Research Note

SOME EVIDENCE ON THE DETERMINANTS OF JAPANESE TRADE

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I. Introduction

The present analysis rests on the Heckscher-Ohlin-Vanek (H-O-V) theorem. The standard textbook treatment of the Heckscher-Ohlin (H-O) theorem utilizes a two country, two factor, and two good model to explain a country's pattern of trade. An empirical analysis would involve a model with more than two factors and two commodities. When extending the H-O theorem to a multi-good, multi-factor dimensional model, the factor intensities cannot be uniquely ordered. This would imply that the commodities cannot be ranked in terms of comparative advantage. Vanek (1968), however, restated the theorem in such a manner that an ordering is possible. Instead of trading commodities, countries will trade factor services where commodities serve as packages or bundles of the factors. This approach is commonly referred to as the factor content version of the H-O theorem or the H-O-V theorem.

Baldwin's (1971) pioneering study on the determinants of US trade introduced regression type analysis to the empirical literature on the factor content of trade. Since then, regression models have become a standard method for analyzing the determinants of trade.(1) The purpose of this paper is to conduct such a regression type analysis to examine the structure of Japanese trade in the manufacturing and natural resource industries from 1970 to 1980. The signs of the estimated regression coefficients are used to infer factor abundance (endowments) in physical capital, human capital, and technology.

II. The Model

The model estimated in the present paper is a three factor, multi-commodity one based on the Heckscher-Ohlin-Vanek theorem. Vanek demonstrated that the factor content of net trade is equivalent to the excess supply of factors. That is,

$$AT_i = V_i - z_i V_w,$$

where A is a m × n matrix of factor input intensities, T_i a n × 1 vector of net exports, V_i a n × 1 vector of factor endowments, z_i is a constant indicating the share of consumption of country i, V_w a n × 1 vector of the world's factor endowments, and $z_i V_w$ a vector of the share of world factor endowments consumed by country i. The subscript notation i denotes the i th country, n the number of industries, and m the number of factors.

The model requires the following assumptions in order to formulate a theoretically consistent econometric model.

i) The model is linear.
ii) Commodities are freely mobile internationally (no tariffs).
iii) Factors are perfectly immobile internationally.
iv) All individuals have identical homothetic preferences.[2]
v) The production functions are the same in all countries and exhibit constant returns to scale.
vi) Perfect competition in the goods and factor markets exists.
vii) Factor price equalization across countries.

The proof follows:

Equilibrium in the factors market requires that factor demand equal factor supply.

$$V_i = A X_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where, V_i is a vector of factor endowments (eg. capital and labor), A a matrix of factor intensities, and X_i a vector of outputs of commodities. The assumption that production functions exhibit constant returns to scale (v) and factor price equalization (vii) imply the factor input matrix, A. The same holds for the world.

$$V_W = A\ X_W \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

In the 2 × 2 case, with capital and labor endowments, the model would take the form

$$\begin{pmatrix} K \\ L \end{pmatrix} = \begin{pmatrix} a_{1K} & a_{2K} \\ a_{1L} & a_{2L} \end{pmatrix} \begin{pmatrix} X_1 \\ X_2 \end{pmatrix}$$

From the assumption of homothetic and identical preferences (iv), we can write (3)

$$C_i = z_i\ X_W \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where C_i is a vector of consumption and z_i the share of world output consumed. The consumption levels of output are proportional to consumption levels in other countries. Trade is then expressed as

$$T_i = X_i - C_i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

A country which produces a good in excess of domestic consumption is assumed to export the surplus (positive net exports). In the case consumption is greater than domestic production, the goods are imported to satisfy consumption demand (negative net exports).

Multiplying both sides of the net export equation (4) by the matrix of factor intensities gives

$$AT_i = A\ (X_i - C_i) \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

Equation (5) represents the factor content embodied in net trade. Substituting (1) and (3) into (5) results in

$$AT_i = V_i - A\ z_i X_W \quad \text{or,}$$
$$AT_i = V_i - z_i V_W$$

Hence, the factor content of trade, AT, of country i is equivalent to its vector of excess factor supply.

Consider the following regression model.

$$T = A'\beta + u$$

where β is a m × 1 vector of coefficients and u a n × 1 vector of disturbance terms. Then the regression coefficient can be expressed as

$$\hat{\beta} = (AA')^{-1} \; AT$$

Since $AT_i = V_i - z_i V_W$,

$$\hat{\beta} = (AA')^{-1} \; (V_i - z_i V_W)$$

In other words, the sign of $\hat{\beta}$ reflects the sign of the vector of excess factor supplies. A positive coefficient ($\hat{\beta} > 0$) indicates relative factor abundance and a negative sign ($\hat{\beta} < 0$) a relative scarcity in the factor.[3]

The factor endowments, hence, are inferred from factor intensities and a measure of trade performance. It is assumed that a country will use intensively the relatively abundant factor implying comparative advantage in commodities (industries) employing the respective factor.[4]

III. The Data

Data for the present work was obtained from the *1970-75-80 Link Input–Output Table* and the *Report on the Survey of Research and Development*. Two different aggregation schemes were utilized in the study. One set includes 61 natural resource and manufacturing industries aggregated at the 71 sector level of the I-O table. The second set is aggregated to the scheme found in the *Report on the Survey of Research and Development* so that R&D data could be utilized in the analysis.[5]

The net exports data was derived directly from the I-O table. Imports were simply subtracted from exports for each industry. Tariffs were not included. The net export variable was adjusted by taking the difference in the shares of the exports and imports for each industry and multiplying by 10000 yen.

The factors examined in the present study are physical capital, human capital, and technology. Conventionally, factor intensities have been measured either in terms of stock[6] or flow. This study employs flow data.[7] Value added was used as a proxy for direct input factor intensity of physical capital and human capital. Several studies have used value added data (eg. (Lee, 1986), (Hirsch, 1974), (Roskamp & McMeekin, 1968), (Lary, 1968)).

Employees compensation (wages & salaries, social insurance, other payments) and non-household consumption expenditure (social expenses, etc.) elements of the value added were assumed to reflect human capital (HC). Physical capital (PC) value added per employee includes depreciation (consumption of fixed capital) and profits (operating surplus).

$$\text{Human Capital}_j = \frac{EC_j + NHC_j}{N_j},$$

$$\text{Physical Capital}_j = \frac{D_j + P_j}{N_j} \qquad j = 1, \ldots, k \text{ industries}$$

EC_j equals the employee compensation part of value added for industry j, NHC_j the non-household expenditures, D_j the depreciation, P_j the profit, and N_j the number of employed in industry j. The higher the physical capital value added per employee, the more capital intensive the industry; the lower the value added, the less intensive. The same holds for human capital value added. It is assumed that the difference in the wage element of the value added per employee is a good proxy reflecting differences in skill intensity (human capital).

Research and Development expenditures (RD) and scientists/engineers (SE) were used as proxies for technology intensity.[8] The ratio of scientists and enginners in each industry to the total number of SE was used; data was obtained from the I-O table. The share of R&D expenditures in each industry was obtained from the *Report on the Survey of Research and Development.*

IV. Results and Discussion

(1) The PC, HC, and Technology Factors

Net exports were regressed on three sets of factor intensities. The following functions were estimated using ordinary least squares (OLS).

NX = f (PC, HC, SE)

NX = f (PC, HC, RD)

where NX is net exports, PC physical capital, HC human capital, SE scientists and engineers, and RD research and development expenditures.

Table 1 summarizes the results of the regressions using data aggregated to the 71 sector scheme of the I-O table for the years 1970, 1975, and 1980. The SE coefficients are positive and the PC coefficient negative indicating that Japan is relatively factor abundant in technology but factor scarce in physical capital. The signs of the HC coefficient imply relative factor abundance in human capital in 1970 but relative scarcity in 1975 and 1980 although the reverse is expected a priori. When the

Table 1. OLS Results for I-O Table 71 Sector Aggregation Scheme

Year	Constant	PC	HC	SE	R^2
(49 industries)					
1970	−156	−14.75	51.23	104.16***	.137**
		(27.94)	(143.05)	(32.84)	F = 3.54
1975	−92	−1.94	−3.39	98.91**	.052
		(14.80)	(72.09)	(41.66)	F = 1.89
1980	146	−2.76	−62.72	53.76	.055
		(15.98)	(39.69)	(33.90)	F = 1.93
(43 industries: excluded petroleum & mineral industries)					
1970	−203	−7.35	377.45***	76.69***	.189**
		(28.35)	(126.53)	(27.89)	F = 4.26
1975	−259	−0.44	138.76**	75.32***	.258***
		(8.59)	(53.51)	(24.35)	F = 5.88
1980	−143	−2.69	57.23**	37.68**	.205***
		(6.81)	(24.11)	(14.20)	F = 4.68

R^2 is adjusted.
Standard error in parentheses.
Significance: * 10%, ** 5%, *** 1%.

petroleum and mineral industries are excluded from the sample, leaving 43 manufacturing and agricultural industries, the HC coefficient turned positive and significant for all years.[9] Also, the explanatory power (R^2) of the regression models improved substantially with the deletion of the natural resource industries.[10] This suggests that Japan is a net importer and highly human capital intensive in the petroleum and mineral industries.

In a second set of regressions, R&D was used as a proxy for technology. The results are found in table 2. The PC signs are negative as in the regression results in table 1. The HC and RD coefficients are positive inferring relative factor abundance. The explanatory power (R^2) tends to improve as we move from 1970 to 1980. The improvement is most marked with the model involving R&D (table 2). This would

Table 2. OLS Results for Report on the Survey of R&D Aggregation Scheme

Year	Constant	PC	HC	RD	R^2
(21 industries)					
1970	−415	−78.82	397.01	24.64	.057
		(86.99)	(324.75)	(16.40)	F = 1.402
1980	−234	−124.06**	120.65	35.87	.352**
		(60.28)	(81.17)	(18.77)	F = 4.625
(19 industries: excluded petroleum & mineral industries)					
1970	−495	−139.67*	670.76***	12.55	.405**
		(74.15)	(195.14)	(10.35)	F = 5.084
1980	−198	−62.55**	102.78**	27.76***	.562***
		(29.42)	(45.78)	(9.14)	F = 8.689

R^2 is adjusted.
Standard error in parentheses.
Significance: * 10%, ** 5%, *** 1%.

indicate that the neo-factor proportion theorem[11] explains Japanese patterns of trade in 1980 relatively well, especially when the petroleum-mineral industries are deleted from the sample.[12]

A difference in the aggregation scheme did not seem to affect the results of the regression models. The R^2 improved when the natural resource industries were deleted in both schemes. Also, the regressions produced similar results in the signs of the estimated coefficients. Finally, note that the performance of the R&D and SE proxies for technology were similar.

The findings in the present work, however, are not entirely consistent with recent empirical studies on the determinants of Japanese trade. Heller (1976) shows through a Leontief type analysis, that Japanese comparative advantage was shifting to capital and skill intensive industries in 1970. The PC coefficients in this study are negative for 1970 in all the regressions (tables 1 & 2), thus partially contradicting Heller's conclusions.

Lee (1986) estimated cross-section regression models annually from 1965 to 1977 for the manufacturing industries. A revealed comparative advantage (trade) index was utilized as a dependent variable and value added per employee for the PC and HC explanatory variables. Therefore, the analysis is similar in nature to the present work. The results, however, differ. Lee found that both the physical and human capital coefficients were negative for all years except 1975 and 1977 where the PC coefficient was positive. The present study confirms the relative scarcity of physical capital but the signs differ for the HC variable. This could be attributed to the difference in the trade markets dealt with in the two studies. Japanese trade with the world is considered in this work, whereas Lee (1986) limits his analysis to the OECD market. The results of this analysis in combination with Lee's findings suggest that Japan exports human capital intensive goods to the world on balance, but tends to be a net importer when trading with advanced industrialized countries.

(2) The Energy Factor

Lee included energy intensity (ENG) in his regression equation and found the coefficient to be positive in 1975. Data on energy consumption for 13 industries were collected from the *Engery Balances of OECD Countries* [13] to test whether the H-O-V model generates similar results. The results of the regression for 1980 is [14]

$$NX = -51 \; -688.4\,PC^* + 331.2\,HC + 70.3\,ENG^* \qquad R^2 = .239$$
$$(310.1) \qquad (328.0) \qquad (34.8)$$

The energy coefficient is positive and significant. The statistics, however, must be interpreted with caution since the sample size is small. The positive coefficient may appear to be intuitively unappealing for it indicates that Japan is relatively energy abundant. The phenomena, however, could be at least partially explained by the findings summarized in tables 1 and 2 of this paper.

By deleting the petroleum related industries from the sample we found these natural resource industries to be human capital and technology intensive, and net importers. Japan's relative scarcity in petroleum/oil has led her to strengthen these industries for security purposes. For example, Japan has accumulated a petroleum stock (government and private) of over 130 days (Ikuta, 1986). The storage of such fuels requires a sizable skilled maintenance and research staff, thus leading to high human capital intensity. In 1980, Japan's government energy R&D spending on oil and gas storage technology amounted to $44.84 million; this accounted for 85%of total R&D expenditures on storage technology made by International Energy Agency member countries. [15] As a consequent, it could be said that through the intensive use of her abundant factors of human capital and technology, Japan created an artificial abundance or pseudo-abundance in energy resources. [16]

V. Conclusion

The empirical analysis conducted in this paper was based on the Heckscher-Ohlin-Vanek theorem. Factor abundance was inferred from the signs of the regression coefficients. Japan was found to be relatively abundant in human capital and technology yet relatively scarce in physical capital.

The performance of the model improves when the petroleum and mineral natural resource related industries were deleted indicating the scarcity of natural resources in Japan. As we move from 1970 to 1980 the explanatory power of the model increases.

In general, the analysis suggests that Japanese trade patterns could possibly be explained within the framework of the neo-factor proportions theorem and that Japan's comparative advantage is shifting towards high-technology industries.

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Notes

(1) Refer to Deardorff (1984) and Stern (1975) for a survey.
(2) The assumption of identical and homothetic preferences may be questionable. A recent empirical study by Ballance, et al. (1985) shows that the assumption is not necessarily valid.
(3) It is not possible to make rigorous inferences on the factor endowments from the signs of the coefficients when there are more than two factors involved in the regression model ((Aw, 1983), (Leamer & Bowen, 1981)). Note, however, the approach and interpretation of the model in this study are consistent with the empirical literature.
(4) A complete test of the H-O-V theorem would involve independent measures of factor endowments, factor intensities, and trade performance. The majority of empirical studies, however, use only two of the three measures.
(5) The following classification was used (RSRD scheme—I-O table scheme):
RSRD industry number (I-O Table industry number (Note 2 digit: 71 sector, 4 digit: 158 sector))
2 (1, 2, 3, 5); 3 (6, 7, 8, 9); 6 (10, 11, 12, 13, 14, 15); 7 (17, 18, 19, 20); 8 (24, 25); 9 (26); 11 (3111, 3112, 29, 31, 33); 12 (3130,

3192); 13 (3119, 3191); 15 (30, 35, 36); 16 (28); 17 (37); 18 (38, 39, 40); 19 (41, 42); 20 (43); 21 (44); 22 (45, 3702); 24 (3703, 3704); 25 (47); 27 (48); 28 (49)

(6) For studies using stock data for factor intensity cross-section regressions refer to Baldwin (1971), Harkness & Kyle (1975), Stern (1976), Branson & Monoyios (1977), Stern & Maskus (1981).

(7) The measurement of physical and human capital is not an easy task in any empirical study for capital is not rigorously defined in the theoretical literature. The proxy employed in the present study have their drawbacks. In the case of PC, for example, the profits part of the value added may be unusually high in a given industry if monopolistic conditions exist. Refer to Lary (1968) for details.

(8) Several studies have used RD and SE as proxies for technology intensity. For example, Tsurumi (1972), Stern & Maskus (1981) and Hughes (1986).

(9) The petroleum refinery products, non-ferrous metal products, coal, metal mining, crude petroleum & natural gas, other non-metal mining, industries were deleted from the sample.

(10) The R^2 is low for several of the estimated OLS equations. High R^2 values, however, are not expected with cross-section studies. The fit of the model is relatively good in comparison with other cross-section studies in the literature.

(11) The neo-factor proportions theorem refers to those models employing measures of human capital and technology in addition to the conventional factors of land, labor, and capital.

(12) The mining and petroleum & coal products manufacturing industries were deleted.

(13) The ENG variable measures the consumption of energy in each industry. Energy derived from solid fuels, crude oil, petroleum products, gas, nuclear power, hydro/geothermal, and electricity are converted to a common unit—tons of oil equivalent.

(14) Regressions which include the energy variable were estimated for 1970 and 1975 but the results were not statistically significant.

(15) Refer to IEA (1981), p. 28.

(16) High R&D expenditures are found in other energy sectors such as nuclear, hydro, and electricity.

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