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Product Quality, Factor Endowment and International Trade: An Empirical Test of the Neo-Heckscher-Ohlin Theory for Japan*

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This paper presents a model of international trade that allows for vertical differentiation and shows that Heckscher-Ohilin type trade should occur. This model is then empirically tested for Japan, and finds that, Japan exports high quality (capital intensive) products and imports low quality (labor intensive) products as the theorem predicts.

1. Introduction

According to Heckscher-Ohlin trade theory, a country will export those products that intensively use the factor of production, capital or labour, that the country is abundant in; and import all other products. Accordingly, inter-industry type trade should predominantly occur. In reality, however, intraindustry trade accounts for a significant proportion of trade in manufactured products, i. e., countries both import and export the same and/or very similar products.

Krugman (1979) and Lancaster (1980) used models that incorporated imperfect competition with horizontal product differentiation, i. e., differentiation by color and/or brand, and economies of scale to explain this phenomenon. These models, however, fail to explain intra-industry trade that occurs between countries with different technology.

Flam and Helpman (1987) and Falvay and Kierzkowski (1987), however, used vertical product differentiation, i. e., goods are differentiated by quality, to explain intra-industry trade. Falvay and Kierzkowski argue that the quality of a product is related to its production capital intensity, i. e., in order to produce higher quality products, a larger amount of capital relative to labour is required. Accordingly, when capital/labour ratios differ within product groups, countries that are capital (labour) abundant have a comparative advantage in producing higher (lower) quality products. Thus capital (labour) abundant countries will produce and export high (low) quality products, i. e., capital (labour) intensive products, and import all other products. This can be thought of as neo-Heckscher-Ohlin (neo-H-O) intra-industry trade.

Torstensson (1991) has tested the neo-H-O trade theory empirically for

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Sweden. He concluded that a positive relationship between the quality of a country's exports and that country's capital/labour endowment ratio does exist. He also found that products traded between Sweden and other capital abundant countries were of almost identical quality, while products imported from labour abundant countries were of lower quality than Sweden's exports. These results empirically support the neo-H-O theory. The measure of product quality Torstensson used to test the theory, however, lacks a theoretical justification.

This paper empirically tests the neo-H-O theory for Japan. Japan's case is interesting in that Japan's capital/labour ratio relative to other countries' capital/labour ratio has significantly increased. This paper tests to see if this change in its capital/labour ratio is reflected in the change in quality, if any, of its exports and imports. This paper is constructed as follows. In section 2 we derive a utility consistent measure of quality of a country's exports relative to its imports. Section 3 discusses the method used to test the neo-H-O theory. Section 4 discusses the empirical results obtained, and these results are summarized in section 5.

2. Model

Falvay and Kierzkowski assume there are two factors of production, capital and labour, and many products, where different products of different quality make up a product group. We will also assume that the price of each product reflects the quality of that product; i.e., the higher the price, the higher the quality of the product. Furthermore, in order to produce higher quality products, a higher capital/labour ratio in production is necessary. Given product quality is continuously differentiable, then each product group has a range of poducticon capital/labour ratios. Lastly, the world consists of many countries. Although all countries have access to the same technology, they have different factor endowments and factor prices. We will also assume that no technological progress occurs.

Under these assumptions, countries will specialize in producing a few products, which are also exported, while importing all other products, i.e., capital (labour) abundant countries will export capital (labour) intensive products and import all other products. When capital/labour ratios differ within product groups, neo-H-O intra-industry trade will occur. That is, capital (labour) abundant countries will export the high (low) quality products and import all other products of different quality.

In order to test the neo-Heckscher-Ohlin theory for Sweden, Torstensson defined $M(T)$, the measure of quality of Swedish exports relative to imports, as

$$M(T)=\sum_{i=1}^{n}\{\ln P_i(IMP)-\ln P_i(EXP)\}/n$$

where n is the number of product groups, $P_i(IMP)$ is the import price of product i and $P_i(EXP)$ is the export price of product i. $M(T)$, however, does not reflect the quality of a country's exports relative to imports because it is the simple geometrical average of all product groups. That is, the weight for all product groups in $M(T)$ is $1/n$, and this does not accurately take account of consumer's preferences for different product groups.

We will argue that if the utility level is constant, then the measure of quality should be unchanged, just like the price index. We will assume that consumers differ in income, that each consumer consumes only one product of a given quality from each product group, and that consumers maximize their utility given their budget constraint. Suppose a utility function as follows:

$$U(Z_1, Z_2, \ldots, Z_n) = \sum_{i=1}^{n} S_i * \ln Z_i \tag{1}$$

where $Z_i(>1)$ is the quality of product i, and $S_i(0<S_i<1, \sum S_i=1)$ is a parameter.

We will assume the price of a product reflects its quality, i. e., price is an increasing function of quality. For simplicity, we assume the price of product is given by

$$P_i(Z_i) = C_i Z_i$$

where C_i is constant. Thus, the measure of quality, Q, is

$$Q = \sum_{i=1}^{n} S_i * \ln P_i. \tag{2}$$

Totally differentiating (1) and (2), it can be shown that the measure of quality is constant as long as the level of utility remains constant.

The budget constraint of the consumer is

$$I = \sum_{i=1}^{n} P_i(Z_i) \tag{3}$$

where I is the consumer's income and each consumer differs in income. Differentiating (1) subject to (3), we obtain,

$$S_i = P_i(Z_i^e) / \{\sum_{i=1}^{n} P_i(Z_i^e)\} \tag{4}$$

where superscript e indicates the utility maximizing quality.

Consequentially, the utility consistent measure of quality of a country's exports relative to imports is

$$M(T)' = \sum_{i=1}^{n} S_i\{\ln P_i(IMP) - \ln P_i(EXP)\}. \tag{5}$$

If the prices for all product groups are equal, then $S_i=1/n$ for any i. In this case, $M(T)'$ is equal to $M(T)$. Thus $M(T)$ is an appropriate measure of the quality of a country's exports relative to imports only when the prices of all products are equal.

3. Methodology

Having derived a utility consistent measure of quality of exports relative to imports, we can use this to test the neo-H-O theory for Japan. $M(T)'$ will be used to test this theory, but the model will also be run using $M(T)$ for comparative purposes. To calculate $M(T)'$, the consumption price weight for each product group, S_i, the consumption prices of imports, $P_i(IMP)$, and exports, $P_i(EXP)$, should be calculated for each consumer. As this was not possible, the average import price weight was used as a proxy for the consumption price weight and average import and export prices were used as a proxy for product prices. Although the export price weight can be used instead of the import price weight, because we are testing the neo-H-O theory for Japan, import prices will be used as imports reflect domestic preferences, while exports reflect foreign preferences for product groups.

Japan's imports in 1975, 1989 and 1990 will be examined. We have chosen the SITC 4-digit level in 1975 and the HS 4-digit level in 1989 and 1990 as a definition of a product group.[1] As shown earlier, the quality of a product is reflected in its price. In Japanese trade statistics, quantity units are usually recorded in metric tons and thus unit prices do not accurately reflect the quality of these products. For some 4-digit manufacturing SITC and HS product groups, however, quantity is recorded in pieces, and thus the unit prices of these products should reflect their quality. This allows us to test our theory using 30 product groups.[2]

Two methods will be used to test the neo-H-O theory. Firstly, we will investigate whether or not Japan's exports are on average of higher quality than its imports. According to the neo-H-O trade theory, Japan should have exported high quality products in 1975 because by this time it was a relatively capital abundant country. In 1975, however, Japan was at the end of its industrialization process. Given that it had just become a capital abundant country, due to time lags that may occur between a change in a country's per-capita GNP and a change in the quality of exports, Japan's exports may still be of relatively low quality. In 1989 and 1990, however, Japan had a relatively high capital/labour endowment, and thus it should have exported high quality products. Accordingly, the sign of $M(T)$ and $M(T)'$ for 1975 is indeterminable, but should be negative in both 1989 and 1990.

Countries will also be divided into two groups according to their capital/labour endowments.[3] Per-capita GNP is used as a proxy for capital/labour endowment. In 1975, countries with a per-capita GNP of more than 3000 US dollars are classified as capital abundant countries, *CA*, and countries with a per-capita GNP of less than 3000 US dollars are classified as labour abundant countries, *LA*. In both 1989 and 1990, countries with a per-capita GNP of more than 9000 US dollars are classified as *CA*, and countries with a per-capita GNP of less than 9000 US dollars are classified as *LA*. Although Japan belonged to the *CA* group throughout the period under consideration, whereas Japan ranked 15th in the world in 1975 in terms of per-capita GNP, in 1989 and 1990, it ranked 2nd and 4th in the world respectively.[4]

Secondly according to the neo-H-O theory, *CA* countries will export high quality products, while *LA* countries will export low quality products. Moreover, the higher Japan's relative per-capita GNP, the higher the relative quality of products it should export. Accordingly, given

$$M(j)' = \sum_{i=1}^{n} S_i\{\ln P_{ij}(\mathrm{IMP}) - \ln P_i(EXP)\} \tag{6}$$

where $P_{ij}(IMP)$ is the average import price of product i from the group j and $j=CA$, LA, then, $M(CA)' > M(LA)'$. If $M(j)'$ is negative, this indicates that imports from country group j are of lower quality than total Japanese exports.

Thirdly, we will look at each product group and country individually. We have argued that the higher relative capital/labour endowments ratio of a country, the higher the quality of the products that it will export. To test this, we will use the regression equation

$$\ln P_{ij} = a_i + b_i * \ln k_j + u_i \tag{7}$$

where P_{ij} is the quality of imports of product group i from country j, k_j is the relative capital/labour endowments ratio of the country j and u_i is a random error term. As before, trade prices are used as a proxy for quality and per-capita GNP as a proxy for capital/labour endowment. As this regression is only used for hypothesis testing and not for prediction purposes, only the sign and statistical significance of b_i is important and not its value per se.

The necessary data was obtainable from two main sources; (1) *International Financial Statistics* issued by the International Monetary Fund; and (2) *Nippon Boeki Geppo* (*Monthly Return, Trade of Japan*) issued by Japan Tariff Association.[5]

4. Results and Analysis

The estimated values of $M(T)'$, $M(T)$, $M(CA)'$, and $M(LA)'$ for 1975, 1989 and 1990 are shown in Table 1. As can be seen, these results support the neo-H-O theory. Looking at $M(T)'$, in 1975 Japan's imports were of higher quality than her exports. In 1989 and 1990, however, as Japan was a relatively capital abundant country, its exports were of higher quality than its imports. The results obtained using $M(T)$ as a measure of quality of exports relative imports suggest, however, that Japan's exports were of lower quality than its imports. This is inconsistent with both theory and reality. Accordingly, $M(T)$ is not an accurate measure of the quality of exports relative to imports for Japan. Torstensson, however, used $M(T)$ to test the neo-H-O theory for Sweden and obtained results consistent with neo-H-O theory. This suggests that the amount of price variation is much lower for each product group in Sweden's case. In this case, the value of $M(T)$ is similar to $M(T)'$, and thus, $M(T)$ can be used as a proxy for $M(T)'$.

Looking at $M(CA)'$ and $M(LA)'$, in 1975 Japan's exports were of lower quality than its imports from both country groups. For the CA group this result was expected, but not for the LA country. Thus, in 1975 Japan exported cheap, low quality exports. This difference in quality was largest against imports from labour abundant countries. In 1989 and 1990, as expected, Japan's exports were of higher quality than its imports from both groups. This difference in quality was largest against imports from LA countries as expected.

The results from the regression analysis are summarized in Table 2. The regression coefficient, b_i, was found to be positive for 25, 28 and 27 of the product groups out of 30 in 1975, 1989 and 1990 respectively. Of these, for 14, 17 and 23 of the product groups, b_i was found to be significant at either the 1, 5, 10 or 20 percent level in 1975, 1989 and 1990 respectively. This leads us to conclude that the more capital abundant a country is, the higher the quality of its exports relative to its imports.

5. Conclusions

This paper empirically tested the neo-H-O theory for Japan. Firstly we derived a utility consistent measure of quality of a country's exports relative to imports. Using this measure, we found that the unit prices of exports, i. e., the relative quality of a country's exports, is positively related to a country's capital/labour endowment relative to other countries.

With regards to Japan, this paper also found that Japan's manufacturing exports were of higher quality than its manufacturing imports in both 1989 and 1990, although its manufacturing exports were of lower quality than its manufacturing imports in 1975. This is not surprising, given that Japan's per-capita GNP has increased rapidly over the last 15 years and is now one of the highest

Table 1. Measure of Quality of Trade

	1975	1989	1990
$M(T)'$	1.17	−1.55	−1.49
$M(T)$	0.35	0.32	0.44
$M(CA)'$	1.21	−0.34	−1.37
$M(LA)'$	0.93	−2.63	−1.79

Table 2. The Relationship between Quality of Imports and a Country's Factor Endowments

	b_i				b_i		
SITC/HS	1975	1989	1990	SITH/HS	1975	1989	1990
6130/4013	−0.069	0.700[b]	0.203	7242/8527	0.924[b]	0.329[c]	0.677[a]
n=29, 12, 11	(0.348)	(2.350)	(0.608)	n=16, 21, 23	(2.693)	(1.736)	(4.059)
	[0.004]	[0.356]	[0.039]		[0.341]	[0.137]	[0.440]
6557/4101	0.068	0.091	0.152[d]	7250/8528	1.573[a]	0.219	0.680[a]
n=8, 11, 18	(0.466)	(0.343)	(1.603)	n=22, 21, 26	(2.903)	(1.209)	(3.095)
	[0.035]	[0.013]	[0.138]		[0.296]	[0.071]	[0.285]
6561/4102	0.015	0.031	0.100	7321/8701	0.317[d]	0.213	2.637[a]
n=5, 13, 15	(0.123)	(0.796)	(1.242)	n=13, 11, 15	(1.413)	(0.886)	(3.984)
	[0.005]	[0.054]	[0.106]		[0.154]	[0.080]	[0.550]
7121/4303	−0.035	0.181	0.391[c]	7323/8703	0.248	0.159[d]	0.278[b]
n=14, 33, 38	(0.115)	(1.066)	(2.014)	n=8, 26, 26	(0.662)	(1.621)	(2.222)
	[0.001]	[0.035]	[0.101]		[0.068]	[0.099]	[0.171]
7122/6101	1.024[d]	0.294[d]	0.569[a]	7329/8704	0.111	0.588[c]	0.362[d]
n=16, 16, 19	(1.755)	(1.475)	(3.431)	n=12, 13, 14	(0.494)	(2.169)	(1.451)
	[0.180]	[0.135]	[0.409]		[0.024]	[0.300]	[0.149]
7125/6113	0.479[d]	0.439	−0.255	7353/8711	−0.099	0.432[a]	0.228[a]
n=9, 38, 10	(1.594)	(1.058)	(0.441)	n=17, 25, 28	(0.106)	(3.653)	(3.013)
	[0.266]	[0.138]	[0.024]		[0.001]	[0.367]	[0.259]
7141/6205	−0.074	0.153[a]	0.304[a]	8411/8901	0.587[a]	−0.889	−0.572
n=15, 9, 32	(0.368)	(3.050)	(3.511)	n=37, 5, 9	(6.204)	(0.518)	(0.790)
	[0.010]	[0.210]	[0.291]		[0.524]	[0.082]	[0.082]
7142/6212	0.516	0.150[b]	0.442[a]	8412/8903	0.233[d]	0.254	0.486[d]
n=19, 22, 20	(1.014)	(2.352)	(4.229)	n=33, 26, 25	(1.421)	(1.118)	(1.325)
	[0.057]	[0.209]	[0.498]		[0.061]	[0.050]	[0.071]
7143/6213	0.207	0.427[b]	0.411[b]	8414/8967	0.094	−0.238	6.198[b]
n=20, 20, 19	(0.996)	(2.754)	(2.380)	n=37, 10, 14	(0.686)	(0.694)	(2.439)
	[0.052]	[0.296]	[0.250]		[0.013]	[0.057]	[0.331]
7149/6215	1.720[c]	0.491[a]	0.350[a]	8613/9011	2.437[a]	0.196	1.274[b]
n=11, 17, 20	(2.196)	(3.044)	(3.859)	n=16, 14, 17	(3.058)	(0.391)	(2.554)
	[0.349]	[0.382]	[0.453]		[0.400]	[0.013]	[0.303]
7172/8450	−0.703	0.863[a]	1.065[a]	8641/9101	0.776[b]	0.380	0.141
n=9, 12, 18	(0.698)	(3.346)	(3.679)	n=15, 17, 18	(2.723)	(1.218)	(0.389)
	[0.065]	[0.528]	[0.459]		[0.363]	[0.090]	[0.009]
7181/8469	0.425	0.871[b]	−0.042	8911/9102	0.150	0.589[a]	0.610[b]
n=14, 11, 13	(0.839)	(2.518)	(0.142)	n=17, 18, 23	(0.489)	(3.231)	(2.797)
	[0.055]	[0.413]	[0.002]		[0.016]	[0.395]	[0.271]
7191/8519	1.138[b]	1.634[a]	0.756[b]	8914/9201	0.686[a]	1.404[a]	0.875[a]
n=18, 18, 21	(2.123)	(5.157)	(2.840)	n=18, 11, 15	(3.772)	(7.293)	(3.460)
	[0.220]	[0.624]	[0.298]		[0.471]	[0.855]	[0.479]
7194/8520	0.269	1.244[b]	0.737[d]	8918/9208	0.348[b]	1.127[b]	0.437
n=15, 15, 15	(0.681)	(2.362)	(1.407)	n=24, 12, 19	(2.363)	(2.450)	(1.063)
	[0.034]	[0.300]	[0.113]		[0.204]	[0.375]	[0.062]
7241/8521	0.368[b]	0.334	0.665[c]	8942/9502	0.215	0.294	0.584[a]
n=20, 16, 18	(2.707)	(1.295)	(1.945)	n=20, 31, 32	(0.906)	(1.129)	(4.360)
	[0.289]	[0.107]	[0.191]		[0.044]	[0.042]	[0.388]

Note: a, b, c and d indicate that the coefficients are significant at the 1, 5, 10 and 20 percent levels respectively. ( ) are their estimated t values, and [ ] the estimated R^2. n is the number of observations for each year.

in the world today. Thus, these results provide empirical support for the neo-H-O theory.

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Notes

1. In Monthly Returns, Trade of Japan, the products were classified according to SITC (Standard International Trade Classification) from 1965 to 1975, CCCN (Customs Co-operation Council Nomenclature) from 1976 to 1987, and HS (Harmonized Commodity Description and Coding System) since 1988.
2. In 1975, the following SITC 4-digit product groups were included in this research: 6130, 6557, 6561, 7121, 7122, 7125, 7141, 7142, 7143, 7149, 7172, 7181, 7191, 7194, 7241, 7242, 7250, 7321, 7323, 7329, 7353, 8411, 8412, 8414, 8613, 8641, 8911, 8914, 8918 and 8942. In 1989 and 1990, the following HS 4-digit product groups were used: 4013, 4101, 4102, 4303, 6101, 6113, 6205, 6212, 6213, 6215, 8450, 8469, 8519, 8520, 8521, 8527, 8528, 8701, 8703, 8704, 8711, 8901, 8903, 8907, 9011, 9101, 9102, 9201, 9208 and 9502. These groups were matched as close as possible.
3. Torstensson divided countries into three groups: *CA*, *LA*, and *IM* countries; where *IM* are intermediate countries, i. e. neither capital nor labour countries. The countries belonging to this group were mostly NIES countries. Given a time lag occurs between a change in a country's per-capita GNP and the quality of their exports, the NIES countries tend to be still producing lower quality products while they have had a significant increase in per-capita GNP. For this reason they were included in *LA* group of countries.
4. Although Japan's economy grew in 1990, due to exchange rate movements, Japan's relative per-capita GNP ranking fell 2 places. Thus exchange rate movements will affect the results obtained for Test 2 and partially explains the low R^2 values obtained.
5. For some countries, 1990 GNP data was not available at the time of this research. For these countries, 1989 data were used. For countries that do not publish GNP data, GDP was used as a proxy for GNP. OPEC members and centrally planned economies were excluded from the analysis.

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