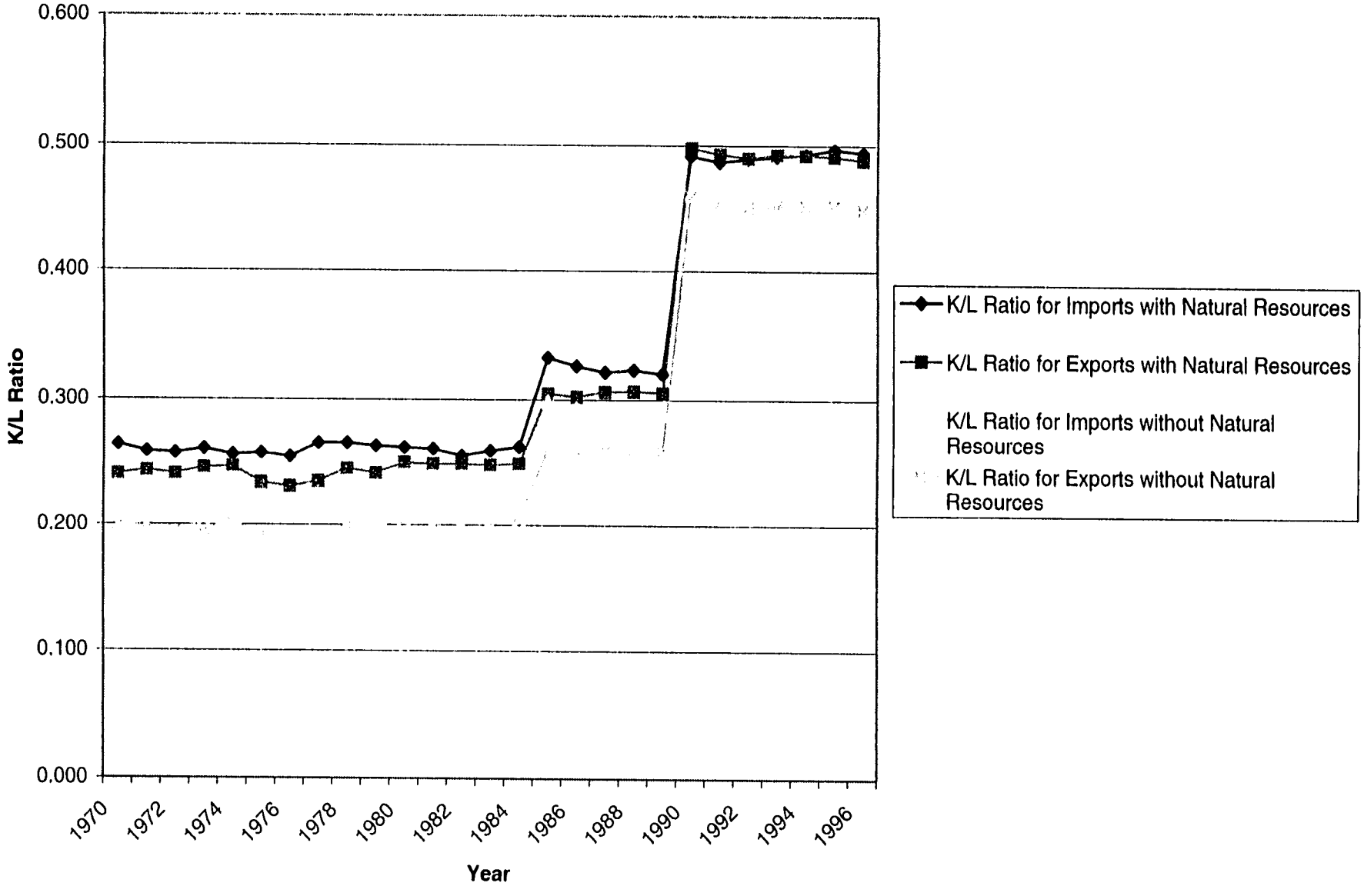
Even though France went through a process of industrialization, the substitution of labor for capital should have improved efficiency and reduced the cost of production. This factor cannot be used to explain the increase in the cost of inputs. One aspect that is not taken into consideration by these numbers is the quality of the products. Since processes and techniques of production change over time, it is difficult to compare the value of products based only on the cost of production. New improvements in technology lead to the introduction of new products which makes comparison less realistic. Therefore, the only conclusion that we can draw from the evolution of capital and labor requirements is that there is a substitution towards more capital-intensive techniques of production.

In order to better perceive the evolution of capital and labor requirements, we must analyze the capital and labor ratios, which are being provided in table 25. A graphical representation is presented in graph 12.

Table 25: France - Capital/Labor Ratios at Current and Constant Prices

	Capital/Labor Ratio at Constant Prices					Capital/Labor Ratio at Current Prices					Leontief Ratio at Constant Prices	
	With Natural Resources		Without Natural Resources			With Natural Resources		Without Natural Resources				
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports		With and Without Natural Resource Intensive Industries	
1970	0.265	0.241	0.220	0.200	1970	0.262	0.236	0.216	0.196	1970	1.10	1.10
1971	0.259	0.244	0.216	0.198	1971	0.256	0.239	0.212	0.194	1971	1.06	1.09
1972	0.258	0.241	0.213	0.194	1972	0.255	0.236	0.210	0.190	1972	1.07	1.10
1973	0.262	0.246	0.214	0.196	1973	0.259	0.242	0.211	0.192	1973	1.06	1.09
1974	0.257	0.247	0.215	0.202	1974	0.253	0.242	0.212	0.199	1974	1.04	1.06
1975	0.258	0.234	0.214	0.192	1975	0.254	0.229	0.211	0.189	1975	1.10	1.11
1976	0.255	0.231	0.212	0.190	1976	0.251	0.225	0.209	0.187	1976	1.11	1.12
1977	0.266	0.235	0.211	0.190	1977	0.265	0.234	0.211	0.190	1977	1.13	1.11
1978	0.266	0.245	0.217	0.200	1978	0.265	0.244	0.217	0.201	1978	1.08	1.08
1979	0.264	0.242	0.219	0.199	1979	0.262	0.240	0.220	0.199	1979	1.09	1.10
1980	0.263	0.251	0.221	0.204	1980	0.263	0.251	0.221	0.204	1980	1.05	1.08
1981	0.262	0.249	0.220	0.201	1981	0.262	0.249	0.220	0.201	1981	1.05	1.10
1982	0.256	0.249	0.217	0.202	1982	0.256	0.249	0.217	0.202	1982	1.03	1.08
1983	0.260	0.249	0.220	0.202	1983	0.260	0.249	0.220	0.202	1983	1.05	1.09
1984	0.263	0.250	0.223	0.203	1984	0.263	0.250	0.223	0.203	1984	1.05	1.10
1985	0.333	0.305	0.298	0.261	1985	0.327	0.301	0.290	0.255	1985	1.09	1.14
1986	0.327	0.302	0.293	0.258	1986	0.320	0.297	0.284	0.251	1986	1.08	1.13
1987	0.322	0.306	0.290	0.263	1987	0.315	0.301	0.281	0.256	1987	1.05	1.10
1988	0.324	0.307	0.292	0.262	1988	0.317	0.302	0.284	0.255	1988	1.06	1.12
1989	0.321	0.305	0.290	0.260	1989	0.314	0.301	0.281	0.253	1989	1.05	1.12
1990	0.491	0.498	0.461	0.459	1990	0.496	0.503	0.466	0.464	1990	0.99	1.00
1991	0.486	0.493	0.455	0.454	1991	0.491	0.498	0.460	0.459	1991	0.99	1.00
1992	0.488	0.489	0.457	0.450	1992	0.493	0.494	0.461	0.454	1992	1.00	1.02
1993	0.490	0.492	0.457	0.451	1993	0.495	0.497	0.462	0.455	1993	1.00	1.01
1994	0.492	0.492	0.460	0.452	1994	0.497	0.497	0.465	0.456	1994	1.00	1.02
1995	0.497	0.491	0.467	0.452	1995	0.502	0.496	0.471	0.456	1995	1.01	1.03
1996	0.494	0.488	0.464	0.449	1996	0.499	0.492	0.468	0.453	1996	1.01	1.03

Graph 12: France - Capital/Labor Ratio at Constant Prices



The effect in the change of input-output tables during the years 1985 and 1990 is noticeable as the graph of the capital-labor ratio illustrates (see graph 12). The ratios following the substitution of the input-output tables show drastic changes, especially in 1990. The graphical representation of the capital-labor ratio delineates the perceptible jumps.

After 1990, the ratios almost doubled, indicating that for the same amount of goods to be produced, almost twice as many inputs of capital were required. During this period, it seems that imports are more capital intensive, although in many instances the difference is insignificant.

Another important observation pertains to the situation where natural resource intensive industries are being removed from our study. The results obtained indicate that the capital-labor ratio drops for both exports and import substitutes. It is evident from table 25 that import substitutes continue to be more capital intensive during the period studied and that the ratios almost doubled. Leontief's ratios are able to validate the Heckscher-Ohlin theory for the period 1970-1975. For the remainder of the period, a slight presence of factor intensity reversal is depicted by an increase in the Leontief ratios.

In order to add statistical support to our conclusions, table 26 provides the Leontief ratios and the lower/upper limits given by the application of the delta method. Both with and without natural resources, we can see the stability of the Leontief ratio over the years analyzed. Since after 1975 France can be considered a capital-abundant nation, there is instead a significant change in the limits to be respected in order to ascertain the validity of the Heckscher-Ohlin theory.

Table 26: Delta Method for France

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Upper Limit Lower Limit	Lower Limit Upper Limit	Ratio	Conclusion	Upper Limit Lower Limit	Lower Limit Upper Limit	Ratio	Conclusion
Labor	1970	1.09	0.91	1.10	NO FIR	1.08	0.92	1.10	NO FIR
Labor	1971	1.09	0.91	1.06	UNDETERMINED	1.08	0.93	1.09	NO FIR
Labor	1972	1.10	0.90	1.07	UNDETERMINED	1.08	0.92	1.10	NO FIR
Labor	1973	1.09	0.91	1.06	UNDETERMINED	1.08	0.92	1.09	NO FIR
Labor	1974	1.09	0.92	1.04	UNDETERMINED	1.07	0.93	1.06	UNDETERMINED
Labor	1975	1.09	0.91	1.10	NO FIR	1.08	0.92	1.11	NO FIR
Inconclusive	1976								
Capital	1977	0.91	1.09	1.13	FIR	0.92	1.08	1.11	FIR
Capital	1978	0.92	1.08	1.08	FIR	0.93	1.07	1.08	FIR
Capital	1979	0.91	1.09	1.09	FIR	0.92	1.08	1.10	FIR
Capital	1980	0.91	1.09	1.05	FIR	0.93	1.07	1.08	FIR
Capital	1981	0.91	1.09	1.05	FIR	0.92	1.08	1.10	FIR
Capital	1982	0.93	1.07	1.03	FIR	0.94	1.06	1.08	FIR
Capital	1983	0.92	1.08	1.05	FIR	0.92	1.08	1.09	FIR
Capital	1984	0.92	1.08	1.05	FIR	0.92	1.08	1.10	FIR
Capital	1985	0.90	1.10	1.09	FIR	0.89	1.11	1.14	FIR
Capital	1986	0.89	1.11	1.08	FIR	0.89	1.11	1.13	FIR
Capital	1987	0.90	1.10	1.05	FIR	0.91	1.09	1.10	FIR
Capital	1988	0.89	1.11	1.06	FIR	0.89	1.11	1.12	FIR
Capital	1989	0.89	1.11	1.05	FIR	0.90	1.10	1.12	FIR
Inconclusive	1990								
Inconclusive	1991								
Inconclusive	1992								
Inconclusive	1993								
Inconclusive	1994								
Inconclusive	1995								
Inconclusive	1996								

Using Leontief's approach, France illustrates the presence of factor intensity reversal during the period 1977–1989. For the rest of the period studied, we can acknowledge that the Heckscher-Ohlin theory is confirmed upon the elimination of natural resource intensive industries.

GERMANY – COMMENTS AND RESULTS

Germany (West Germany) joins Australia and Canada, as a capital abundant nation for the entire period covered by our study. In a short time since World War II, Germany has become one of the world's strongest industrial countries. The chief industrial areas are on or near Germany's coal and lignite deposits. By far the most important industrial area includes the Ruhr and Aachen coalfields in western Germany. This area produced more than half of Germany's total industrial output during the seventies. Industries within the Ruhr produced a variety of products, most of which were very bulky. Examples include iron and steel, fabricated metals, farm machinery, synthetic rubber, locomotives, cement, industrial chemicals and paper.

A belt of separated industrial cities extends across north central Germany from Munster to Magdeburg. Berlin is Germany's chief manufacturing city. Its early growth was due to its importance as a seat of government, a cultural center and a focal point for main transportation routes. In addition, Germany is one of the world's leading shipbuilding countries.

The implementation of Leontief's approach incorporates the input-output tables for 1978, 1986, 1988 and 1990 at constant prices and the import and export data at current prices. An identical method of deflating the import and export data previously mentioned has been implemented here as well. Based on our classification of the capital stock per worker, it is expected that Germany, being a capital abundant nation, will export capital-intensive goods.

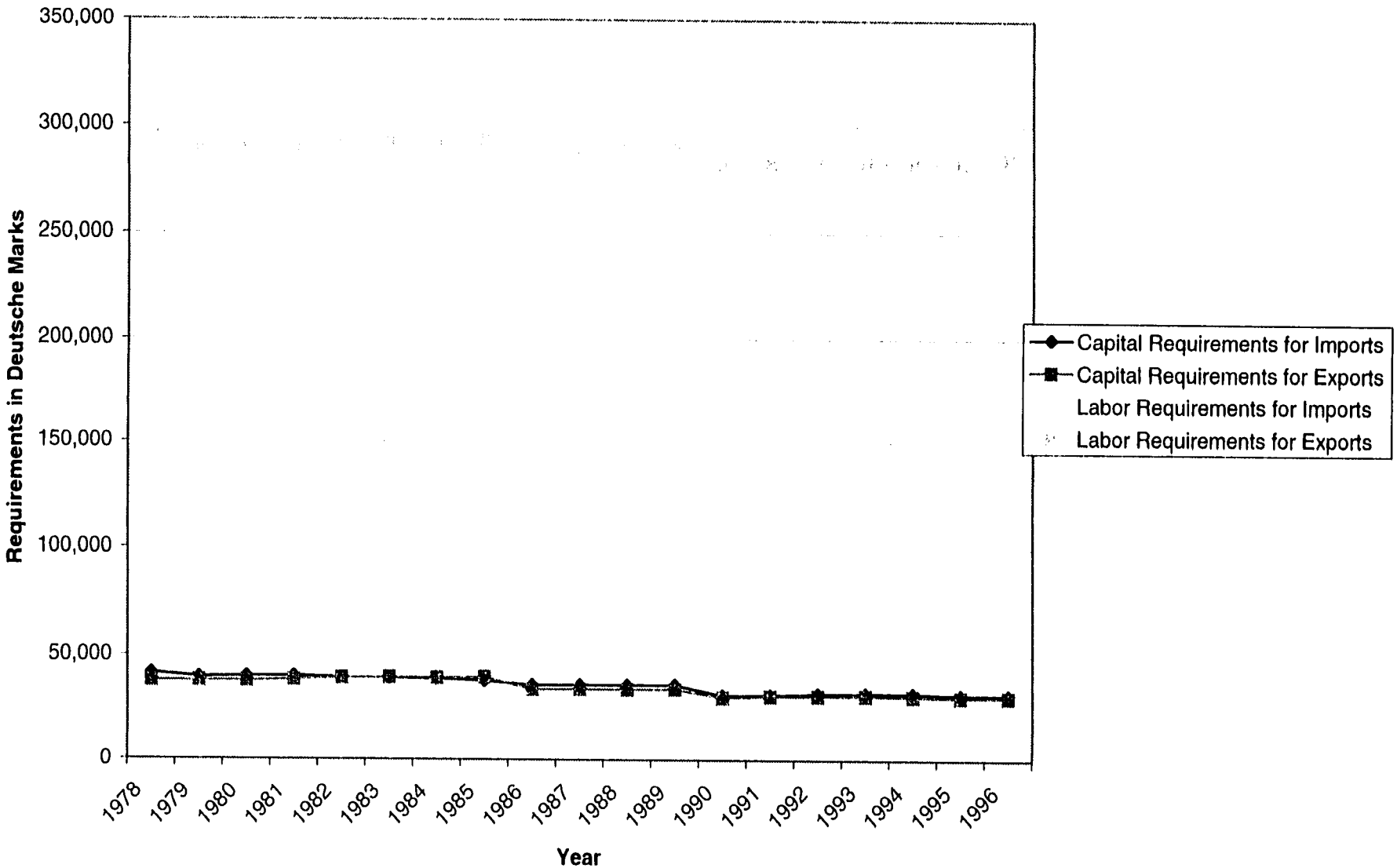
Upon testing each of the available input-output tables, we obtained the net capital and labor requirements per million Deutsche Mark ("DM") of exports and competitive imports. These values were obtained for each year with and without natural resource intensive industries and are illustrated in table 27.

Once again, apparent changes in the capital and labor requirements occur when different input-output tables are being used. One interesting note is that the capital requirements for both imports and exports have dropped substantially from 1978 to 1996. Graphs 13 and 14 represent the apparent changes in the economy during the period mentioned. During this period the labor requirements remain fairly constant with no big fluctuations. The process of industrialization led to a reduction of approximately twenty-five percent in the capital requirements for exports and import substitutes. This fact points to a substantial improvement in the efficiency of capital used and it is confirmed by the much greater amount of labor required for the production of both imports and exports. In order to produce one million DM worth of goods destined for international trade it is necessary to employ between thirty and forty thousand DM. The same production requires more than five times the use of labor for both import substitutes and exports. This indicates a relatively higher intensity of labor in the production than in all other countries studied.

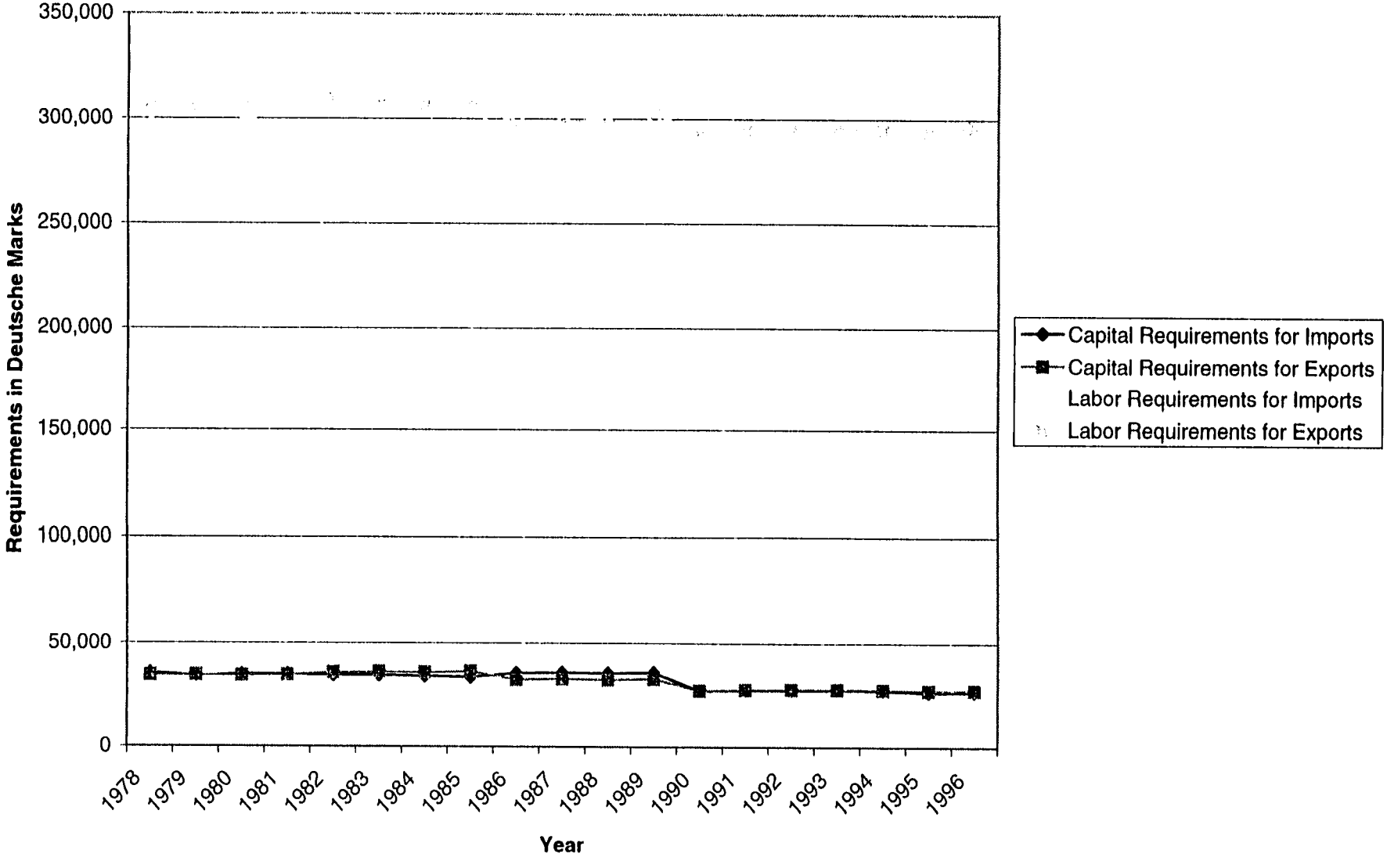
Table 27: Germany - Net Capital and Labor Requirements per Million Deutsche Marks of Exports and Imports at Constant Prices

	Capital Requirements With Natural Resources		Labor Requirements With Natural Resources			Capital Requirements Without Natural Resources		Labor Requirements Without Natural Resources	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports
1978	41,355	37,806	260,745	294,624	1978	35,841	34,856	298,001	308,406
1979	39,434	37,911	255,358	289,713	1979	34,792	34,994	296,058	304,377
1980	39,835	37,832	259,007	289,201	1980	35,239	34,786	298,715	305,019
1981	39,959	38,306	261,303	289,719	1981	35,368	35,025	305,538	306,987
1982	39,289	39,190	261,415	293,429	1982	34,672	36,153	307,161	309,756
1983	39,198	39,394	261,484	292,786	1983	34,785	36,391	306,569	308,352
1984	38,780	39,138	262,758	291,898	1984	34,342	36,099	305,231	307,391
1985	37,939	39,540	263,896	294,264	1985	33,809	36,612	307,228	308,749
1986	35,881	33,761	253,884	285,575	1986	35,853	32,730	281,842	297,146
1987	35,939	33,929	258,719	286,968	1987	36,181	33,043	283,966	297,754
1988	35,881	33,761	260,405	289,559	1988	35,853	32,730	281,594	300,983
1989	35,939	33,929	263,062	291,260	1989	36,181	33,043	283,780	302,536
1990	30,921	30,023	254,344	282,437	1990	27,356	27,412	274,889	293,323
1991	31,172	30,752	258,830	282,811	1991	27,702	27,986	279,538	294,767
1992	31,858	30,853	260,283	283,325	1992	27,745	28,123	280,422	295,536
1993	31,965	30,941	260,132	283,000	1993	27,820	28,081	280,947	295,886
1994	32,007	30,640	260,305	282,368	1994	27,536	27,817	279,149	294,547
1995	31,189	30,194	259,297	282,844	1995	26,656	27,424	276,486	293,950
1996	31,190	30,257	261,206	284,812	1996	26,991	27,550	280,739	296,381

Graph 13: Germany - Capital and Labor Requirements With Natural Resources at Constant Prices Per Million Deutsche Marks for Imports and Exports



Graph 14: Germany - Capital and Labor Requirements Without Natural Resources at Constant Prices Per Million Deutsche Marks for Imports and Exports



In order to understand the evolution of capital and labor requirements, we need to analyze the capital and labor ratios for import substitutes and exports. Table 28 presents the ratios obtained. Graph 15 helps us visualize the changes that occurred during the period studied, namely 1978-1996.

As Leontief ratios indicate, factor intensity reversal is present throughout the entire period of our study. The basis for this conclusion lies in the fact that when a nation is capital abundant, the Leontief ratio is expected to be less than one. In order to statistically test these results we implemented the delta method which confirms our results. Table 29 illustrates the numbers obtained upon the application of the delta method. These results confirm the existence of factor intensity reversal during the period 1978-1996. Upon the elimination of natural resource intensive industries we obtain lower ratios during the period 1982-1985, although their values do not support the hypothesis that exports are more capital intensive than import substitutes.

We can notice that the ratios obtained for Germany are much higher than the lower limits obtained from the application of the delta method. The lower limits are generally smaller than 0.8, but the Leontief ratios are almost always greater than one (with the exception of the period 1982-1985 already indicated) and reach a maximum of 1.28.

Table 28: Germany - Capital/Labor Ratios at Current and Constant Prices

	Capital/Labor Ratio at Constant Prices					Capital/Labor Ratio at Current Prices					Leontief Ratio at Constant Price	
	With Natural Resources		Without Natural Resources			With Natural Resources		Without Natural Resources			With and Without Natural Resource Intensive Industries	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports			
1978	0.159	0.128	0.120	0.113	1978	0.159	0.129	0.122	0.114	1978	1.24	1.06
1979	0.154	0.131	0.118	0.115	1979	0.156	0.131	0.119	0.116	1979	1.18	1.02
1980	0.154	0.131	0.118	0.114	1980	0.155	0.131	0.120	0.115	1980	1.18	1.03
1981	0.153	0.132	0.116	0.114	1981	0.155	0.133	0.118	0.115	1981	1.16	1.01
1982	0.150	0.134	0.113	0.117	1982	0.152	0.134	0.115	0.118	1982	1.13	0.97
1983	0.150	0.135	0.113	0.118	1983	0.152	0.135	0.116	0.119	1983	1.11	0.96
1984	0.148	0.134	0.113	0.117	1984	0.150	0.135	0.115	0.119	1984	1.10	0.96
1985	0.144	0.134	0.110	0.119	1985	0.147	0.135	0.113	0.120	1985	1.07	0.93
1986	0.159	0.124	0.138	0.114	1986	0.164	0.127	0.141	0.117	1986	1.28	1.21
1987	0.157	0.124	0.139	0.114	1987	0.162	0.127	0.141	0.116	1987	1.27	1.22
1988	0.138	0.117	0.127	0.109	1988	0.137	0.119	0.128	0.111	1988	1.18	1.17
1989	0.137	0.116	0.127	0.109	1989	0.135	0.119	0.128	0.112	1989	1.17	1.17
1990	0.122	0.106	0.100	0.093	1990	0.118	0.106	0.095	0.093	1990	1.14	1.06
1991	0.120	0.109	0.099	0.095	1991	0.117	0.108	0.095	0.094	1991	1.11	1.04
1992	0.122	0.109	0.099	0.095	1992	0.119	0.109	0.095	0.095	1992	1.12	1.04
1993	0.123	0.109	0.099	0.095	1993	0.119	0.109	0.094	0.094	1993	1.12	1.04
1994	0.123	0.109	0.099	0.094	1994	0.119	0.108	0.094	0.094	1994	1.13	1.04
1995	0.120	0.107	0.096	0.093	1995	0.116	0.106	0.092	0.093	1995	1.13	1.03
1996	0.119	0.106	0.096	0.093	1996	0.115	0.106	0.092	0.092	1996	1.12	1.03

Graph 15: Germany - Capital/Labor Ratios at Constant Prices

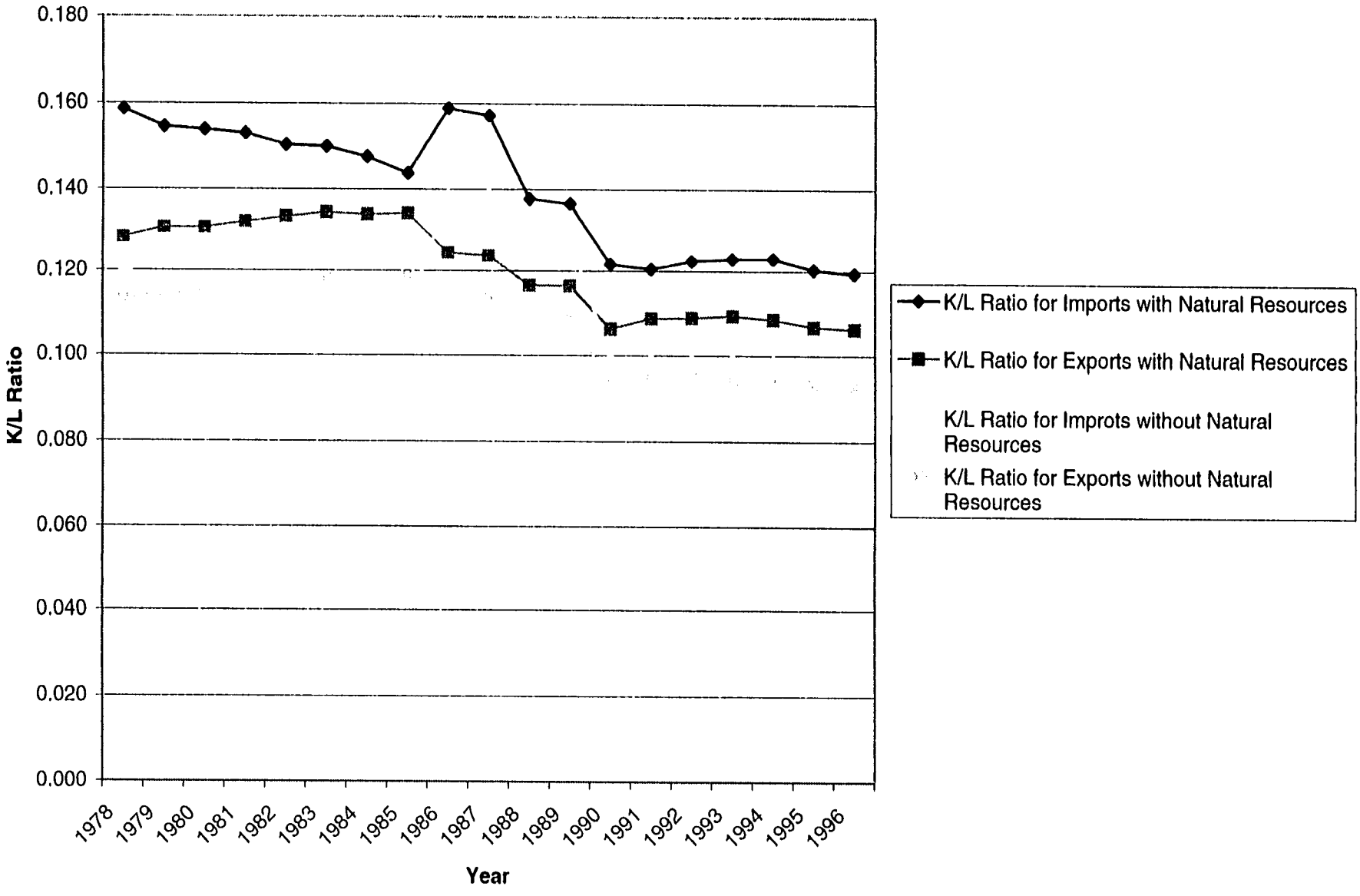


Table 29: Delta Method for Germany

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Lower Limit	Upper Limit	Ratio	Conclusion	Lower Limit	Upper Limit	Ratio	Conclusion
Capital	1978	0.67	1.33	1.24	FIR	0.79	1.21	1.06	FIR
Capital	1979	0.70	1.30	1.18	FIR	0.79	1.21	1.02	FIR
Capital	1980	0.71	1.29	1.18	FIR	0.78	1.22	1.03	FIR
Capital	1981	0.71	1.29	1.16	FIR	0.77	1.23	1.01	FIR
Capital	1982	0.70	1.30	1.13	FIR	0.78	1.22	0.97	UNDETERMINED
Capital	1983	0.72	1.28	1.11	FIR	0.80	1.20	0.96	UNDETERMINED
Capital	1984	0.73	1.27	1.10	FIR	0.80	1.20	0.96	UNDETERMINED
Capital	1985	0.74	1.27	1.07	FIR	0.80	1.20	0.93	UNDETERMINED
Capital	1986	0.72	1.28	1.28	FIR	0.78	1.22	1.21	FIR
Capital	1987	0.73	1.28	1.27	FIR	0.78	1.22	1.22	FIR
Capital	1988	0.78	1.22	1.18	FIR	0.82	1.18	1.17	FIR
Capital	1989	0.79	1.21	1.17	FIR	0.82	1.18	1.17	FIR
Capital	1990	0.80	1.20	1.14	FIR	0.82	1.18	1.06	FIR
Capital	1991	0.83	1.18	1.11	FIR	0.84	1.16	1.04	FIR
Capital	1992	0.80	1.20	1.12	FIR	0.82	1.80	1.04	FIR
Capital	1993	0.79	1.21	1.12	FIR	0.79	1.21	1.04	FIR
Capital	1994	0.79	1.21	1.13	FIR	0.80	1.20	1.04	FIR
Capital	1995	0.79	1.21	1.13	FIR	0.80	1.20	1.03	FIR
Capital	1996	0.79	1.21	1.12	FIR	0.80	1.20	1.03	FIR

Based on the analysis performed for the period 1978-1996 it appears that the Heckscher-Ohlin theory is not supported when applying the methodology proposed by Leontief.

ITALY – COMMENTS AND RESULTS

The case of Italy is somewhat different since the availability of the input-output table is limited to only one year, namely 1985. Therefore, we are compelled to use the twenty-seven years of import substitutes and exports data with the same intermediate coefficients. Consequently we are assuming that the Italian economy remained stable during the period of our study. We have made use of the 1985 input-output table to compute the input requirements of the economy in a two-decade period where industrialization and increasing costs of labor led to the adoption of new production techniques; namely, more capital intensive and labor saving. With the availability of input-output tables every five years, this phenomenon would be depicted by a change in the labor and capital requirements.

Our assumption leads to a reduction in the reliability of the results obtained for Italy. Given the importance of this nation within the European Union and the industrialized countries, we decided to keep it in the group of countries studied despite the necessity to rely only on one input-output table.

Notwithstanding our limitations, Italy's developments necessitate the same attention accorded to all countries previously commented in this section. Italy's economy has flourished over the years. Agriculture has been the principal means of livelihood, and this in spite of the spurs of rugged mountains that cover so large a part of Italy. The city of Carrara is quarried with the beautiful marble so prized for fine sculpture. This is the most important of Italian mineral resources, though granite and other building stone, zinc, iron, lead, copper, sulfur, rock salt and quicksilver are mined

in small quantities. Coal, which is a vital commodity in the development of manufacturing industries, is almost entirely lacking. Textiles are the leading manufactures.

The brief description of Italy's economy coincides with our findings of a labor abundant nation based on the capital stock per worker from the PWT. Despite the lack of data we will attempt a similar evaluation of the Leontief approach for the years 1968-1996. The input-output table is expressed at current prices just like the imports and exports data. Therefore, there is no need to deflate the available data.

Italy being a labor abundant nation is expected to export labor-intensive goods. During 1985 the most important exporting industries were fabricated metal products, non-electrical machinery, other manufacturing, textiles, apparel and leather, chemical, machinery and equipment and professional goods. Since we do not have data past 1985 we can only assume that the nation remained labor abundant and perhaps improved its production efficiency.

Traditionally, Italy is known for its small businesses where labor is still the most prevalent means of employment, despite the advanced status that it holds as a nation. These small businesses make up a large percentage of the economy and perhaps it is for this reason that as of 1985 the nation is still classified as a labor abundant nation. Nevertheless, over the years Italy imported goods such as food, beverages and tobacco, basic metal used in manufacturing and even fabricated metal products.

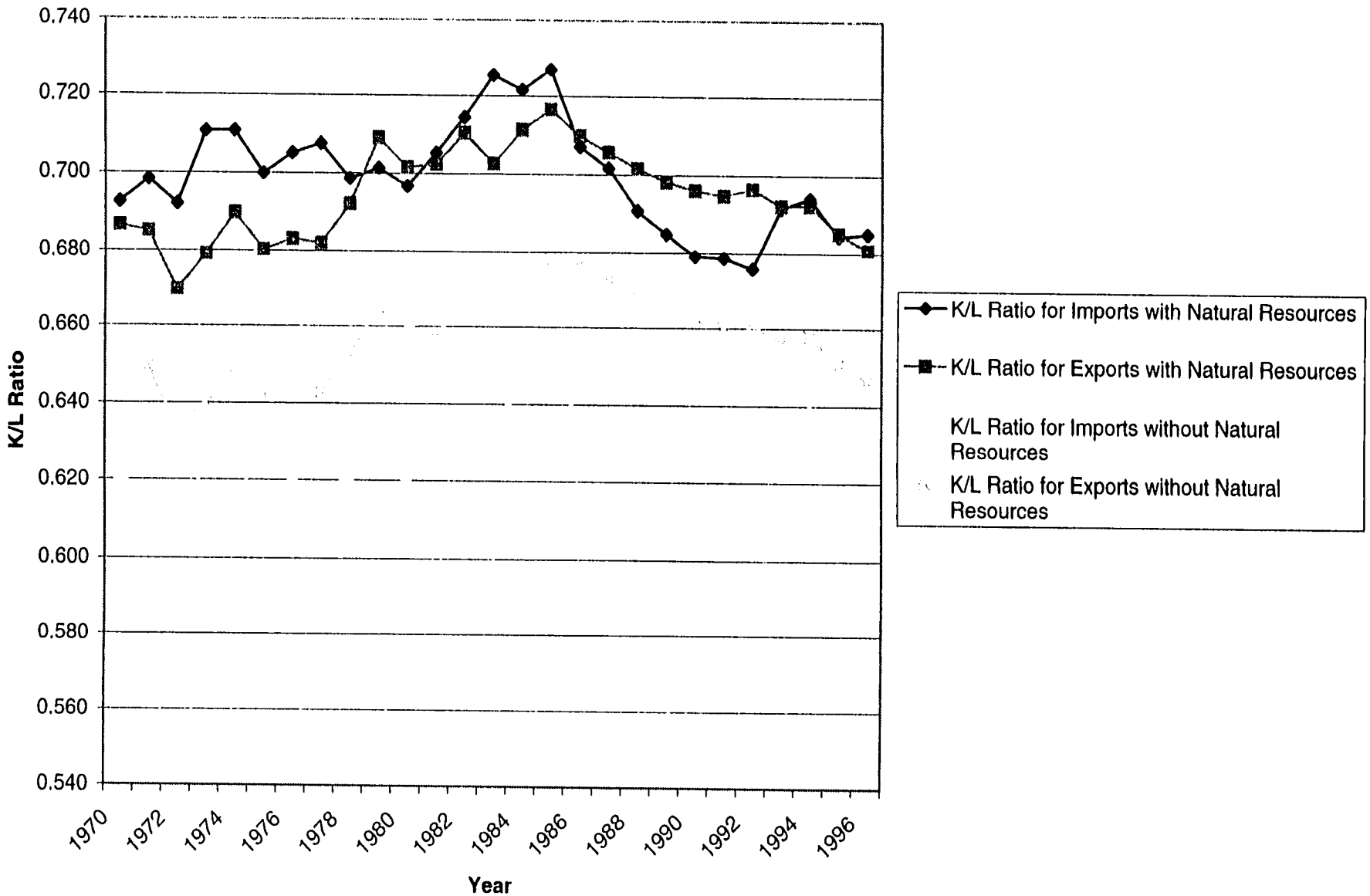
Table 30 illustrates the change in the capital-labor ratios for imports and exports at current prices. These values are accounting for the thirty-three industries of the input-

output table. In order to fully test the Leontief approach we will also eliminate the natural resource intensive industries in order to observe any possible improvements in the available data. In addition, a graphical representation of the capital-labor ratios at current prices is provided for a visual enhancement of the data description (see graph 16).

Table 30: Italy - Capital/Labor Ratios at Current Prices

	Capital/Labor Ratio at Current Prices					Leontief Ratio	
	With Natural Resources		Without Natural Resources			At Current Prices	
	Imports	Exports	Imports	Exports		With and Without Natural Resource Intensive Industries	
1970	0.692	0.687	0.621	0.654	1970	1.01	0.95
1971	0.698	0.685	0.617	0.649	1971	1.02	0.95
1972	0.692	0.670	0.609	0.634	1972	1.03	0.96
1973	0.711	0.679	0.624	0.640	1973	1.05	0.97
1974	0.711	0.690	0.628	0.647	1974	1.03	0.97
1975	0.700	0.680	0.609	0.643	1975	1.03	0.95
1976	0.705	0.683	0.620	0.645	1976	1.03	0.96
1977	0.708	0.682	0.618	0.643	1977	1.04	0.96
1978	0.699	0.692	0.620	0.653	1978	1.01	0.95
1979	0.701	0.709	0.622	0.665	1979	0.99	0.94
1980	0.697	0.702	0.622	0.660	1980	0.99	0.94
1981	0.705	0.702	0.628	0.658	1981	1.00	0.96
1982	0.714	0.710	0.630	0.667	1982	1.01	0.95
1983	0.725	0.703	0.638	0.663	1983	1.03	0.96
1984	0.721	0.711	0.642	0.673	1984	1.01	0.95
1985	0.727	0.717	0.645	0.678	1985	1.01	0.95
1986	0.707	0.710	0.638	0.677	1986	1.00	0.94
1987	0.702	0.706	0.635	0.673	1987	0.99	0.94
1988	0.691	0.702	0.634	0.669	1988	0.98	0.95
1989	0.685	0.698	0.628	0.666	1989	0.98	0.94
1990	0.679	0.696	0.624	0.663	1990	0.98	0.94
1991	0.679	0.695	0.623	0.660	1991	0.98	0.94
1992	0.676	0.696	0.623	0.661	1992	0.97	0.94
1993	0.692	0.692	0.634	0.657	1993	1.00	0.96
1994	0.694	0.692	0.639	0.658	1994	1.00	0.97
1995	0.684	0.685	0.634	0.651	1995	1.00	0.98
1996	0.685	0.681	0.634	0.646	1996	1.01	0.98

Graph 16: Italy - Capital/Labor Ratios at Current Prices



Since we were constrained to use the 1985 input-output table with twenty-seven years of exports and import substitutes data with the same intermediate production coefficients, our capital/labor ratios do not vary considerably from 1968 through 1996. Although this assumption is fairly strong and less realistic, it enables us to state that for each unit of capital used in the production of goods, Italy needs 1.45 units of labor. Heckscher-Ohlin theory is confirmed for the period 1970-1978, 1981-1986 and 1993-1996. Factor intensity reversal is slightly exhibited during 1979-1980 and 1987-1992.

Upon the elimination of natural intensive industries, the validity of the Heckscher-Ohlin cannot be confirmed. In order to validate our conclusion of the presence of factor intensity reversal we are applying the delta method, which is used to obtain the asymptotic distribution of measures of association. Table 31 supports our conclusion that Italy exhibits the presence of factor intensity reversal throughout the entire period of our study.

Despite the use of only one input-output table, Heckscher-Ohlin theory can be confirmed when all thirty-three industries are considered.

Table 31: Delta Method for Italy

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Upper Limit	Lower Limit	Ratio	Conclusion	Upper Limit	Lower Limit	Ratio	Conclusion
Labor	1970	1.15	0.86	1.05	FIR	1.04	0.96	0.95	FIR
Labor	1971	1.16	0.84	1.05	FIR	1.04	0.96	0.94	FIR
Labor	1972	1.15	0.85	1.06	FIR	1.04	0.96	0.94	FIR
Labor	1973	1.15	0.85	1.08	FIR	1.03	0.97	0.96	FIR
Labor	1974	1.14	0.86	1.07	FIR	1.03	0.97	0.97	FIR
Labor	1975	1.16	0.84	1.09	FIR	1.04	0.96	0.96	FIR
Labor	1976	1.15	0.86	1.08	FIR	1.03	0.97	0.97	FIR
Labor	1977	1.16	0.85	1.08	FIR	1.04	0.96	0.97	FIR
Labor	1978	1.14	0.86	1.06	FIR	1.04	0.96	0.96	FIR
Labor	1979	1.12	0.88	1.05	FIR	1.04	0.96	0.96	FIR
Labor	1980	1.11	0.89	1.04	FIR	1.05	0.96	0.95	FIR
Labor	1981	1.11	0.89	1.04	FIR	1.05	0.95	0.95	FIR
Labor	1982	1.12	0.88	1.05	FIR	1.05	0.95	0.95	FIR
Labor	1983	1.10	0.90	1.03	FIR	1.06	0.94	0.96	FIR
Labor	1984	1.09	0.91	1.01	FIR	1.06	0.94	0.95	FIR
Labor	1985	1.09	0.91	1.01	FIR	1.06	0.94	0.95	FIR
Labor	1986	1.09	0.91	1.00	FIR	1.06	0.94	0.94	FIR
Labor	1987	1.09	0.91	0.99	FIR	1.06	0.94	0.94	FIR
Labor	1988	1.08	0.92	0.98	FIR	1.06	0.94	0.95	FIR
Labor	1989	1.08	0.92	0.98	FIR	1.06	0.94	0.94	FIR
Labor	1990	1.08	0.92	0.98	FIR	1.06	0.94	0.94	FIR
Labor	1991	1.08	0.92	0.98	FIR	1.06	0.94	0.94	FIR
Labor	1992	1.08	0.92	0.97	FIR	1.06	0.94	0.94	FIR
Labor	1993	1.08	0.92	1.00	FIR	1.06	0.94	0.96	FIR
Labor	1994	1.08	0.92	1.00	FIR	1.06	0.95	0.97	FIR
Labor	1995	1.07	0.93	1.00	FIR	1.06	0.94	0.98	FIR
Labor	1996	1.08	0.92	1.01	FIR	1.06	0.94	0.98	FIR

JAPAN – COMMENTS AND RESULTS

According to our classification, Japan evolves from its status of a labor abundant nation during the period 1968-1988 to a capital abundant state during 1990-1996. This classification corresponds to the growth performance of the country over the period covered by this study.

The Japanese began to modernize their country in the mid-19th century. At that time almost eighty percent of its work force was engaged in agriculture. The manufacturing workers were few. Since that time the percentage of farmers has decreased and the percentage of manufacturing workers has increased. Japan was defeated in World War II, however, the energetic Japanese people quickly rebuilt their war-torn country and today they are far more prosperous after the war. By the mid-60s approximately one-fifth of all employed workers were found in agriculture and one-fourth were in manufacturing. The rest were engaged in other occupations.

Despite the decrease in the number of workers employed in agriculture, this sector is still extremely important in Japan. Rice is by far the most important crop. It is grown by more than 90 percent of all farm households and more than half of the usable land is planted with rice. Japanese farmers also grow other crops such as sweet and white potatoes, soybeans, vegetables, fruits and tobacco.

Japan has a very large population with respect to the land that it covers; in no other country does such a small living area have to support so many people. Therefore,

the land cannot produce enough food to meet the total demand. Food and most industrial raw materials have to be bought from other countries.

On the other hand, industry has made Japan one of the world's great manufacturing powers. Until the 1960's, the competition for jobs was enormous. As a result of inexpensive labor people were willing to work for low wages. Because labor was abundant and cheap, industries could operate profitably even though the cost of importing raw materials was very high. As industry expanded and the economy prospered, labor shortages occurred and wages rose. This resulted in the substitution of labor for capital, which led Japan to be considered a capital abundant nation after 1990.

Tatemono and Ichimura certify the characterization of Japan as a labor abundant nation[9]. The two economists used a 1951 input-output table for Japan and found that "an average million yen's worth of Japanese exports embodies more capital and less labor than would be required for the domestic replacements of competitive imports of an equivalent amount" (1959, p. 455). Under the postulation that Japan is relatively labor abundant, this conclusion is consistent with the Leontief Paradox and inconsistent with the Heckscher-Ohlin hypothesis. However, the two economists were able to dispel the paradox by a closer examination of Japanese exports and imports. Additionally, they found that Japan's exports to the U.S. were indeed more labor abundant, therefore confirming the Heckscher-Ohlin theory.

The industry of Japan is very well diversified. The production of iron, steel, and other kinds of materials contributes to the value of the Japanese economy. Chemicals

[9] Tatemono, Masahiro, and Ichimura, Shinichi. "Factor Proportions and Foreign Trade: The case of Japan:" Rev. Econ. and Statis., XLI (November, 1959), 442-46.

and machinery have become increasingly important as export items. Japan's fishery also contributes to the economy.

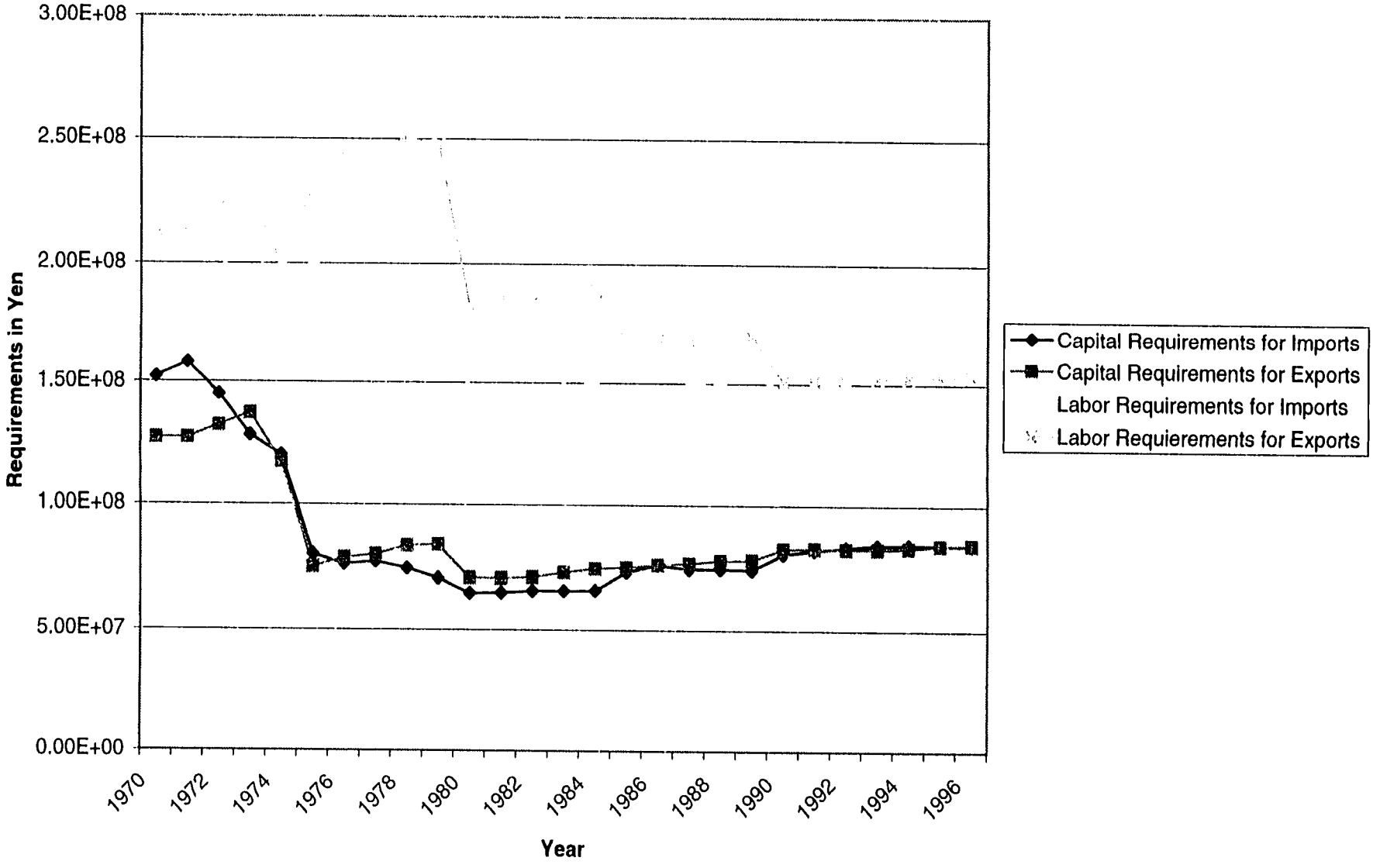
The input-output tables provide the data used to evaluate Japan for 1970, 1975, 1980, 1985 and 1990 at constant prices. The import substitutes and exports data are available only at current prices for the years 1970 through 1996. In order to deflate the import substitutes and exports data to be used with the input-output tables at constant prices we obtained the yearly GDP deflator from the IFS. A previously used method of deflating the data was used here as well (see equation 32).

As a result of our classification method, Japan is shown to be a labor abundant nation during 1968-1988 and is expected to export labor-intensive goods and import capital-intensive goods. After running the programs using each of the available input-output tables we obtained the net capital and labor requirements per billion Yen of exports and competitive imports. These values were obtained for each year, with and without natural resource intensive sectors of the economy. Table 32 illustrates the net

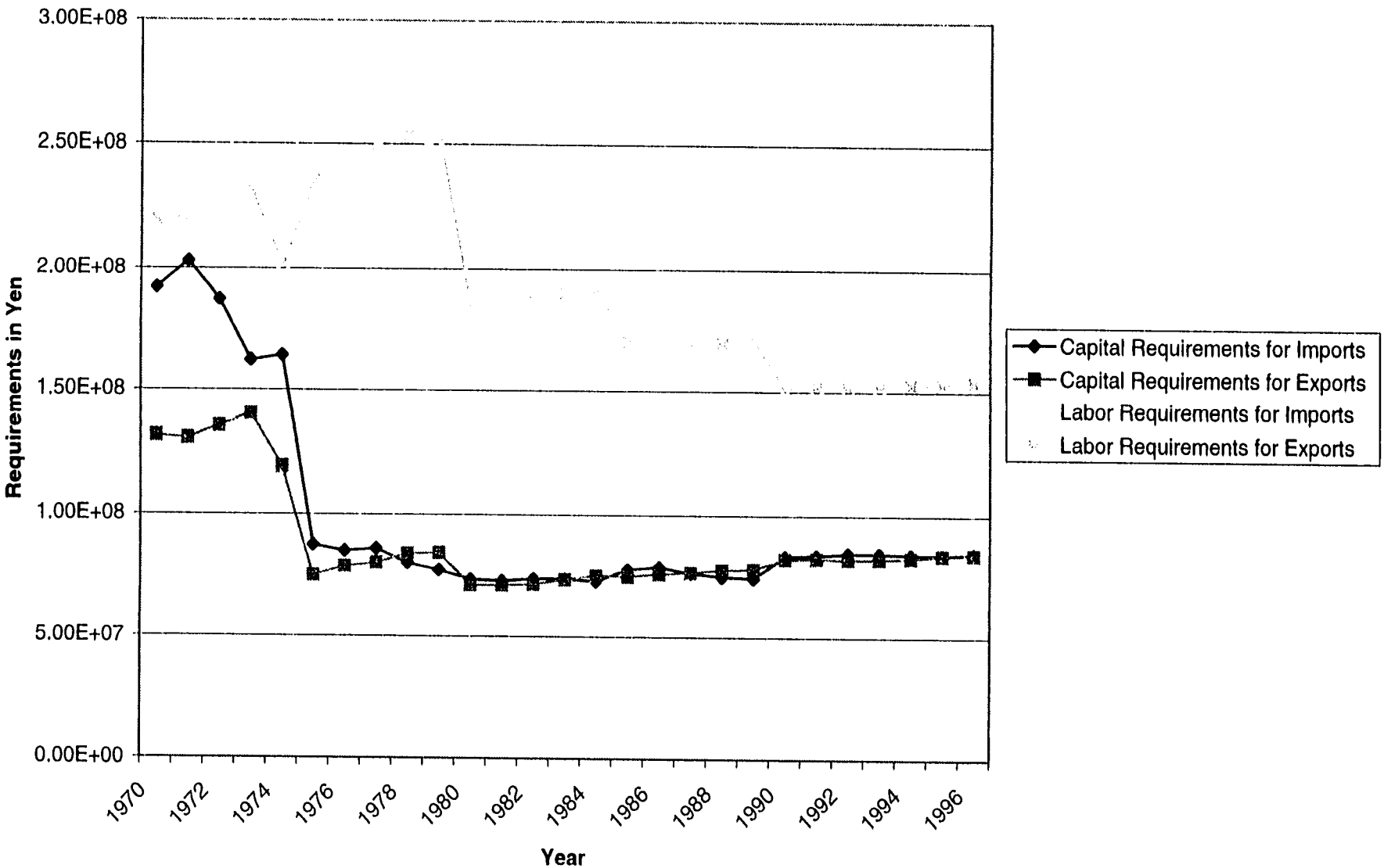
Table 32: Japan - Net Capital and Labor Requirements per Billion Yen of Exports and Imports at Constant Prices

	Capital Requirements With Natural Resources		Labor Requirements With Natural Resources			Capital Requirements Without Natural Resources		Labor Requirements Without Natural Resources	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports
1970	1.52E+08	1.27E+08	2.08E+08	2.13E+08	1970	1.92E+08	1.31E+08	2.61E+08	2.20E+08
1971	1.58E+08	1.27E+08	2.16E+08	2.15E+08	1971	2.03E+08	1.30E+08	2.74E+08	2.21E+08
1972	1.45E+08	1.32E+08	2.03E+08	2.24E+08	1972	1.87E+08	1.35E+08	2.59E+08	2.30E+08
1973	1.28E+08	1.37E+08	1.86E+08	2.27E+08	1973	1.62E+08	1.40E+08	2.33E+08	2.32E+08
1974	1.20E+08	1.17E+08	1.74E+08	1.99E+08	1974	1.64E+08	1.19E+08	2.37E+08	2.02E+08
1975	80059558	74971637	2.01E+08	2.33E+08	1975	87665074	75194229	2.68E+08	2.36E+08
1976	76016821	78658583	1.92E+08	2.43E+08	1976	85263034	78901182	2.60E+08	2.46E+08
1977	77133496	80053478	1.93E+08	2.47E+08	1977	86272705	80404140	2.60E+08	2.50E+08
1978	74469331	83623927	1.93E+08	2.50E+08	1978	80380819	84113875	2.53E+08	2.54E+08
1979	70434628	84069495	1.86E+08	2.48E+08	1979	77335917	84637561	2.48E+08	2.53E+08
1980	64510387	70683612	1.47E+08	1.82E+08	1980	73575871	71300012	1.90E+08	1.84E+08
1981	64737101	70583092	1.47E+08	1.86E+08	1981	72955637	71199562	1.91E+08	1.88E+08
1982	65423628	71048885	1.47E+08	1.85E+08	1982	73914451	71639945	1.89E+08	1.87E+08
1983	65444186	72960442	1.48E+08	1.88E+08	1983	73892488	73641928	1.89E+08	1.90E+08
1984	65631692	74548800	1.50E+08	1.90E+08	1984	72844289	75249457	1.88E+08	1.92E+08
1985	72978570	75019511	1.40E+08	1.69E+08	1985	77921021	74960717	1.69E+08	1.70E+08
1986	75831102	76027720	1.47E+08	1.69E+08	1986	78981963	76035547	1.70E+08	1.70E+08
1987	74315117	76682059	1.49E+08	1.68E+08	1987	76427614	76741197	1.71E+08	1.69E+08
1988	74430942	77926798	1.52E+08	1.69E+08	1988	75015953	77963259	1.69E+08	1.70E+08
1989	73961952	78196484	1.54E+08	1.70E+08	1989	74449010	78304078	1.72E+08	1.71E+08
1990	80567608	82598805	1.47E+08	1.51E+08	1990	83577573	82513618	1.58E+08	1.51E+08
1991	82033564	82827838	1.49E+08	1.51E+08	1991	84034979	82738135	1.57E+08	1.52E+08
1992	83278571	82631182	1.51E+08	1.51E+08	1992	84919053	82571505	1.60E+08	1.52E+08
1993	84218377	82661356	1.54E+08	1.52E+08	1993	84927763	82661689	1.59E+08	1.52E+08
1994	84388387	83088425	1.55E+08	1.52E+08	1994	84473297	83109882	1.60E+08	1.53E+08
1995	84263565	84125617	1.53E+08	1.53E+08	1995	84421820	84142275	1.57E+08	1.53E+08
1996	84153976	84506516	1.54E+08	1.53E+08	1996	84945081	84464683	1.58E+08	1.54E+08

Graph 17: Japan - Capital and Labor Requirements with Natural Resources at Constant Prices Per Billion Yen for Imports and Exports



Graph 18: Japan - Capital and Labor Requirements without Natural Resources at Constant Prices Per Billion Yen for Imports and Exports



capital and labor requirements. A graphical representation of the results follows table 32 (see graphs 17 and 18).

What we are actually observing is a decrease in the capital and labor requirements for imports and exports throughout the entire period studied. The requirements almost halved during these twenty-seven years. This could be interpreted as a confirmation of the increased efficiency in the use of capital and labor in Japan. The lowest point for the capital requirements is 1983. After this year the capital requirements for imports and exports increase slightly. Upon the elimination of natural resource intensive industries the results signify no major changes.

Next, our discussion revolves around the capital-labor ratios for import substitutes and exports at constant prices. Based on table 33 and graph 19 we can conclude that Japan sustains the confirmation of the Heckscher-Ohlin theory. Once natural resource intensive industries are removed, factor intensity reversal is somewhat present during 1974-1979, 1984 and 1987-1989. The Leontief ratios show a reduction when natural resource intensive industries are not considered. Their value is lower than one for the period in which Japan is a capital abundant nation. However, given the high variance of the capital and labor requirements, we obtain a lower limit which is approximately 0.9. The hypothesis that the Heckscher-Ohlin theory drives the pattern of trade for this nation is rejected. This is illustrated in table 34 provided on the proceeding pages illustrating the results obtained from the application of the delta method.

Therefore, by applying the Leontief method using the delta method, the Heckscher-Ohlin theory can only be verified for the period 1970-1974, otherwise the theory is confirmed using the traditional implementation of the Leontief approach.

Table 33: Japan - Capital/Labor Ratios at Current and Constant Prices

	Capital/Labor Ratio at Constant Prices					Capital/Labor Ratio at Current Prices					Leontief Ratio at Constant Prices	
	With Natural Resources		Without Natural Resources			With Natural Resources		Without Natural Resources			With and Without Natural Resource Intensive Industries	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports			
1970	0.727	0.596	0.737	0.595	1970	0.588	0.514	0.574	0.509	1970	1.22	1.24
1971	0.732	0.589	0.741	0.588	1971	0.583	0.512	0.563	0.507	1971	1.24	1.26
1972	0.714	0.588	0.722	0.587	1972	0.572	0.506	0.549	0.502	1972	1.21	1.23
1973	0.686	0.603	0.695	0.603	1973	0.550	0.508	0.527	0.504	1973	1.14	1.15
1974	0.689	0.590	0.695	0.589	1974	0.571	0.525	0.544	0.521	1974	1.17	1.18
1975	0.398	0.322	0.327	0.318	1975	0.388	0.315	0.294	0.310	1975	1.23	1.03
1976	0.395	0.324	0.328	0.320	1976	0.381	0.317	0.291	0.312	1976	1.22	1.02
1977	0.400	0.325	0.332	0.322	1977	0.387	0.318	0.295	0.314	1977	1.23	1.03
1978	0.386	0.334	0.318	0.331	1978	0.368	0.329	0.279	0.325	1978	1.16	0.96
1979	0.379	0.338	0.311	0.335	1979	0.364	0.335	0.277	0.330	1979	1.12	0.93
1980	0.439	0.388	0.388	0.387	1980	0.439	0.388	0.388	0.387	1980	1.13	1.00
1981	0.440	0.380	0.382	0.379	1981	0.440	0.380	0.382	0.379	1981	1.16	1.01
1982	0.445	0.384	0.390	0.383	1982	0.445	0.384	0.390	0.383	1982	1.16	1.02
1983	0.443	0.388	0.391	0.388	1983	0.443	0.388	0.391	0.388	1983	1.14	1.01
1984	0.437	0.393	0.388	0.393	1984	0.437	0.393	0.388	0.393	1984	1.11	0.99
1985	0.520	0.444	0.462	0.441	1985	0.520	0.444	0.462	0.441	1985	1.17	1.05
1986	0.515	0.451	0.463	0.448	1986	0.515	0.451	0.463	0.448	1986	1.14	1.03
1987	0.499	0.456	0.447	0.454	1987	0.499	0.456	0.447	0.454	1987	1.09	0.99
1988	0.491	0.462	0.443	0.460	1988	0.491	0.462	0.443	0.460	1988	1.06	0.96
1989	0.481	0.461	0.434	0.459	1989	0.481	0.461	0.434	0.459	1989	1.04	0.95
1990	0.548	0.548	0.530	0.546	1990	0.560	0.557	0.540	0.555	1990	1.00	0.97
1991	0.551	0.547	0.534	0.545	1991	0.562	0.556	0.545	0.554	1991	1.01	0.98
1992	0.551	0.546	0.531	0.544	1992	0.561	0.555	0.542	0.553	1992	1.01	0.98
1993	0.548	0.545	0.533	0.543	1993	0.558	0.554	0.543	0.552	1993	1.00	0.98
1994	0.545	0.546	0.529	0.544	1994	0.555	0.555	0.540	0.553	1994	1.00	0.97
1995	0.549	0.551	0.537	0.549	1995	0.559	0.560	0.547	0.558	1995	1.00	0.98
1996	0.548	0.552	0.537	0.550	1996	0.558	0.561	0.546	0.559	1996	0.99	0.98

Graph 19: Japan - Capital/Labor Ratios at Constant Prices

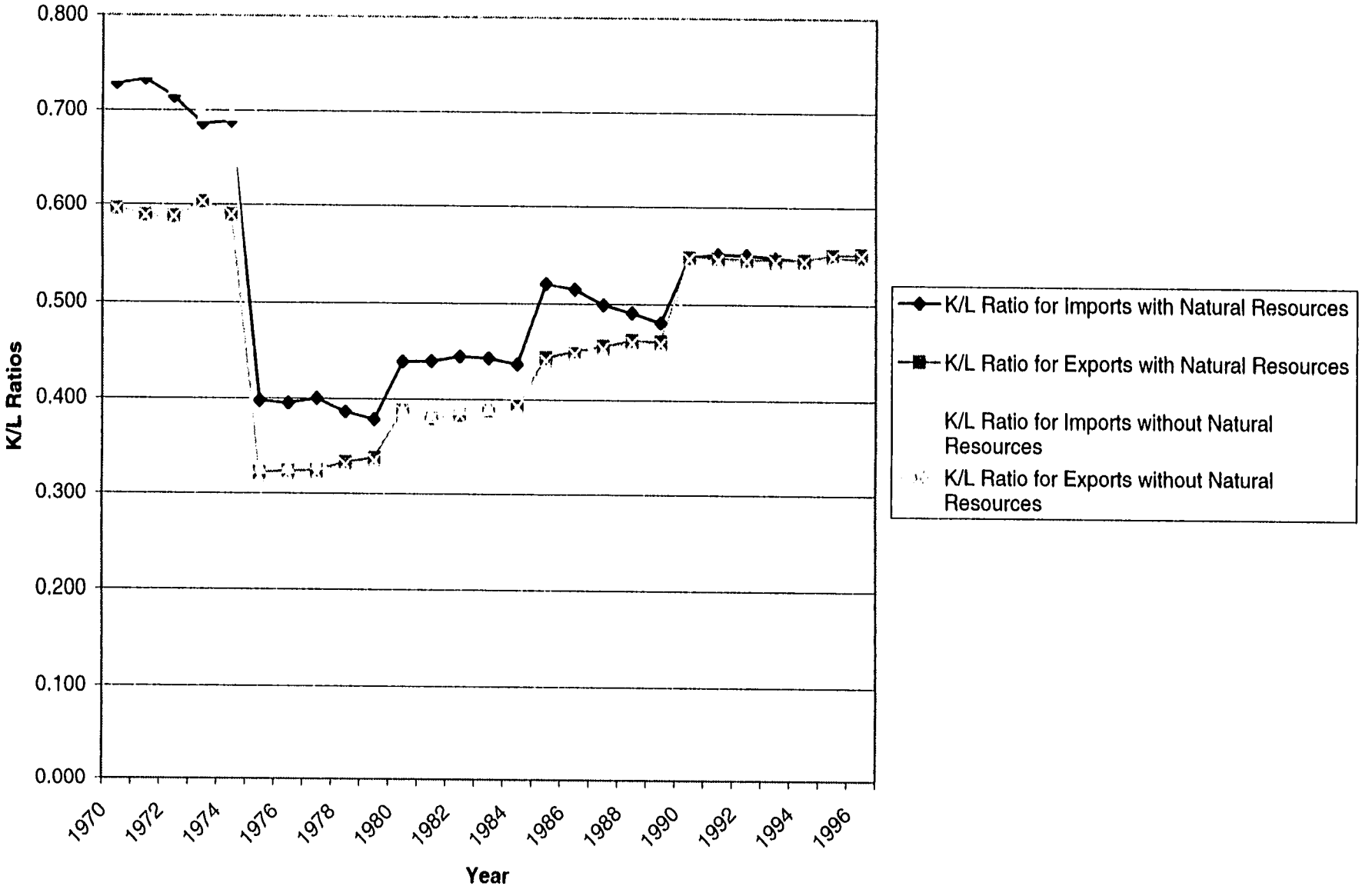


Table 34: Delta Method for Japan

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Upper Limit Lower Limit	Lower Limit Upper Limit	Ratio	Conclusion	Upper Limit Lower Limit	Lower Limit Upper Limit	Ratio	Conclusion
Labor	1970	1.12	0.88	1.22	NO FIR	1.12	0.88	1.24	NO FIR
Labor	1971	1.13	0.87	1.23	NO FIR	1.13	0.87	1.26	NO FIR
Labor	1972	1.13	0.87	1.21	NO FIR	1.13	0.87	1.23	NO FIR
Labor	1973	1.12	0.88	1.14	NO FIR	1.13	0.87	1.15	NO FIR
Labor	1974	1.14	0.86	1.17	NO FIR	1.15	0.85	1.18	NO FIR
Labor	1975	1.37	0.63	1.23	UNDETERMINED	1.24	0.76	1.03	UNDETERMINED
Labor	1976	1.37	0.63	1.22	UNDETERMINED	1.27	0.73	1.02	UNDETERMINED
Labor	1977	1.38	0.62	1.23	UNDETERMINED	1.27	0.73	1.03	UNDETERMINED
Labor	1978	1.39	0.61	1.16	UNDETERMINED	1.29	0.71	0.96	FIR
Labor	1979	1.36	0.64	1.12	UNDETERMINED	1.25	0.75	0.93	FIR
Labor	1980	1.32	0.68	1.13	UNDETERMINED	1.29	0.71	1.00	UNDETERMINED
Labor	1981	1.34	0.66	1.16	UNDETERMINED	1.29	0.71	1.01	UNDETERMINED
Labor	1982	1.35	0.65	1.16	UNDETERMINED	1.30	0.70	1.02	UNDETERMINED
Labor	1983	1.31	0.69	1.14	UNDETERMINED	1.27	0.73	1.01	UNDETERMINED
Labor	1984	1.31	0.69	1.11	UNDETERMINED	1.26	0.74	0.99	FIR
Labor	1985	1.24	0.76	1.17	UNDETERMINED	1.21	0.80	1.05	UNDETERMINED
Labor	1986	1.21	0.79	1.14	UNDETERMINED	1.20	0.80	1.03	UNDETERMINED
Labor	1987	1.21	0.79	1.09	UNDETERMINED	1.19	0.81	0.99	FIR
Labor	1988	1.21	0.80	1.06	UNDETERMINED	1.18	0.82	0.96	FIR
Inconclusive	1989								
Capital	1990	0.87	1.13	1.00	UNDETERMINED	0.89	1.11	0.97	UNDETERMINED
Capital	1991	0.87	1.13	1.00	UNDETERMINED	0.88	1.12	0.98	UNDETERMINED
Capital	1992	0.86	1.14	1.01	FIR	0.87	1.13	0.98	UNDETERMINED
Capital	1993	0.86	1.14	1.00	UNDETERMINED	0.87	1.13	0.98	UNDETERMINED
Capital	1994	0.86	1.14	1.00	UNDETERMINED	0.87	1.13	0.97	UNDETERMINED
Capital	1995	0.87	1.13	1.00	UNDETERMINED	0.88	1.12	0.98	UNDETERMINED
Capital	1996	0.88	1.12	0.99	UNDETERMINED	0.88	1.12	0.98	UNDETERMINED

UNITED KINGDOM – COMMENTS AND RESULTS

United Kingdom is a small country with a fairly high population density. Consequently, land is very valuable and every possible acre must be used efficiently. Most English farmers carry out what is known as mixed farming, although farms in certain areas specialize in one type of farming due to the quality of soil and climate. Livestock is the most important farm occupation in Highland England.

On the other hand, industry forms the heart of England's economy. More than one third of the working people in England are engaged in manufacturing. England produces a great variety of manufactured goods, from machinery to automobiles to textiles. Coal is the most important product in the country. Since coal is bulky and heavy it was easier and cheaper to build the industries needing coal near the coalfields than to transport the coal to other areas. Coal accounts for almost ninety percent of the income from mining. The fishing industry, although it employs relatively few people, ranks among the largest in the world in its annual catch.

Despite the major historical inventions on how to use steam power to make machines run, leading to the Industrial Revolution taking place before it did in any other country, England turns out to be a labor abundant nation based on our classification. As a result, England is expected to export more labor-intensive goods and import more capital-intensive commodities.

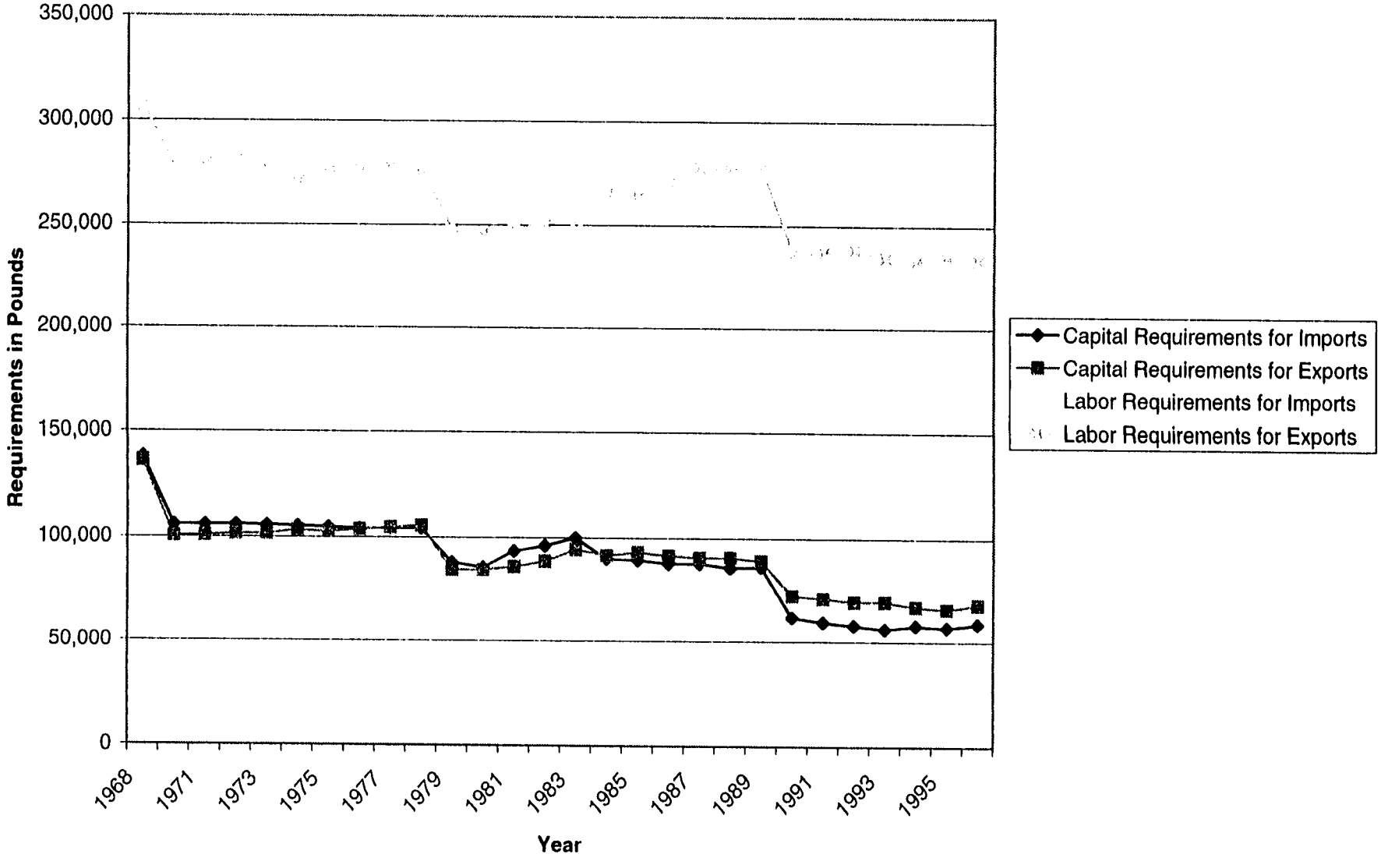
Upon the use of the four input-output tables (1968, 1979, 1984 and 1990) we obtained the net capital and labor requirements per million pounds of exports and

competitive imports. These values were obtained at constant prices, with and without natural resource intensive sectors of the economy. Table 35 illustrates our findings. Graphical representations are illustrated in graphs 20 and 21.

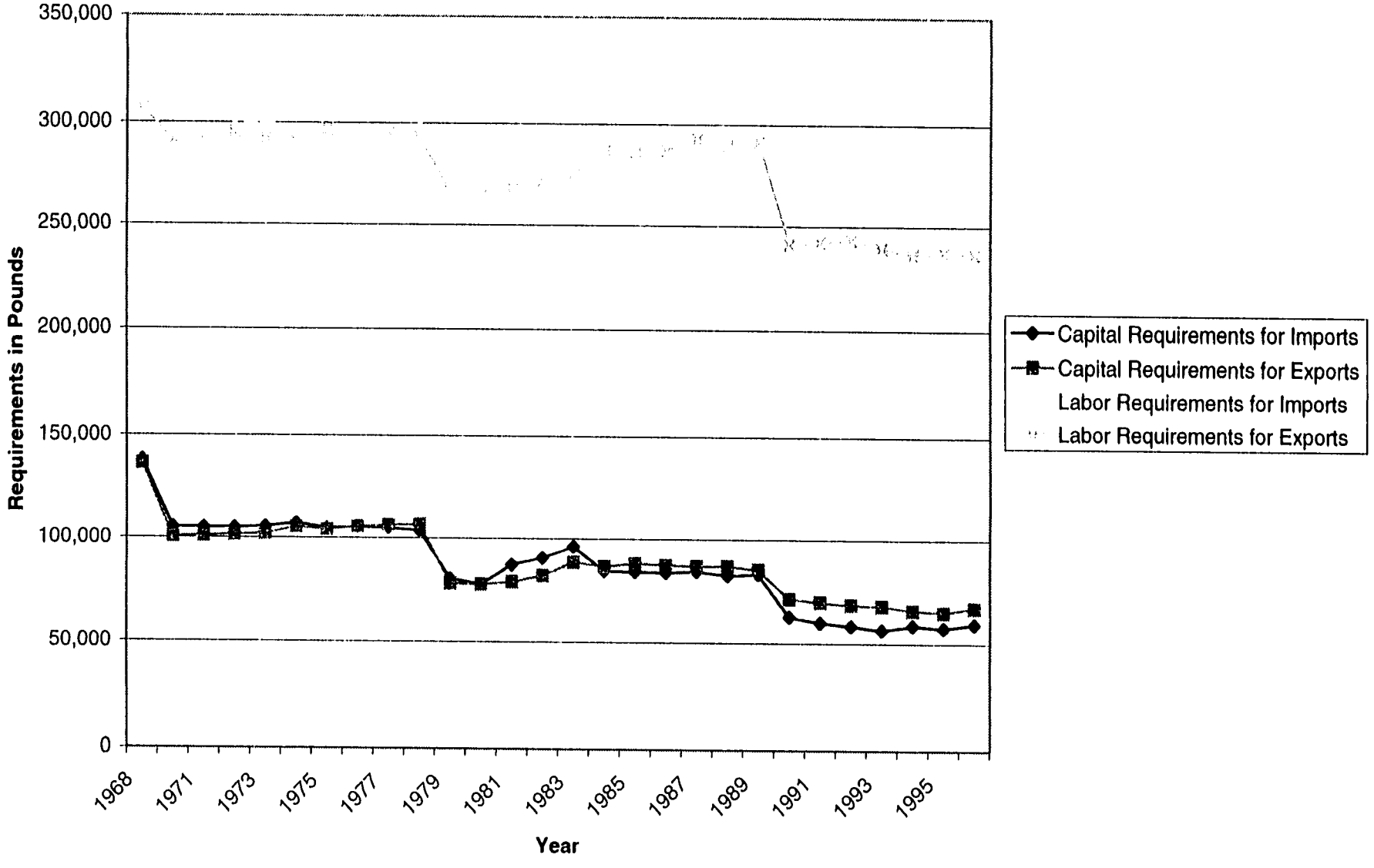
Table 35: United Kingdom - Net Capital and Labor Requirements per Million British Pounds of Exports and Imports at Constant Prices

	Capital Requirements With Natural Resources		Labor Requirements With Natural Resources			Capital Requirements Without Natural Resources		Labor Requirements Without Natural Resources	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports
1968	138,111	136,354	277,479	307,167	**1968**	138,111	136,354	277,479	307,167
1970	106,041	100,606	255,160	278,245	**1970**	105,348	100,660	287,050	291,707
1971	106,026	100,816	260,012	279,206	**1971**	105,169	100,901	294,305	293,129
1972	106,109	101,612	265,392	281,115	**1972**	105,060	101,524	298,079	295,172
1973	105,738	101,709	268,402	277,381	**1973**	105,628	102,053	301,640	292,881
1974	105,403	103,377	259,768	271,362	**1974**	107,421	105,512	292,685	290,889
1975	104,782	102,655	262,046	277,758	**1975**	104,962	104,146	295,841	296,864
1976	104,244	103,825	264,746	276,285	**1976**	105,497	105,777	296,101	295,694
1977	104,466	104,897	267,206	277,629	**1977**	105,029	106,575	296,143	295,527
1978	104,327	105,737	271,816	275,920	**1978**	103,676	106,862	298,068	293,339
1979	87,962	84,538	245,118	249,365	**1979**	80,324	77,959	269,777	266,796
1980	85,671	84,536	242,865	246,198	**1980**	77,630	77,584	266,129	265,076
1981	93,629	86,037	250,918	247,949	**1981**	87,073	78,845	280,000	268,817
1982	96,087	88,786	255,240	250,728	**1982**	90,404	82,013	284,264	272,454
1983	99,963	94,528	260,530	251,967	**1983**	96,108	88,474	287,710	275,365
1984	90,016	91,729	257,845	265,755	**1984**	84,286	86,501	285,237	287,384
1985	89,394	93,187	262,239	264,377	**1985**	84,061	88,066	286,799	286,719
1986	87,748	91,713	270,687	270,997	**1986**	83,657	87,400	287,792	287,431
1987	87,836	90,804	273,942	278,277	**1987**	84,308	86,848	289,333	293,035
1988	85,755	90,746	277,046	276,973	**1988**	82,409	86,955	290,042	290,209
1989	86,373	89,256	276,028	278,068	**1989**	83,022	85,217	289,008	292,012
1990	61,677	72,441	241,224	236,647	**1990**	62,659	71,428	243,211	241,387
1991	59,414	71,138	242,899	237,219	**1991**	59,972	69,848	245,083	242,476
1992	57,870	69,612	244,217	238,651	**1992**	58,497	68,674	245,992	243,363
1993	56,224	69,544	242,873	234,802	**1993**	56,596	68,146	244,292	239,787
1994	57,791	67,181	240,774	233,122	**1994**	58,736	66,017	241,089	236,528
1995	56,964	66,032	239,688	234,991	**1995**	57,624	65,081	239,766	237,611
1996	58,719	68,226	238,702	233,842	**1996**	59,520	67,274	238,926	236,775

Graph 20: United Kingdom - Capital and Labor Requirements With Natural Resources at Constant Prices Per Million British Pounds for Imports and Exports



Graph 21: United Kingdom - Capital and Labor Requirements Without Natural Resources at Constant Prices Per Million British Pounds for Imports and Exports



Labor and capital requirements per one million pounds of goods have decreased throughout the period studied. In 1968 we required capital in the amount of 138,111 of British pounds for the production of one million British pounds worth of goods to be imported, whereas, in 1996, we needed less than half of the initial amount, namely 58,719 British pounds. Respectively, we required capital in the amount of 136,354 British pounds for exports in 1968 and 68,226 British pounds in 1996. Therefore the amount of capital needed for both import substitutes and exports decreased by more than half whereas the amount of labor decreased by one fourth of the initial investment.

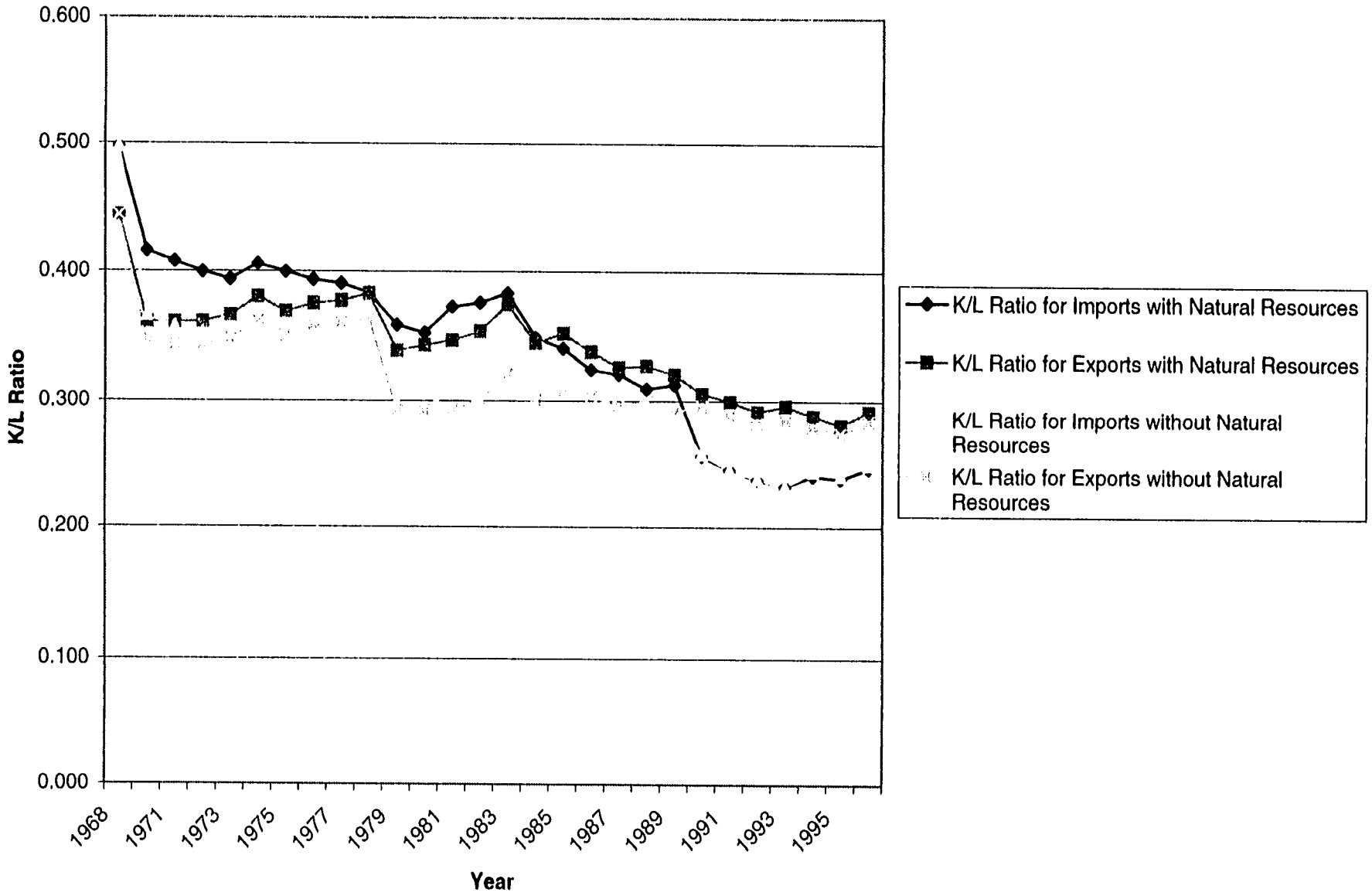
Upon the elimination of natural resource intensive industries no major changes occurred. The capital requirements for both import substitutes and exports halved during our period of study whereas the labor requirements decreased only somewhat.

In order to better understand the evolution of capital and labor requirements we need to consider the relative behavior of these variables and contrast import substitutes with exports. The capital and labor ratios are illustrated in table 36. Graph 22 helps us visualize the evolution pattern of these variables.

Table 36: United Kingdom - Capital/Labor Ratios at Current and Constant Prices

	Capital/Labor Ratios at Constant Prices					Capital/Labor Ratios at Current Prices					Leontief Ratio	
	With Natural Resources		Without Natural Resources			With Natural Resources		Without Natural Resources			at Constant Prices	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports			
1968	0.498	0.444	0.498	0.444	1968	0.498	0.444	0.498	0.444	1968	1.12	1.12
1970	0.416	0.362	0.367	0.345	1970	0.418	0.358	0.365	0.339	1970	1.15	1.06
1971	0.408	0.361	0.357	0.344	1971	0.410	0.357	0.355	0.338	1971	1.13	1.04
1972	0.400	0.361	0.352	0.344	1972	0.401	0.357	0.350	0.338	1972	1.11	1.02
1973	0.394	0.367	0.350	0.348	1973	0.396	0.363	0.349	0.343	1973	1.07	1.00
1974	0.406	0.381	0.367	0.363	1974	0.408	0.378	0.365	0.356	1974	1.07	1.01
1975	0.400	0.370	0.355	0.351	1975	0.402	0.366	0.352	0.344	1975	1.08	1.01
1976	0.394	0.376	0.356	0.358	1976	0.396	0.374	0.353	0.352	1976	1.05	1.00
1977	0.391	0.378	0.355	0.361	1977	0.382	0.379	0.343	0.357	1977	1.03	0.98
1978	0.384	0.383	0.348	0.364	1978	0.382	0.379	0.343	0.357	1978	1.00	0.95
1979	0.359	0.339	0.298	0.292	1979	0.300	0.282	0.234	0.234	1979	1.06	1.02
1980	0.353	0.343	0.292	0.293	1980	0.294	0.286	0.228	0.234	1980	1.03	1.00
1981	0.373	0.347	0.311	0.293	1981	0.313	0.290	0.243	0.235	1981	1.08	1.06
1982	0.376	0.354	0.318	0.301	1982	0.313	0.293	0.246	0.236	1982	1.06	1.06
1983	0.384	0.375	0.334	0.321	1983	0.314	0.306	0.254	0.247	1983	1.02	1.04
1984	0.349	0.345	0.295	0.301	1984	0.347	0.346	0.300	0.306	1984	1.01	0.98
1985	0.341	0.352	0.293	0.307	1985	0.340	0.352	0.298	0.313	1985	0.97	0.95
1986	0.324	0.338	0.291	0.304	1986	0.325	0.340	0.295	0.309	1986	0.96	0.96
1987	0.321	0.326	0.291	0.296	1987	0.322	0.330	0.296	0.303	1987	0.98	0.98
1988	0.310	0.328	0.284	0.300	1988	0.311	0.331	0.289	0.305	1988	0.94	0.95
1989	0.313	0.321	0.287	0.292	1989	0.315	0.324	0.292	0.297	1989	0.97	0.98
1990	0.256	0.306	0.258	0.296	1990	0.268	0.312	0.268	0.312	1990	0.84	0.87
1991	0.245	0.300	0.245	0.288	1991	0.256	0.307	0.256	0.307	1991	0.82	0.85
1992	0.237	0.292	0.238	0.282	1992	0.249	0.298	0.249	0.298	1992	0.81	0.84
1993	0.231	0.296	0.232	0.284	1993	0.247	0.308	0.247	0.308	1993	0.78	0.82
1994	0.240	0.288	0.244	0.279	1994	0.258	0.301	0.258	0.301	1994	0.83	0.87
1995	0.238	0.281	0.240	0.274	1995	0.258	0.297	0.258	0.297	1995	0.85	0.88
1996	0.246	0.292	0.249	0.284	1996	0.267	0.308	0.267	0.308	1996	0.84	0.88

Graph 22: United Kingdom - Capital/Labor Ratios at Constant Prices



The capital-labor ratios for import substitutes and exports reduce from approximately 0.5 to nearly 0.25. Even upon the removal of natural resource intensive industries our ratios remain more or less unchanged.

The reduction in the amount of capital used in the production of goods for exports and import substitutes could be attributed to the increased efficiency across the industries. A closer look at the Leontief ratios helps us confirm the validity of the Heckscher-Ohlin theory with and without natural resource intensive industries during 1968-1984. After 1985 the ratios reduce below one, which indicates the presence of factor intensity reversal.

In order to statistically validate our findings, we employed the delta method. Table 37 presents our results which illustrate the presence of factor intensity reversal by comparing the Leontief ratio at the ten percent confidence level interval obtained with and without natural resource intensive industries. Since England is a labor abundant nation, the Leontief ratio should be above one. Upon the implementation of the delta method, the Leontief ratios should be higher than the results of the upper limit. According to the statistical method implemented the theory cannot be confirmed. It is important to note that when the traditional Leontief approach is implemented the Heckscher-Ohlin theory is confirmed for the period 1968-1984.

Table 37: Delta Method for the United Kingdom

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Upper Limit	Lower Limit	Ratio	Conclusion	Upper Limit	Lower Limit	Ratio	Conclusion
Labor	1968	1.38	0.62	1.12	UNDETERMINED				
Labor	1969								
Labor	1970	1.16	0.84	1.15	UNDETERMINED	1.09	0.91	1.09	UNDETERMINED
Labor	1971	1.15	0.85	1.13	UNDETERMINED	1.09	0.91	1.07	UNDETERMINED
Labor	1972	1.14	0.86	1.11	UNDETERMINED	1.06	0.94	1.04	UNDETERMINED
Labor	1973	1.13	0.87	1.07	UNDETERMINED	1.05	0.95	1.02	UNDETERMINED
Labor	1974	1.12	0.88	1.07	UNDETERMINED	1.06	0.94	1.03	UNDETERMINED
Labor	1975	1.13	0.88	1.08	UNDETERMINED	1.06	0.94	1.02	UNDETERMINED
Labor	1976	1.10	0.90	1.05	UNDETERMINED	1.05	0.95	1.01	UNDETERMINED
Labor	1977	1.09	0.91	1.03	UNDETERMINED	1.04	0.96	0.99	FIR
Labor	1978	1.09	0.91	1.00	UNDETERMINED	1.04	0.96	0.97	FIR
Labor	1979	1.10	0.90	1.06	UNDETERMINED	1.09	0.91	1.02	UNDETERMINED
Labor	1980	1.10	0.90	1.03	UNDETERMINED	1.09	0.91	1.00	UNDETERMINED
Labor	1981	1.12	0.88	1.08	UNDETERMINED	1.13	0.87	1.06	UNDETERMINED
Labor	1982	1.12	0.88	1.06	UNDETERMINED	1.13	0.87	1.06	UNDETERMINED
Labor	1983	1.12	0.88	1.02	UNDETERMINED	1.12	0.88	1.04	UNDETERMINED
Labor	1984	1.12	0.88	1.01	UNDETERMINED	1.10	0.90	0.98	FIR
Labor	1985	1.11	0.89	0.97	FIR	1.09	0.91	0.95	FIR
Labor	1986	1.03	0.87	0.96	FIR	1.11	0.89	0.96	FIR
Labor	1987	1.12	0.88	0.98	FIR	1.10	0.90	0.98	FIR
Labor	1988	1.11	0.89	0.94	FIR	1.09	0.91	0.95	FIR
Labor	1989	1.13	0.87	0.97	FIR	1.12	0.88	0.98	FIR
Labor	1990	1.11	0.89	0.84	FIR	1.09	0.91	0.87	FIR
Labor	1991	1.12	0.88	0.82	FIR	1.13	0.87	0.85	FIR
Labor	1992	1.13	0.87	0.81	FIR	1.13	0.87	0.84	FIR
Labor	1993	1.13	0.87	0.78	FIR	1.13	0.87	0.82	FIR
Labor	1994	1.13	0.88	0.83	FIR	1.12	0.88	0.87	FIR
Labor	1995	1.11	0.89	0.85	FIR	1.11	0.89	0.88	FIR
Labor	1996	1.12	0.88	0.84	FIR	1.12	0.88	0.88	FIR

UNITED STATES – COMMENTS AND RESULTS

United States is the leading country of the world in the production of manufactured and agricultural products. Other countries are larger than the United States in both area and population, but the U.S. alone produces more than twenty-five percent of the total world output of goods and services.

There are many reasons why the United States became the leading commercial country of the world. A few however are outstandingly important. The abundance of resources within the United States borders – fertile land, fuel, mining and hydroelectric power – made possible the rapid growth of the U.S. industry. The development of excellent transportation, especially railroads, made it easy to bring raw materials together to make products. A free enterprise system of trade encouraged the growth of business and industry.

The U.S. manufacturing industries produce almost twice as much as the next largest economic group. The largest of the many kinds of industries are those that produce processed foods, primary metals, machinery, transportation equipment, chemicals and clothing.

The U.S. uses tremendous amounts of power to run its industries and provide heat and light for homes. Most of the power used in the U.S. manufacturing sector comes from such fuels as petroleum, natural gas and coal. Until the 1950s, coal was the leading source of energy. It has been surpassed, however, by both petroleum and natural gas.

United States farmers produce more food than the country can consume. Surplus agricultural products are exported to other countries or are stored by the government. Industry has surpassed agriculture in the value of production, but agricultural production has increased steadily.

The U. S. is the world's leading exporter and importer. The leading export group is machinery of all types. Other major exports include but are not limited to: food, paper products, chemical products, industrial chemicals, basic metal industries, iron and steel, fabricated metal products, non-electrical machinery and textiles. Leading imports include fuels, products of tropical agriculture and raw or semi-manufactured materials. Other imported items include petroleum, coffee and sugar cane, some chemical products, fabricated metal and transport equipment.

The U. S. carries on most foreign trade with neighboring countries in the western hemisphere. Canada is perhaps the most important trade partner, then Latin America and Western European countries.

For the purposes of our study, the U. S. is classified as a capital abundant nation during 1968 – 1976, and as a labor abundant nation during 1978-1981 and 1989-1996. It is important to mention that our classification of a capital abundant nation during the period indicated coincides with the description provided above. With respect to the evolution toward a labor abundant nation during the latter part of the 1970s and early part of the 1990s, a more in-depth explanation is necessary.

The U. S. has gone through major transformations during the twentieth century: from an agricultural society it has moved quite rapidly to an industrial society, to a

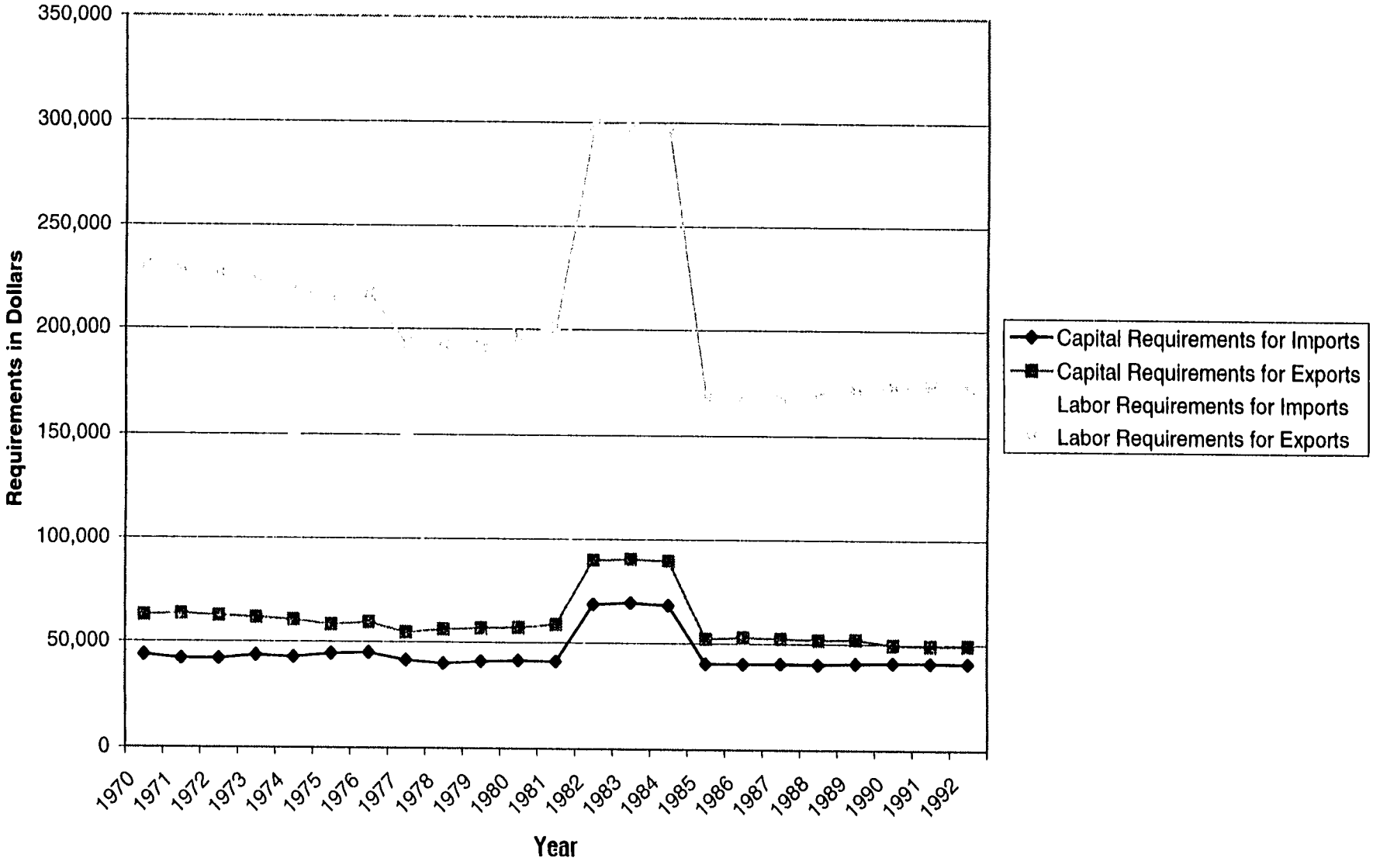
service provider nation and currently to a technology driven economy. Our classification of the U. S. as a labor abundant nation can be supported by the mere fact that the country has relied heavily on the provision of services over the last ten to twenty years. The provision of services involves a great deal of labor, but a very highly skilled labor. Most importantly the employment of human capital played a large role in the latter part of the twentieth century.

Upon the implementation of the Gauss programs created for each of the input-output tables, namely 1972, 1977, 1982, 1985 and 1990, we obtained values the net capital and labor requirements per million $US of exports and competitive imports. These values were obtained at constant prices with and without natural resource intensive sectors of the economy. Table 38 illustrates our findings. Graphical representations are illustrated in graphs 23 and 24.

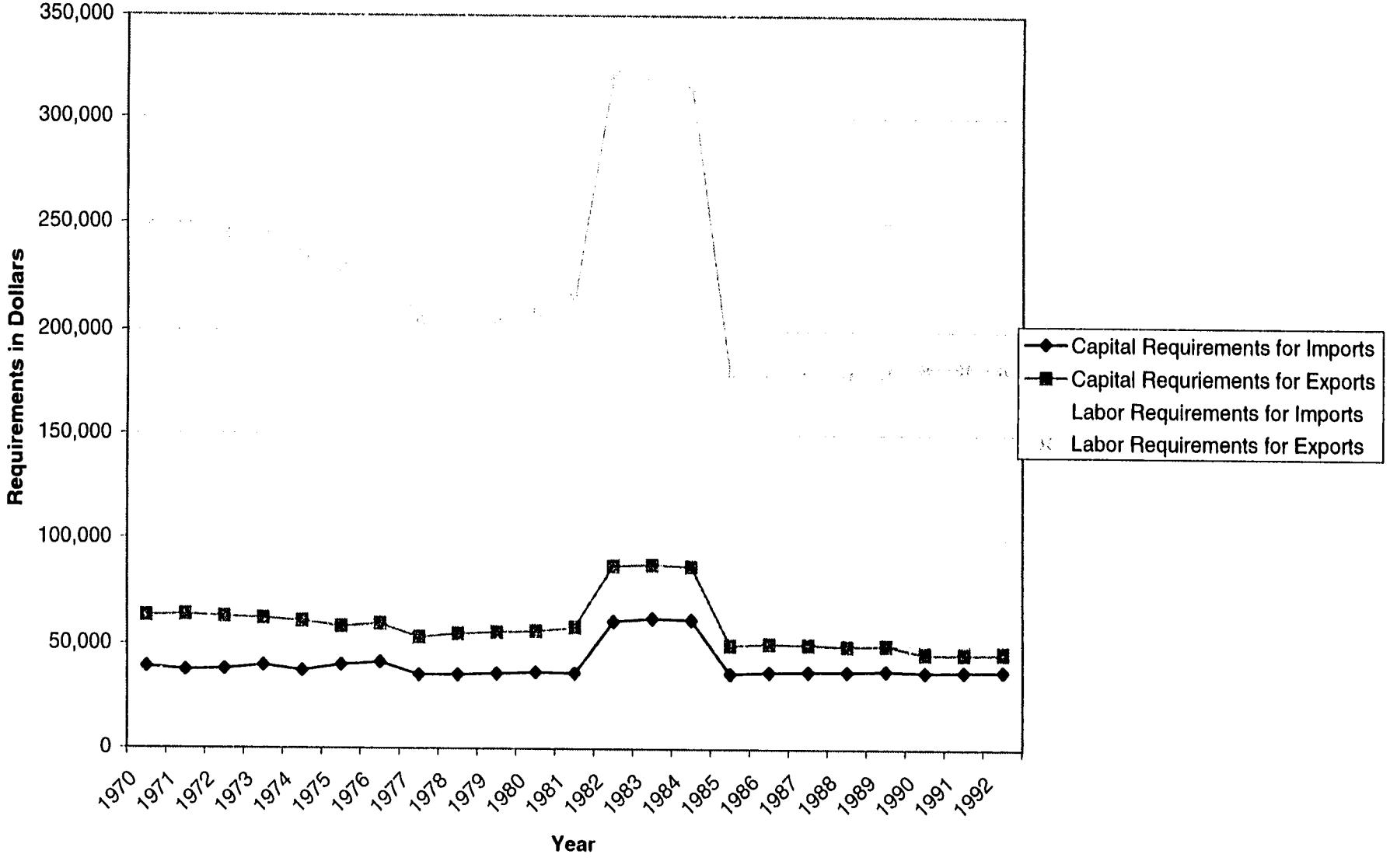
Table 38: United States - Net Capital and Labor Requirements per Million U.S. Dollars of Exports and Imports at Constant Prices

	Capital Requirements With Natural Resources		Labor Requirements With Natural Resources			Capital Requirements Without Natural Resources		Labor Requirements Without Natural Resources	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports
1970	43,849	62,825	162,697	229,789	**1970**	39,259	63,051	187,199	248,514
1971	42,021	63,416	161,705	227,707	**1971**	37,632	63,659	183,619	246,359
1972	42,003	62,516	165,295	226,478	**1972**	38,185	62,754	187,108	244,808
1973	43,724	61,715	166,800	223,824	**1973**	39,987	61,868	193,625	243,349
1974	42,754	60,636	153,112	219,060	**1974**	37,436	60,593	186,106	236,165
1975	44,561	58,395	160,287	214,850	**1975**	40,245	58,192	190,565	229,140
1976	44,946	59,549	168,518	216,917	**1976**	41,536	59,524	196,205	232,611
1977	41,467	54,748	152,010	192,789	**1977**	35,434	53,217	173,634	205,648
1978	39,956	56,326	155,085	192,347	**1978**	35,531	54,828	171,482	205,417
1979	40,957	56,985	153,609	191,970	**1979**	36,132	55,683	172,751	204,746
1980	41,508	57,337	155,853	196,897	**1980**	36,714	56,189	175,870	209,872
1981	41,074	58,840	159,087	200,978	**1981**	36,362	57,893	179,529	215,192
1982	68,511	89,808	271,826	299,553	**1982**	60,638	86,877	303,397	321,547
1983	69,358	90,284	269,732	297,969	**1983**	62,109	87,409	299,804	318,937
1984	68,200	89,519	275,226	295,935	**1984**	61,465	86,648	303,412	314,858
1985	40,367	52,406	159,565	168,720	**1985**	36,180	49,786	171,707	178,711
1986	40,308	53,075	161,673	169,563	**1986**	36,942	50,511	170,420	179,069
1987	40,527	52,547	161,879	169,086	**1987**	37,308	50,047	170,184	177,994
1988	40,278	51,986	164,049	170,269	**1988**	37,267	49,422	171,903	178,814
1989	40,719	52,282	163,570	172,140	**1989**	37,803	49,857	171,541	181,018
1990	41,025	49,660	168,221	173,752	**1990**	37,117	46,022	178,178	182,751
1991	40,941	49,378	168,776	174,139	**1991**	37,367	45,915	177,292	182,732
1992	40,861	49,565	168,971	174,304	**1992**	37,586	46,082	176,554	182,764

Graph 23: United States - Capital and Labor Requirements with Natural Resources at Constant Prices Per Million US Dollars for Imports and Exports



Graph 24: United States - Capital and Labor Requirements without Natural Resources at Constant Prices Per Million US Dollars for Imports and Exports



Data illustrated in table 38 indicates that the amount of capital used in the production of both imports and exports has decreased over the period studied, most noticeably for exports. During the period of our study the labor requirements used in the production of goods has decreased for exports and increased for imports.

Evident changes in the capital and labor requirements are caused by the use of a different input-output table, particularly in 1977, 1982, 1985 and 1990. The input-output table shows the direct input requirements of each industry for the products generated by other industries. Periodic updates and continuous progress in an economy are accounted for in every input-output table.

It is also immediately apparent that the labor requirements for exports are higher than all the other requirements over the period studied. For exports, there is over the years a tendency for the capital and labor requirements to decrease. With respect to imports, labor requirements have increased whereas capital has decreased only slightly.

One of the attempts to solve the Leontief paradox relied upon the elimination of natural resource intensive industries since they were considered the third factor of production. Since our study takes this hypothesis into consideration, all analyses are performed with and without natural resource intensive sectors of the economy. In the case of the United States the exclusion of natural resources leads to an increase in labor requirements for exports and competitive imports. Additionally, the capital requirements for import substitutes decrease.

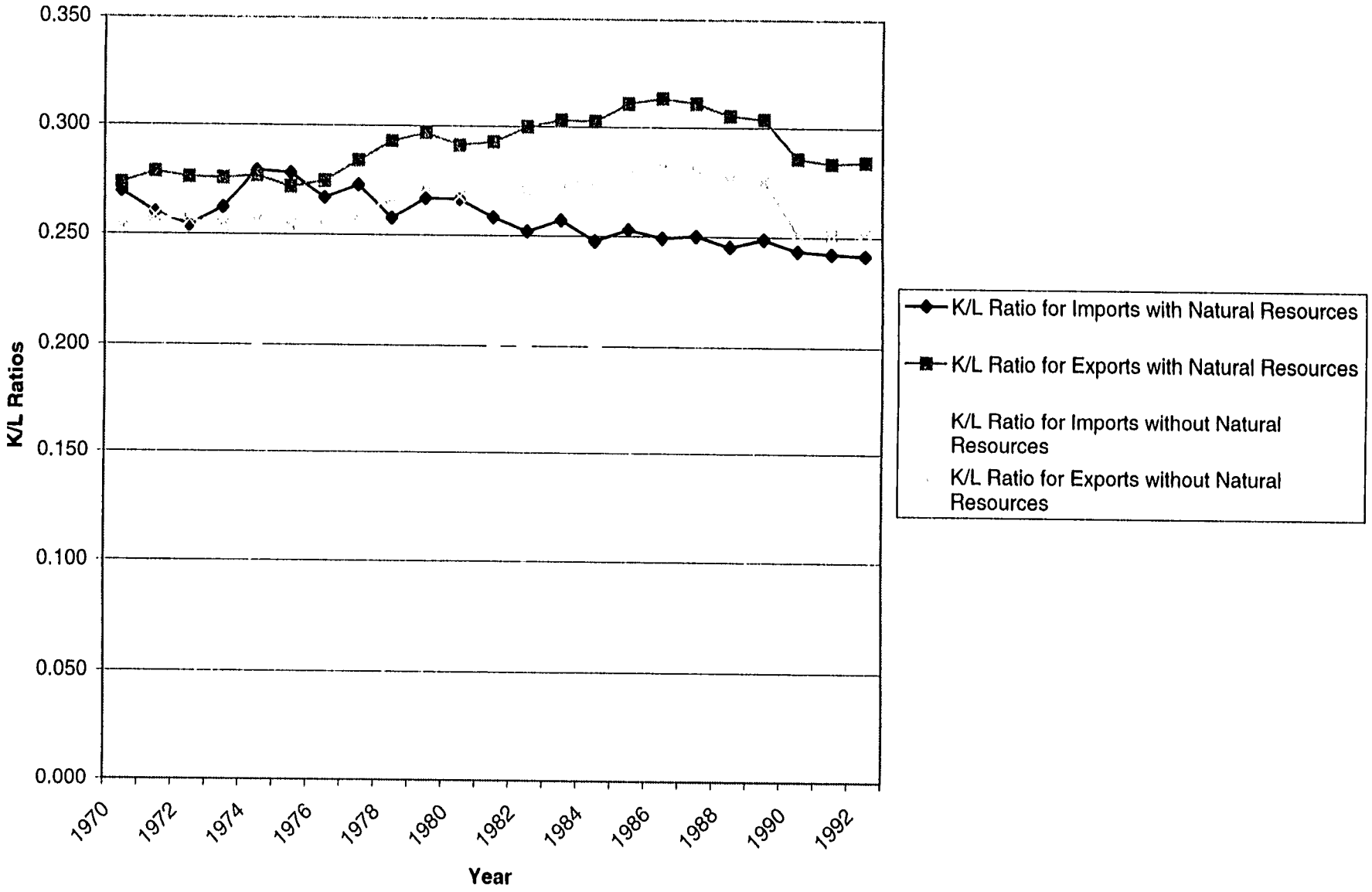
In order to better understand the evolution of capital and labor requirements we need to consider the relative behavior of the capital-labor ratios. Table 39 illustrates the

changes that occurred during the period of our study. A visual representation of our findings is available in graph 25.

Table 39: United States - Capital/Labor Ratios at Current and Constant Prices

	Capital/Labor Ratio at Constant Prices					Capital/Labor Ratio at Current Prices					Leontief Ratio	
	With Natural Resources		Without Natural Resources			With Natural Resources		Without Natural Resources			At Constant Prices	
											With and Without Natural Resource Intensive Industries	
	Imports	Exports	Imports	Exports		Imports	Exports	Imports	Exports			
1970	0.270	0.273	0.210	0.254	1970	0.305	0.298	0.217	0.268	1970	0.99	0.83
1971	0.260	0.278	0.205	0.258	1971	0.293	0.303	0.211	0.274	1971	0.93	0.79
1972	0.254	0.276	0.204	0.256	1972	0.286	0.300	0.211	0.272	1972	0.92	0.80
1973	0.262	0.276	0.207	0.254	1973	0.305	0.300	0.214	0.270	1973	0.95	0.81
1974	0.279	0.277	0.201	0.257	1974	0.351	0.300	0.208	0.272	1974	1.01	0.78
1975	0.278	0.272	0.211	0.254	1975	0.338	0.292	0.219	0.267	1975	1.02	0.83
1976	0.267	0.275	0.212	0.256	1976	0.320	0.297	0.223	0.271	1976	0.97	0.83
1977	0.273	0.284	0.204	0.259	1977	0.293	0.293	0.211	0.266	1977	0.96	0.79
1978	0.258	0.293	0.207	0.267	1978	0.274	0.302	0.214	0.274	1978	0.88	0.78
1979	0.267	0.297	0.209	0.272	1979	0.286	0.308	0.216	0.280	1979	0.90	0.77
1980	0.266	0.291	0.209	0.268	1980	0.286	0.302	0.216	0.276	1980	0.91	0.78
1981	0.258	0.293	0.203	0.269	1981	0.277	0.304	0.209	0.277	1981	0.88	0.75
1982	0.252	0.300	0.200	0.270	1982	0.252	0.300	0.200	0.270	1982	0.84	0.74
1983	0.257	0.303	0.207	0.274	1983	0.257	0.303	0.207	0.274	1983	0.85	0.76
1984	0.248	0.302	0.203	0.275	1984	0.248	0.302	0.203	0.275	1984	0.82	0.74
1985	0.253	0.311	0.211	0.279	1985	0.257	0.311	0.211	0.278	1985	0.81	0.76
1986	0.249	0.313	0.217	0.282	1986	0.252	0.313	0.217	0.282	1986	0.80	0.77
1987	0.250	0.311	0.219	0.281	1987	0.253	0.311	0.219	0.281	1987	0.81	0.78
1988	0.246	0.305	0.217	0.276	1988	0.247	0.305	0.217	0.276	1988	0.80	0.78
1989	0.249	0.304	0.220	0.275	1989	0.251	0.304	0.220	0.275	1989	0.82	0.80
1990	0.244	0.286	0.208	0.252	1990	0.246	0.282	0.207	0.248	1990	0.85	0.83
1991	0.243	0.284	0.211	0.251	1991	0.243	0.280	0.209	0.248	1991	0.86	0.84
1992	0.242	0.284	0.213	0.252	1992	0.241	0.280	0.211	0.248	1992	0.85	0.84

Graph 25: United States - Capital/Labor Ratios at Constant Prices



Having obtained the Leontief ratios the Heckscher-Ohlin theory is confirmed during the period 1970-1973 and 1976. Years 1977 and 1982-1988 are inconclusive which unable us to make any calculations. When natural resource intensive industries are removed, the Heckscher-Ohlin theory is verified during the period 1970-1976. Upon the implementation of the delta method the theory is challenged during the period 1978-1981 and 1989-1992. Table 40 exemplifies the validity of the theory during the period 1970-1976.

For the period 1978-1981 and 1989-1992 the United States is listed as a labor abundant nation where despite the high productivity compared with foreign competition, labor plays an important role in the determination of the composition of those U.S. exports and competitive imports. One argument in the substantial employment of labor in the U. S. economy is due to the provision of services that are actually securing human capital, which does not reflect the provision of capital that goes into it.

Table 40: Delta Method for the United States

Capital/Labor Abundant Nation	Year	With Natural Resources				Without Natural Resources			
		Lower Limit Upper Limit	Upper Limit Lower Limit	Ratio	Conclusion	Lower Limit Upper Limit	Upper Limit Lower Limit	Ratio	Conclusion
Capital	1970	0.76	1.24	0.99	UNDETERMINED	0.84	1.16	0.83	NO FIR
Capital	1971	0.77	1.23	0.93	UNDETERMINED	0.82	1.18	0.79	NO FIR
Capital	1972	0.79	1.21	0.92	UNDETERMINED	0.84	1.16	0.80	NO FIR
Capital	1973	0.79	1.21	0.95	UNDETERMINED	0.85	1.15	0.81	NO FIR
Capital	1974	0.71	1.30	1.01	FIR	0.82	1.18	0.78	NO FIR
Capital	1975	0.74	1.26	1.02	FIR	0.84	1.16	0.83	NO FIR
Capital	1976	0.77	1.23	0.97	UNDETERMINED	0.84	1.16	0.83	NO FIR
Inconclusive	1977								
Labor	1978	1.22	0.78	0.88	FIR	1.18	0.82	0.78	FIR
Labor	1979	1.23	0.77	0.90	FIR	1.18	0.82	0.77	FIR
Labor	1980	1.24	0.76	0.91	FIR	1.17	0.83	0.78	FIR
Labor	1981	1.24	0.75	0.88	FIR	1.19	0.81	0.75	FIR
Inconclusive	1982								
Inconclusive	1983								
Inconclusive	1984								
Inconclusive	1985								
Inconclusive	1986								
Inconclusive	1987								
Inconclusive	1988								
Labor	1989	1.15	0.85	0.82	FIR	1.14	0.86	0.80	FIR
Labor	1990	1.14	0.86	0.85	FIR	1.13	0.87	0.83	FIR
Labor	1991	1.13	0.87	0.86	FIR	1.12	0.88	0.84	FIR
Labor	1992	1.12	0.88	0.85	FIR	1.12	0.88	0.84	FIR

COUNTRY SUMMARY

The purpose of this section is to summarize the results obtained for each of the countries analyzed. Tables 41 and 42 contain a synthetic summary of the approach undertaken in this chapter.

Table 41: Capital-Labor Ratios With Natural Resource Intensive Industries

	Australia	Canada	Denmark	France	Germany	Italy	Japan	U.K.	U.S.
1970	**0.61**	**0.91**		*1.10*		*1.01*	*1.22*	*1.15*	**0.99**
1971	**0.62**	**0.92**		*1.06*		*1.02*	*1.24*	*1.13*	**0.93**
1972	**0.62**	**0.95**		*1.07*		*1.03*	*1.21*	*1.11*	**0.92**
1973	**0.62**	**0.95**		*1.06*		*1.05*	*1.14*	*1.07*	**0.95**
1974	**0.52**	**0.96**		*1.04*		*1.03*	*1.17*	*1.07*	**1.01**
1975	**0.49**	**0.96**		*1.10*		*1.03*	*1.23*	*1.08*	**1.02**
1976	**0.48**	**0.99**	*0.83*			*1.03*	*1.22*	*1.05*	**0.97**
1977	**0.49**	**1.00**	*0.84*	**1.13**		*1.04*	*1.23*	*1.03*	
1978	**0.49**	**0.97**		**1.08**	**1.24**	*1.01*	*1.16*	*1.00*	*0.88*
1979	**0.49**	**0.95**		**1.09**	**1.18**	*0.99*	*1.12*	*1.06*	*0.90*
1980	**0.50**	**0.95**		**1.05**	**1.18**	*0.99*	*1.13*	*1.03*	*0.91*
1981	**0.49**	**0.95**		**1.05**	**1.16**	*1.00*	*1.16*	*1.08*	*0.88*
1982	**0.47**	**0.99**	*0.94*	**1.03**	**1.13**	*1.01*	*1.16*	*1.06*	
1983	**0.47**	**1.02**	*0.98*	**1.05**	**1.11**	*1.03*	*1.14*	*1.02*	
1984	**0.48**	**1.02**	*0.94*	**1.05**	**1.10**	*1.01*	*1.11*	*1.01*	
1985	**0.48**	**1.02**	*0.94*	**1.09**	**1.07**	*1.01*	*1.17*	*0.97*	
1986	**0.61**	**0.96**	*0.88*	**1.08**	**1.28**	*1.00*	*1.14*	*0.96*	
1987	**0.63**	**0.95**	*0.89*	**1.05**	**1.27**	*0.99*	*1.09*	*0.98*	
1988	**0.67**	**0.92**	*0.91*	**1.06**	**1.18**	*0.98*	*1.06*	*0.94*	
1989	**0.68**	**0.95**	*0.88*	**1.05**	**1.17**	*0.98*		*0.97*	*0.82*
1990	**0.69**	**0.99**	*0.90*		**1.14**	*0.98*	**1.00**	*0.84*	*0.85*
1991	**0.71**	**1.00**	*0.89*		**1.11**	*0.98*	**1.01**	*0.82*	*0.86*
1992	**0.74**	**1.02**	*0.90*		**1.12**	*0.97*	**1.01**	*0.81*	*0.85*
1993	**0.78**	**1.04**	*0.90*		**1.12**	*1.00*	**1.00**	*0.78*	
1994	**0.77**	**1.05**	*0.89*		**1.13**	*1.00*	**1.00**	*0.83*	
1995	**0.78**	**1.03**	*0.89*		**1.13**	*1.00*	**1.00**	*0.85*	
1996	**0.78**	**1.06**	*0.88*		**1.12**	*1.01*	**0.99**	*0.84*	

Table 42: Capital-Labor Ratios Without Natural Resource Intensive Industries

	Australia	Canada	Denmark	France	Germany	Italy	Japan	U.K.	U.S.
1970	**0.64**	**0.89**		*1.10*		*0.95*	*1.24*	*1.06*	**0.83**
1971	**0.66**	**0.90**		*1.09*		*0.95*	*1.26*	*1.04*	**0.79**
1972	**0.66**	**0.92**		*1.10*		*0.96*	*1.23*	*1.02*	**0.80**
1973	**0.69**	**0.92**		*1.09*		*0.97*	*1.15*	*1.00*	**0.81**
1974	**0.63**	**0.93**		*1.06*		*0.97*	*1.18*	*1.01*	**0.78**
1975	**0.59**	**0.94**		*1.11*		*0.95*	*1.03*	*1.01*	**0.83**
1976	**0.59**	**0.95**	*0.99*			*0.96*	*1.02*	*1.00*	**0.83**
1977	**0.59**	**0.96**	*0.97*	**1.11**		*0.96*	*1.03*	*0.98*	
1978	**0.60**	**0.94**		**1.08**	**1.06**	*0.95*	*0.96*	*0.95*	*0.78*
1979	**0.60**	**0.93**		**1.10**	**1.02**	*0.94*	*0.93*	*1.02*	*0.77*
1980	**0.57**	**0.94**		**1.08**	**1.03**	*0.94*	*1.00*	*1.00*	*0.78*
1981	**0.56**	**0.92**		**1.10**	**1.01**	*0.96*	*1.01*	*1.06*	*0.75*
1982	**0.53**	**0.96**	*0.97*	**1.08**	**0.97**	*0.95*	*1.02*	*1.06*	
1983	**0.53**	**0.98**	*1.11*	**1.09**	**0.96**	*0.96*	*1.01*	*1.04*	
1984	**0.52**	**0.98**	*1.05*	**1.10**	**0.96**	*0.95*	*0.99*	*0.98*	
1985	**0.52**	**0.98**	*1.08*	**1.14**	**0.93**	*0.95*	*1.05*	*0.95*	
1986	**0.64**	**0.95**	*1.02*	**1.13**	**1.21**	*0.94*	*1.03*	*0.96*	
1987	**0.67**	**0.95**	*1.03*	**1.10**	**1.22**	*0.94*	*0.99*	*0.98*	
1988	**0.74**	**0.91**	*1.04*	**1.12**	**1.17**	*0.95*	*0.96*	*0.95*	
1989	**0.70**	**0.94**	*1.00*	**1.12**	**1.17**	*0.94*		*0.98*	*0.80*
1990	**0.72**	**0.95**	*1.01*		**1.06**	*0.94*	**0.97**	*0.87*	*0.83*
1991	**0.74**	**0.96**	*1.00*		**1.04**	*0.94*	**0.98**	*0.85*	*0.84*
1992	**0.78**	**0.97**	*1.00*		**1.04**	*0.94*	**0.98**	*0.84*	*0.84*
1993	**0.83**	**0.99**	*1.00*		**1.04**	*0.96*	**0.98**	*0.82*	
1994	**0.83**	**0.98**	*0.99*		**1.04**	*0.97*	**0.97**	*0.87*	
1995	**0.82**	**0.98**	*0.97*		**1.03**	*0.98*	**0.98**	*0.88*	
1996	**0.83**	**1.00**	*0.95*		**1.03**	*0.98*	**0.98**	*0.88*	

Values in bold are representative of a capital abundant nation whereas values in italics are representative of a labor abundant nation. The ratios are not reported for the years in which the utilization of the PWT led to inconclusive results. The highlighted areas represent years for which the Heckscher-Ohlin theory is validated by our analysis.

It appears that the presence of factor intensity reversal is less frequent than instances where the Heckscher-Ohlin theory is validated. The results improve upon the elimination of natural resource intensive industries for all nations with the exception of Italy.

CHAPTER 4: ANALYSIS OF FACTOR INTENSITY REVERSAL PER INDUSTRY

The previous chapter has made considerable analytical and empirical progress in proving that a simple two-factor (capital and labor) version of the Heckscher-Ohlin theory is adequate. Such assumptions of this traditional theory as identical production functions among countries for identical commodities, the homogeneity of labor supplies, constant returns to scale and the international immobility of productive factors seem to be sufficiently realistic in the actual world. Robert E. Baldwin acknowledged that the simple factor proportions theory has not been completely tested against the trade patterns of large numbers of countries. This study has accomplished this task and now the theory has been tested and the results have proven to be successful. In a world assumed to be composed of nine countries, with only one exception, that being Germany, the Heckscher-Ohlin theory has been validated for all or most of the years covered by our study.

Despite the positive results obtained from the previous approach, an alternative method to examine the Heckscher-Ohlin theory has been developed from Leontief's original approach. In the previous chapter a shortcoming that Leontief had to face was the unavailability of actual imports data distinguished by industry and country of origin. The solution consisted in the use of import substitutes.

This chapter deals with the development of an alternative method that does not involve the employment of import substitutes. As we know, factor intensity reversal is defined as the situation in which one good is capital intensive in one nation and labor

intensive in a different nation. If we can compare the factor intensity of each industry across nations, we can verify the Heckscher-Ohlin theory without using exports and import substitutes data. For example, assume that agriculture is labor intensive in Australia, Canada, Denmark and Italy and capital intensive in all the other nations. This is exactly the case depicted by the definition of factor intensity reversal. If this situation is common for most of the thirty-three industries studied, we can conclude that factor intensity reversal is a common situation for this group of countries and that the Heckscher-Ohlin theory is not an appropriate model to describe their evolution and pattern of trade.

It is well known that Heckscher-Ohlin theory does not hold when one good is capital intensive in one nation and labor intensive in the other nation. In the multi-country, multi-product case, the decision of factor intensity reversal is not straightforward and we use quantile ranges to categorize the degree of factor intensity for each industry. For this approach, we do not need to use the imports and exports data since this empirical verification is based only in comparing the industry production across nations without taking into account international trade. The only existent disadvantage of this approach is that we can only use the years in which the input-output tables are available. This approach is more realistic than the one used by Leontief because it involves the use of simultaneous input-output tables. We, then, compare the results obtained from the two methods.

Numerous economists have studied estimations of cross-country differences. These comparisons are another way to test the validity of the Heckscher-Ohlin theory. Usually the tool of analysis is multiple regression, with some measure of trade performance as the dependent variable and various characteristics of countries as the

explanatory variable. Examples of such studies include Chenery (1960), Chenery and Taylor (1968), Chenery and Syrquin (1975). Most of these studies dealt with more aggregate features of the economy, such as the ratio of gross imports to GNP, instead of the details of the structure of trade.

Minhas (1962) uses the constant elasticity of substitution ("CES") production function to examine both the empirical importance of factor intensity reversal and international differences in technology. He uses factor data on only labor and capital and claims to find factor intensity reversal as well as differences in technology.

Learner was amongst the first to study commodity composition questions, contrasting the performance of groups of variables as predictions of imports disaggregated by commodity.

This approach relies on few assumptions: (1) since labor and capital stock data are not available for several countries, we measure the labor and capital content of each industry instead of verifying the labor and capital content of competitive imports and exports, and (2) for each industry in the nation we obtain the capital-labor ratio in order to verify the existence of factor intensity reversal. By classifying these ratios we will be able to judge which industries within a nation are labor or capital intensive. By comparing capital or labor-intensive industries across nations we are depicting the frequency with which factor intensity reversal occurs. Another important assumption is that the production function is a Cobb-Douglas function with two factors, homogeneous of degree one. If this is the case the remuneration of the inputs is proportional to the quantity in which they are used to obtain the output (i.e., if 20% of capital is used, then

20% of the output will go to the remuneration of capital). A Cobb-Douglas production function of degree one is used in order to have constant returns to scale.

The approach is similar to the one previously implemented where we have the following notations:

$$O = \begin{bmatrix} O_1 \\ O_2 \\ . \\ . \\ O_n \end{bmatrix}$$ is an *n x 1* column vector of outputs of *n* industries of the economy;

$$A = \begin{bmatrix} a_{11} & . & . & a_{1n} \\ . & . & . & . \\ . & . & . & . \\ a_{n1} & . & . & a_{nn} \end{bmatrix}$$ is a square matrix (nxn) of input coefficients;

that is for $i = 1,2, \ldots, n$ and $j = 1, 2, \ldots n$; a_{ij} is the amount of industry i's product used by industry *j* per unit of output of industry *j*;

$K = [k_1 k_2 \ldots k_n]$ is a row vector (1xn) of capital coefficients.

$L = [l_1 l_2 \ldots l_n]$ is a row vector (1xn) of labor coefficients.

The capital and labor coefficients are calculated as follows:

$$k = k(O * I)^{-1} \quad (48)$$

$$l = l(O * I)^{-1} \quad (49)$$

where *I* is an identity matrix.

In order to calculate the capital and labor requirements for each industry we must use the following information:

$$kr = k * [I - A]^{-1} \tag{50}$$

$$lr = l * [I - A]^{-1} \tag{51}$$

where *kr* stands for capital requirements and *lr* stands for labor requirements.

In the previous program we calculated the following product

$$[k][I - A]^{-1}[b] \tag{52}$$

which gives capital requirements per million dollars of exports, and the product

$$[k][I - A]^{-1}[c] \tag{53}$$

which gives capital requirements per million dollars of competitive import replacements.

Labor requirements per million dollars of competitive import replacements and exports, were, of course, computed for the two systems by the same method, as were capital requirements.

With respect to the original Leontief approach the capital and labor requirements per industry are not multiplied by the vector of exports or import substitutes coefficients

and therefore they produce as a result a vector instead of a number. The previous result produced the value of capital and labor requirements for exports and import substitutes. In this approach the two expressions give as a result two vectors, containing the capital and labor requirements per industry. The multiplication with the import substitutes and exports was aggregating the requirements across industry for the nation considered.

Additionally we designed a program that assisted us in the verification of the factor intensity reversal that can occur in each industry. We implemented a procedure that identifies for each input-output matrix the capital or labor-intensive industries. The quantile levels of 40% and 60% are applied to the capital-labor ratios of each industry. The procedure locates all industries for each country whose percentages fall below 40% and identifies them as labor intensive. Correspondingly, the procedure locates all industries for each country whose percentages are higher than 60% and identifies them as capital intensive. For intermediate values, the result is undetermined. This procedure is implemented for each year for which the input-output tables are available.

If for an industry there are at least two countries for which the industry is labor intensive and at least two countries for which the same industry is capital intensive, then we conclude for the presence of factor intensity reversal in that particular industry. As we can see this approach is particularly restrictive given the fact that we are considering only nine countries. Therefore, if factor intensity reversal were rejected by this method, this test would be considered strong supporting evidence in favor of the Heckscher-Ohlin theory.

Table 43 illustrates the results obtained for 1970, 1975, 1980, 1985 and 1990 when measuring the labor and capital content of each of the thirty-three industries of the input-output tables used in our study.

Table 43: Presence of FIR in the 33 Industries Analyzed

Industry	Period				
	1970	1975	1980	1985	1990
Agriculture, forestry & fishing (1)					
Mining & quarrying (2)	FIR			FIR	FIR
Food, beverages & tobacco (3)					
Textiles, apparel & leather (4)					
Wood products & furniture (5)		FIR	FIR		
Paper, paper products & printing (6)	FIR	FIR	FIR	FIR	
Industrial chemicals (7)		FIR			
Drugs & medicines (8)					
Petroleum & coal products (9)					FIR
Rubber & plastic products (10)	FIR				
Non-metallic mineral products (11)					
Iron & steel (12)	FIR	FIR			FIR
Non-ferrous metals (13)		FIR			FIR
Metal products (14)					
Non-electrical machinery (15)					FIR
Office & computing machinery (16)			FIR		FIR
Electrical apparatus, nec (17)					FIR
Radio, TV & communication equipment (18)			FIR		FIR
Shipbuilding & repairing (19)					
Other transport (20)					
Motor vehicles (21)	FIR	FIR			
Aircraft (22)					
Professional goods (23)		FIR	FIR		
Other manufacturing (24)		FIR	FIR	FIR	FIR
Electricity, gas & water (25)					
Construction (26)	FIR			FIR	FIR
Wholesale & retail trade (27)				FIR	FIR
Restaurants & hotels (28)	FIR			FIR	FIR
Transport & storage (29)	FIR	FIR	FIR	FIR	
Communication (30)			FIR		
Finance & insurance (31)			FIR		FIR
Real estate & business services (32)					
Community, social & personal services (33)	FIR	FIR			FIR
Factor Intensity Reversal Occurrence	9	10	9	7	14

By looking at Table 43 we can notice that for each of the five periods analyzed, factor intensity reversal is found in the following number of industries:

- 1970 – FIR occurs in 9 industries;
- 1975 – FIR occurs in 10 industries;
- 1980 – FIR occurs in 9 industries;
- 1985 – FIR occurs in 7 industries; and
- 1990 – FIR occurs in 14 industries.

For four out of the five periods, less than one third of the industry grouping leads to the rejection of the Heckscher-Ohlin theory. For eleven industries out of the thirty-three included in the input-output tables used, we never detected the presence of factor intensity reversal in any of the years studied. This means that at all times one third of the economy was either capital or labor intensive across the nine countries for the twenty-seven year period studied.

The methodology employed sought to detect the presence of FIR based on the observations of the factor intensity across industries. If one industry is capital intensive for at least two countries and labor intensive for at least two other countries, our procedure detects the failure of the Heckscher-Ohlin theory. However, this methodology does not account for the fact that over time certain industries shift from labor intensive to capital intensive. It is natural to assume that this process will evolve gradually throughout all the nations. The problem here is that when an industry is changing the combination of the factors of production used, there will be a transitional period in which the industry is labor intensive in some countries and capital intensive in others. Even

though this will be considered as factor intensity reversal and counted as a rejection of the Heckscher-Ohlin theory, in reality it is just part of the evolution process of any industry. Only when factor intensity reversal occurs for the same industry throughout several periods can we be sure that it is not caused by changes of the factors of production in the respective industry.

Our analysis covers a period of twenty-seven years due to the availability of our input-output tables. If we consider agriculture, there has been a technology evolution since the seventies, which transformed the production processes of this industry: (i.e., use of more automated machinery led to the employment of less labor). We have seen that generally European countries lag behind in technological breakthrough. These developments for the most part took place first in the United States. During this intermediate period for the same industry, certain European countries may be showing a different capital-labor ratio than the United States. Even though this causes the factor intensity reversal to be detected for certain years, this is mainly the result of an evolution process. Once all countries will adopt the new technology, factor intensity reversal will be eliminated.

In addition, one industry can be capital intensive in one nation and labor intensive in another nation due to geographical, historical or technological reasons. The Heckscher-Ohlin theory was introduced and demonstrated mathematically in a two country, two goods framework. It has been shown that almost all the assumptions of this theory can be relaxed. This is certainly a positive aspect of the theory. In this study we are testing the Heckscher-Ohlin theory in a world of nine nations and thirty-three goods. It is not given that we can extend the theory to all the nations and all the goods. Therefore, obtaining factor intensity reversal across certain industries cannot necessarily

be interpreted as a rejection of the theory. If we consider, for example, industries such as 'other manufacturing' (industry number 24), 'construction' (industry number 26), 'wholesale and retail trade' (industry number 27), 'community, social and personal' (industry number 33) it would not be surprising to realize that each nation for a mixed number of reasons carry out these activities using more labor or capital. The difference could lie in the skilled and unskilled level of the workers employed in these industries and the effects they have on wage inequalities. Even the definition of the industry itself may lead to discrepancies across nations. To pretend that Heckscher-Ohlin theory is valid for all these industries would not be necessarily correct.

When we look at table 43, the industries just mentioned show factor intensity reversal. The results obtained from other industries may hide similar problems i.e., 'mining' (industry number 2), 'wood products and furniture' (industry number 5) and 'paper and paper products' (industry number 6).

To summarize the results of this approach we need to look at the persistence of factor intensity reversal across the period analyzed. If one industry shows continuous presence of factor intensity reversal, the issue highlighted when warning about the possible evolution of an industry does not hold. From table 43 we observe that only eight industries show factor intensity reversal for at least three of the five periods analyzed. After a careful look at these industries we notice that five of them are those for which the Heckscher-Ohlin theory may not apply as we have explained in the previous paragraphs. For the remaining five industries factor intensity reversal does not represent a rejection of the theory; it can merely depict the heterogeneity (historical, social, cultural or geographical) of these industries across nations. Even if we do not consider this aspect, factor intensity reversal is present in less than one third of the industries analyzed.

CHAPTER 5: MULTICOUNTRY USE OF INPUT-OUTPUT TABLES AND THE UTILIZATION OF ACTUAL IMPORTS DATA

The full-fledged application of Leontief's general equilibrium approach to the explanation of the level and composition of trade between the United States and the rest of the world is implemented in this chapter. Having available the (1) endowment of each of the most important trading partners of the United States with the so-called primary factors of production; (2) the shapes of the production functions, i.e., the input-output relationships which govern in each country the transformation of these primary resources into various goods and services, and (3) preferences determining in each area the choice among alternative bundles of finished commodities which it could actually attain through alternative combinations of domestic production and foreign trade, we can continue the investigation into the structural basis of the trade relationships between the United States and the rest of the world.

In order to develop this final application of Leontief's general equilibrium approach we made use of all the input-output tables and the actual imports to the U.S. from the rest of the countries that comprise of our world. The capital and labor requirements are now computed without the use of competitive imports, but rather with data obtained from the simultaneous utilization of the nine input-output tables. The calculations of the capital and labor requirements for imports account for the following items:

Capital Requirements for Imports

$$K_A[I - A_A]^{-1}M_A + K_C[I - A_C]^{-1}M_C + K_D[I - A_D]^{-1}M_D + K_F[I - A_F]^{-1}M_F + K_G[I - A_G]^{-1}M_G + K_I[I - A_I]^{-1}M_I + K_J[I - A_J]^{-1}M_J + K_{UK}[I - A_{UK}]^{-1}M_{UK} \quad (54)$$

Labor Requirements for Imports

$$L_A[I - A_A]^{-1}M_A + L_C[I - A_C]^{-1}M_C + L_D[I - A_D]^{-1}M_D + L_F[I - A_F]^{-1}M_F + L_G[I - A_G]^{-1}M_G + L_I[I - A_I]^{-1}M_I + L_J[I - A_J]^{-1}M_J + L_{UK}[I - A_{UK}]^{-1}M_{UK} \quad (55)$$

where

- K_X is a row vector of capital coefficients for each of the countries considered in our study.
- L_X is a row vector of labor coefficients for each of the countries considered in our study.
- A_X is a matrix of input-output coefficients.
- M_X is the value of total imports into all 'n' industries (nX1) for each of the countries considered in our study.

The calculation of the capital and labor requirements of the U. S. relies on the availability of the input-output tables generated by the statistical offices of each of the countries evaluated in our study. Each input-output table is generated approximately every five years (see table 44).

Table 44: OECD Input-Output Database Coverage

Country	1968-1973	1974-1979	1980-1983	1984-1988	1989-1992
Australia	1968	1974	1974	1986	1989
Canada	1971	1976	1981	1986	1990
Denmark	1972	1977	1980	1985	1990
France	1972	1977	1980	1985	1990
Germany	1978	1978	1978	1986	1990
Italy				1985	
Japan	1970	1975	1980	1985	1990
United Kingdom	1968	1979	1979	1984	1990
United States	1972	1977	1982	1985	1990

Note: Data for Italy was available only for 1985.

Since we compute the U.S. requirements for imports for each year between 1970 and 1992, each input-output table is used for intervals of time. This is based on the

unavailability of yearly input-output tables and on the assumption that the economic structure of the nations considered does not invalidate the accuracy of our calculations.

In order to calculate the capital and labor requirements for exports we had to account for the following items:

$$\underline{\text{Capital Requirements for Exports}} = [K]_{US}\,[I - A]^{-1}\,[b] \qquad (56)$$

$$\underline{\text{Labor Requirements for Exports}} = [L]_{US}\,[I - A]^{-1}\,[b] \qquad (57)$$

where:

- $b = (b_1\ b_2\ \ldots\ldots b_n)$ is a column vector of export coefficients, for all i ($i = 1, 2, \ldots n$);

After the computation of the capital-labor ratios for imports and exports we then resumed to calculate the Leontief ratios. The results obtained are illustrated below; they are presented with and without natural resource intensive industries as Leontief recommended:

Table 45: Leontief's Ratios With Natural Resource Intensive Industries

Year	Leontief's Ratio
1970	1.750
1971	1.683
1972	1.719
1973	1.726
1974	1.495
1975	1.657
1976	1.635
1977	1.583
1978	1.256
1979	1.505
1980	1.627

Year	Leontief's Ratio
1981	1.670
1982	1.666
1983	1.555
1984	1.696
1985	1.614
1986	1.488
1987	1.457
1988	1.456
1989	1.561
1990	1.597
1991	1.642
1992	1.636

Table 46: Leontief's Ratios Without Natural Resource Intensive Industries

Year	Leontief's Ratio
1970	1.521
1971	1.502
1972	1.522
1973	1.494
1974	1.334
1975	1.475
1976	1.509
1977	1.489
1978	1.108
1979	1.385
1980	1.524

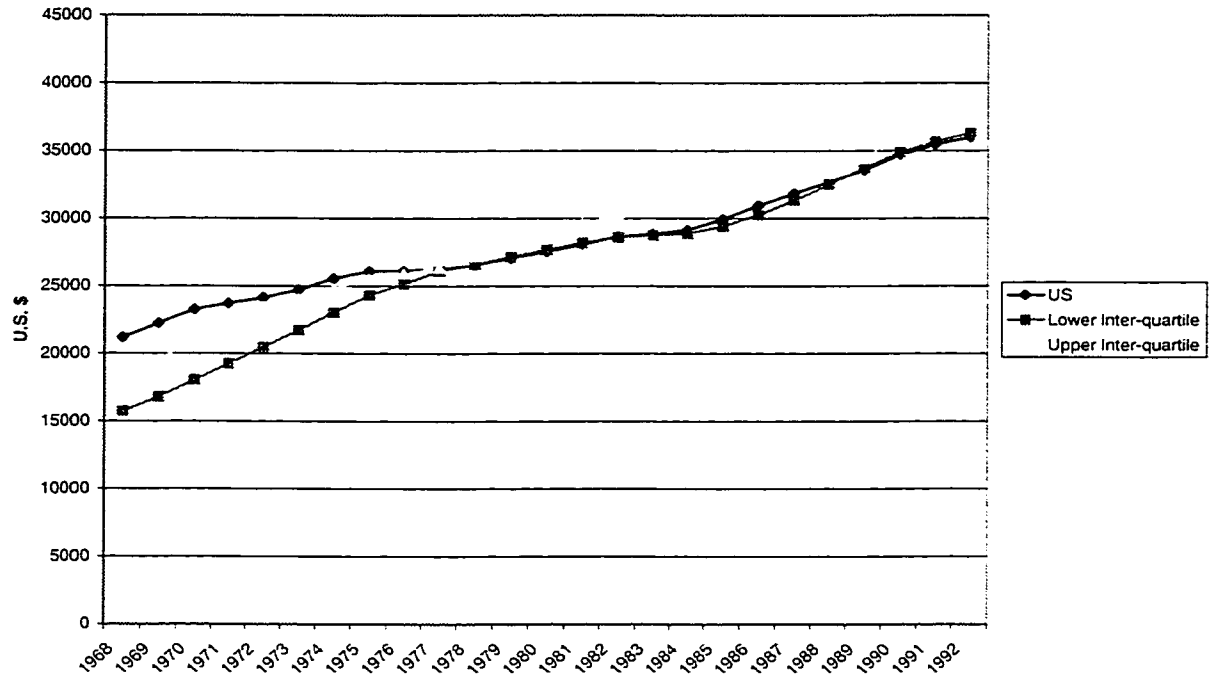
Year	Leontief's Ratio
1981	1.541
1982	1.548
1983	1.462
1984	1.712
1985	1.648
1986	1.530
1987	1.473
1988	1.486
1989	1.649
1990	1.679
1991	1.727
1992	1.722

The results obtained indicate that Leontief's paradox is eliminated during 1978-1981 and 1989-1992 when the United States is characterized as a labor abundant nation. During these years the Heckscher-Ohlin theory is confirmed and the findings are consistent with the original approach recommended by Wassily Leontief in 1953 and 1956, but never implemented due to the unavailability of data. Therefore, comparative advantage theory, as specified in the Heckscher-Ohlin model holds that nations export those commodities, which intensively embody their relative abundant factors of production. Factor endowments then dictate world trade patterns in the general equilibrium models of international trade.

The results shown in tables 45 and 46 demonstrate the validity of the Heckscher-Ohlin theory during 1978-1981 and 1989-1992. The difficulty in characterizing the United States as a labor or capital abundant nation is due to the utilization in the analysis of the most industrialized nations of the world. At first sight, every nation in the sample could be considered capital abundant. Given the fact that our analysis relies on the relative levels of factor utilization, some nations need to be identified as labor abundant.

Graph 26 compares the capital stock per worker for the United States with lower and upper limits, which determine the classification of a nation as labor or capital abundant.

Graph 26: U.S. Capital Stock Per Worker



As we have explained in the previous chapter, factor intensity reversal may be found in transitional cases. In the industry approach when a change of techniques or of technology takes place, an industry may be identified as capital intensive in one nation and labor intensive in the other. However, this result is temporary and eventually the predictions of the Heckscher-Ohlin theory take place. In the case of the United States we can notice that FIR is present during the first few years (1970-1977). The subsequent indetermination of the factor abundancy leads to a period in which U.S. is characterized as a labor abundant nation and where the Heckscher-Ohlin theory is validated.

When compared with the great majority of the countries, United States is a capital abundant nation. However the PWT shows that there is a great deal of similarity between the values shown by the G-7 countries[10]. In particular, Australia, Canada, France, Germany and Japan have slightly higher capital stock per worker than the United States. Therefore, the results of this approach are consistent with the results obtained from the previous two methods in which the Heckscher-Ohlin theory was confirmed. Even though the classification of the United States is very difficult to ascertain, the theoretical objective of this study is to assist us in predicting the pattern of international trade.

Another important aspect that the Heckscher-Ohlin theory does not convey is the product differentiation. We are aware of the fact that both international patterns of production and consumption determine international trade. Additionally, most theoretical literature in international economics concentrates on the production side and often uses assumptions that neutralize demand as a determinant of the composition of trade. And this is true since it is the differentiation among products that stimulate demand and international trade.

Furthermore, the dynamic models of international trade emphasize the role of innovation in determining trade patters. If innovators are responsive to the relative factor costs, innovative activities may be found in those sectors with the heaviest usage of the most skilled labor. The results of this study then suggest that United States does indeed export more labor-intensive goods during periods when the nation is classified as a

[10] U.S., Japan, Germany, France, the U.K., Italy and Canada.

capital abundant nation. Nevertheless, we believe that this test provides "a best case" development for Heckscher-Ohlin to hold empirically because of the restriction to similar developed nations.

SUMMARY AND CONCLUSIONS

The main purpose of this dissertation was to test empirically the validity of Heckscher-Ohlin theorem over the period 196ð – 1996 by modifying the original framework implemented by Wassily Leontief using the input-output tables of Australia, Canada, France, Denmark, Germany, Italy, Japan, the United Kingdom and the United States. Three methods have been implemented to test the theorem: (1) the replication of the original Leontief method making use of the exports and import substitutes for the countries mentioned above, (2) the use of the input-output tables to measure the labor and capital content of each industry, and (3) the use of multicountry input-output tables and actual imports of the U.S.

According to the Heckscher-Ohlin theorem, the trade pattern of a country should be based on its endowment; the capital abundant nation should export relatively more capital-intensive goods and import labor-intensive goods. The original study implemented first by Wassily Leontief gave unpredicted results. The pattern of American exports did not conform to the American endowment of 1947 and 1951. More precisely, the 1947 input-output table substantiated that United States was exporting labor-intensive goods and importing capital-intensive goods. This trade pattern was not in agreement with the hypothesis that America was relatively capital abundant comparing to its labor endowment. This conclusion later became known as the Leontief paradox.

Since the pioneering work of Leontief many researchers have attempted to improve the empirical methodology or to give alternative explanations as to its validity, but none sought to implement the original idea suggested by Wassily Leontief in his

papers due to various constraints amongst which data availability was the most important one. Amid those involved in the attempts have been Vanek who tried to improve the dimension of Leontief model and introduced the concept of factor content. Leamer tried to consider the fact that American trade is not balanced. Deardorff and others have tried to improve the model by introducing more realistic assumptions. Baldwin pioneered the use of regression analysis in testing empirically the Heckscher-Ohlin theorem. Many others have made numerous attempts to prove or disprove the theorem.

Given the availability of factor endowments of other nations and comparable input-output tables this dissertation used the Leontief approach in testing the Heckscher-Ohlin theorem. The results obtained are consistent across the three methods implemented. The Heckscher-Ohlin theorem is generally confirmed as valid even in an environment of nine developed nations where intra-industry trade plays a major role.

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