Shujiro Urata

Factor Inputs and Japanese Manufacturing Trade Structure


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FACTOR INPUTS AND JAPANESE MANUFACTURING TRADE STRUCTURE

Shujiro Urata*

I. Introduction

Two different approaches are often used to explain the structure of trade (Stern (1975)). The first, developed by Leontief (1953), compares the relative total (direct and indirect) factor intensities of exports and imports. Tatemoto and Ichimura (1959) used this method to analyze the 1951 pattern of Japanese trade, where they found an interesting dualism with respect to capital-labor intensity. Exports to developed countries were labor intensive, while exports to developing countries were capital intensive. Applying the same method to trade during the 1955-1968 period, Heller (1976) found support for this dualism for both capital-labor and skill intensities, but also observed a substantial narrowing of the differential in the factor intensities of exports to developed and developing countries.

The second approach, which is used in this paper to analyze the Japanese manufacturing trade structure in 1967 and 1975, regresses interindustry variations in net exports, exports and imports on sectoral factor usage. The explanatory variables include energy inputs, as well as the more traditional primary inputs of labor, capital and human capital (Baldwin (1971), Branson and Monoyios (1977)). Although energy itself is not a primary factor of production, Griffin and Gregory’s (1976) demonstration of substitutability between energy and value added provides a rationale for inclusion of the energy variable. Unlike the previous studies of Japan cited above, which examined the full range of tradable commodities, only trade in manufactured goods is analyzed in this paper. Analysis is undertaken for the years 1967 and 1975, which bracket major monetary and energy shocks, and for which detailed sectoral data are readily available. After performing separate regressions on data for each year, the changes in trade structure between 1967 and 1975 are examined. Finally, the results are analyzed in light of the changes in patterns of factor usage that occurred in Japan and her trading partners.

II. Methodology

Two different sets of regressions have been carried out in analyzing the Japanese trade structure in manufactured goods based on alternative measures of human capital: the skill measure (section A) and the wage differential measure (section B). One explanatory note on the wage differential measure that is utilized below: Although this type of wage differential measure is often used as a human capital variable in analyzing the trade structure of the United States, it may not be appropriate as an explanatory variable for the Japanese trade structure for several reasons. First, wage payments in Japan traditionally include not only regular salary, but also a sizeable bonus payment, which is usually paid twice a year based on the performance of the company. Therefore, wage payments are highly correlated with the company’s profit but not with the characteristics of the employees. Second, the relative immobility of labor across industries and the significant amount of non-wage compensation such as company housing makes wage comparison difficult.

* The World Bank.

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See, for example, Branson and Monoyios (1977), and Stern and Maskus (1981).
A. Skill Measure

The regression equation takes the following form:

\[ \frac{NX}{X} = a_0 + a_1UL + a_2SL + a_3CA + a_4EN \]

where

\[ \begin{align*}
NX &= \text{net exports} \\
X &= \text{exports} \\
M &= \text{imports} \\
UL &= \text{unskilled labor (production workers)} \\
SL &= \text{skilled labor (technical and administrative workers)} \\
CA &= \text{capital (book value of depreciable assets)} \\
EN &= \text{energy (cost of fuels and electricity)}.
\end{align*} \]

The regression coefficients are estimated separately for Japan's trade in 1967 and 1975 with (1) the world; (2) the OECD countries; and (3) developing countries. The problem of heteroscedasticity is treated using the generalized least squares method following Branson and Monoyios (1977) which in turn followed the Goldfeld and Quandt and Glejser procedures outlined in Johnston (1972). According to this approach, when heteroscedasticity is detected, the absolute value of the calculated residuals from ordinary least squares is regressed on \( VS \) (the value of shipments), \( VS^2 \) and \( VS^{1/2} \) with a constant term. Then the equation which gives the largest multiple correlation coefficient \( R^2 \) is used as a weight for the generalized least squares regression.\(^3\)

B. Wage Differential Measure

Similar regression analyses to those of section A are conducted using the human capital variable measured by wage differentials. The following equation is used for the regression analysis:

\[ \frac{NX}{X} = a_0 + a_1TL + a_2WD + a_3CA + a_4EN \]

where

\[ \begin{align*}
TL &= \text{total labor (UL + SL)} \\
WD &= \text{human capital measured by wage differential}.
\end{align*} \]

The notations for the rest of the variables are as given earlier.

III. The Data

Sixty-four SITC (5-8) 2- and 3-digit commodities are analyzed for 1967 and 1975 in 1975 prices. The data on trade variables are taken from OECD's Trade by Commodities, Series B for the respective years. The conversion of trade data to constant 1975 prices is based on export and import price indices derived from the Price Indexes Manual (1970 and 1975), published by the Bank of Japan. The data on factor usage and other explanatory variables and the value of shipments \( VS \) are compiled from the Census of Manufactures (1967 and 1975), published by the Ministry of International Trade and Industry in Japan. Unskilled labor \( (UL) \) and skilled labor \( (SL) \) are the numbers of production workers and technical and administrative workers, respectively. The human capital measure based on wage differentials \( (WD) \) is calculated by discounting the excess of the average wage in each industry over the average wage earned in 1975 by a worker under age 17\(^4\) (taken to represent unskilled labor) and by multiplying this excess wage by employment in the industry.\(^5\) Capital \( (CA) \) is the book value of depreciable assets. The value of energy \( (EN) \) is the cost of fuels and electricity.

The manufacturing wage index taken from the Japan Statistical Yearbook (1972 and 1978) is used as a deflator for the computation of the wage differential measure. The wholesale prices of capital goods and energy from the Price Indexes Manual (1978) are utilized for computing input values at constant prices. The producers' price of manufactured goods from the Price

\(^2\)The world here consists of the OECD countries, developing countries and other countries, where the last category is comprised mainly of the socialist countries.

\(^3\)The estimated value of the dependent variable is used for weights if both coefficients on the constant term and the variable are statistically significant. Otherwise, the value of the independent variable is used as a weight. Although Branson and Monoyios (1977) had the same procedure described in the text, they miscalculated the weighted regression equation by including a constant term as pointed out by Stern and Maskus (1981). On the other hand, Maskus (1981) uses the real value of shipment as a scaling factor. Therefore, the factor-output ratios can be interpreted as the measure of factor intensities in the long run.

\(^4\)The average wage earned by a worker under age 17 in 1975 was obtained from the Census of Wages, vol 1, 1975, Ministry of Labor, Japan. The definition of skilled labor used here is based on workers' age rather than workers' educational background, which was used in earlier studies on the U.S. trade structure (e.g., see Branson and Monoyios (1977)). While the unavailability of data on Japanese workers' educational background precluded use of the latter definition, the definition based on workers' age may in fact be more applicable to Japan. Japanese workers usually gain their professional skills through on-the-job training, so that close relationship exists between workers' skill level and their duration of employment at a particular company. While data on duration of employment are not available, the immobility of Japanese labor markets means that the workers' age may be a good proxy for employment duration and hence skill level.

\(^5\)See Branson and Monoyios (1977), p. 114 for a more complete description of this method.
### Table 1.—Estimates of Regressions for 1967: Skill Measure

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Independent Variables</th>
<th>Dependent Variables</th>
<th>( C )</th>
<th>( UL )</th>
<th>( SL )</th>
<th>( CA )</th>
<th>( EN )</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>World</td>
<td>( NX )</td>
<td>-22.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-2.06</td>
<td>-0.04</td>
<td>-0.13</td>
<td>0.269&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( X )</td>
<td>2.99</td>
<td>2.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-1.22</td>
<td>0.34</td>
<td>-0.34</td>
<td>0.537&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( M )</td>
<td>23.99&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.43</td>
<td>0.37</td>
<td>0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.35</td>
<td>0.353&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>1.4</td>
<td>OECD</td>
<td>( NX )</td>
<td>-11.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.79&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-2.55</td>
<td>-0.11</td>
<td>0.12</td>
<td>0.226&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( X )</td>
<td>3.58</td>
<td>1.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.64</td>
<td>0.03</td>
<td>-0.006</td>
<td>0.414&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( M )</td>
<td>18.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.22</td>
<td>0.510&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>1.6</td>
<td>Developing Countries</td>
<td>( NX )</td>
<td>-3.01</td>
<td>0.84&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.23</td>
<td>0.14</td>
<td>-0.20</td>
<td>0.429&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( X )</td>
<td>-0.62</td>
<td>0.85&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-0.15</td>
<td>0.21</td>
<td>-0.24</td>
<td>0.478&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( M )</td>
<td>2.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.01</td>
<td>-0.38</td>
<td>0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-0.04</td>
<td>0.223&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Notes: \( C \) should be interpreted as \( V S^{-1/2} \) in all equations except 1.3 and 1.6, where it should be interpreted as \((23.761 + 0.035 VS)^{-1}\) and \((11.518 + 0.704 VS^{1/2})^{-1}\), respectively. \( t \)-values are in parentheses.

<sup>a</sup>Significant at the 1% level.

<sup>b</sup>Significant at the 5% level.

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**Indexes Manual** (1970, 1975) is used as a deflator for the value of shipments.

### IV. Results<sup>6</sup>

#### A. Trade Structure in 1967 and 1975

Table 1 shows the results obtained for 1967. Unskilled labor is positively related to net exports and exports to all three regions with at least a 5% significance level, and shows a significant negative relation with imports from the OECD countries. The coefficient on skilled labor is positive and significant only for imports from the OECD countries. Capital is positively associated with imports in all the cases. From these results Japan appears to have exported unskilled labor intensive goods and imported capital intensive goods in its trade with developing countries as well as OECD countries, thereby countering the evidence of dualism suggested by earlier studies.

<sup>6</sup>Only the results based on the skill measure are reported here because of two reasons: (1) the results from the two approaches are very similar and (2) the skill measure seems more appropriate to describe human capital in Japan than the wage differential measure as explained above. However, the results of regressions based on the wage differential measure are available from the author.

This inconsistency with previous studies may be attributable to differences in the measure of factor usage applied and differences in the range of commodities examined. As was mentioned in the introduction, the previous studies on the Japanese trade structure analyzed indirect as well as direct factor inputs whereas in this paper only direct factor inputs are examined. Although the total measure (indirect and direct inputs) should be used in the analysis as suggested by Deardorff (1982), lack of input-output tables at a suitable disaggregation level and for the desired years precludes us from utilizing the total measure. However, the results do not seem to be affected much by employing only direct measures, since the correlation coefficient between the direct and total measures of capital-labor ratios in 1965 is 0.87 (significant at 1% level). The previous studies analyzed trade in the primary and services sectors as well as manufactured goods, while our study analyzes only manufactured goods. Therefore, Japan might be shown to have exported capital intensive goods and imported labor intensive goods from developing countries as the previous studies indicated if labor intensive primary goods were included.

<sup>7</sup>The “Sources of Growth and Structural Change” (RPO 671-32) project data bank at the World Bank. 1965 is the closest year to the period analyzed here for which the data are available.
Table 2.—Estimates of Regression Equations for 1975: Skill Measure

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Independent Variables</th>
<th>( C )</th>
<th>( UL )</th>
<th>( SL )</th>
<th>( \Delta )</th>
<th>( EN )</th>
<th>( R^2 )</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>( NX )</td>
<td>-20.61a</td>
<td>-0.15</td>
<td>0.10</td>
<td>0.90a</td>
<td>-1.78a</td>
<td>0.517a</td>
<td>2.1</td>
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<tr>
<td></td>
<td>(2.87)</td>
<td>(-0.22)</td>
<td>(0.05)</td>
<td>(3.64)</td>
<td>(-1.98)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( X )</td>
<td>3.48</td>
<td>-0.0001</td>
<td>0.47</td>
<td>0.92a</td>
<td>-1.92b</td>
<td>0.638a</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>(0.54)</td>
<td>(-0.0002)</td>
<td>(0.24)</td>
<td>(4.14)</td>
<td>(-2.39)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( M )</td>
<td>18.75a</td>
<td>0.34b</td>
<td>0.52</td>
<td>-0.06</td>
<td>0.13</td>
<td>0.565a</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>(3.25)</td>
<td>(2.21)</td>
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<td>(-1.10)</td>
<td>(0.64)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OECD</td>
<td>( NX )</td>
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<td>0.18</td>
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<td>(3.77)</td>
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<td>(1.46)</td>
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</tr>
<tr>
<td></td>
<td>( X )</td>
<td>2.36</td>
<td>0.16</td>
<td>1.08</td>
<td>0.19c</td>
<td>-0.41</td>
<td>0.512a</td>
<td>2.5</td>
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<tr>
<td></td>
<td>(0.76)</td>
<td>(0.56)</td>
<td>(1.18)</td>
<td>(1.78)</td>
<td>(-1.07)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>( M )</td>
<td>12.36a</td>
<td>-0.07</td>
<td>1.01a</td>
<td>-0.01</td>
<td>0.008</td>
<td>0.527a</td>
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<tr>
<td></td>
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<td>(3.11)</td>
<td>(-0.36)</td>
<td>(0.05)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing Countries</td>
<td>( NX )</td>
<td>-0.65</td>
<td>-0.44</td>
<td>-0.10</td>
<td>0.63a</td>
<td>-1.41a</td>
<td>0.506a</td>
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</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(-1.12)</td>
<td>(-0.08)</td>
<td>(4.41)</td>
<td>(-2.70)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( X )</td>
<td>1.21</td>
<td>-0.10</td>
<td>0.53</td>
<td>0.61a</td>
<td>-1.38a</td>
<td>0.348a</td>
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</tr>
<tr>
<td></td>
<td>(0.30)</td>
<td>(-0.25)</td>
<td>(-0.43)</td>
<td>(4.36)</td>
<td>(-2.70)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( M )</td>
<td>2.26</td>
<td>0.35a</td>
<td>-0.34a</td>
<td>-0.05a</td>
<td>0.11</td>
<td>0.56Sa</td>
<td>2.9</td>
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<td></td>
<td>(1.32)</td>
<td>(7.20)</td>
<td>(-2.47)</td>
<td>(-2.39)</td>
<td>(1.61)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: \( C \) should be interpreted as \( V^{2/3} \) in all equations except 2.3, 2.6, 2.9, where it should be interpreted as \( (20.716 + 0.299 V^{2/3})^{-1} \), \( (12.616 + 0.272 V^{2/3})^{-1} \) and \( (4.651 + 0.102 V^{2/3})^{-1} \), respectively. \( t \)-values are in parentheses.

- Significant at the 1% level.
- Significant at the 5% level.
- Significant at the 10% level.

In 1965, for which the data are available from the “Sources of Growth and Structural Change” project at the World Bank, labor-capital ratios for the primary and for the manufacturing sectors are 1.41 and 0.66.

Other possible explanations include factor intensity reversal, domestic demand bias and distortions. In addition, Leamer and Bowen (1981) have recently demonstrated that analyzing the structures of trade and production in one country does not necessarily allow robust conclusions on the factor endowment of that country in relation to its trading partners, except in the highly restrictive two factor case.

In our equation, there remain some manufactured goods whose major inputs are natural resources (e.g., wood pulp into the paper sector). This would explain the positive, significant capital coefficient on manufactured imports from the developing countries, since due to its poor endowment of natural resources, Japan would import natural resource intensive manufactured goods whose production in Japan would require use of a capital intensive technology.

The estimates for 1975 are shown in table 2. Unskilled labor shows a positive and significant relationship with imports from the world and developing countries. The coefficients on skilled labor are significantly positive and negative for imports from the OECD and developing countries, respectively. Capital is positive and significant for net exports and exports to the world and developing countries and marginally significant to the OECD countries. For the imports from the
developing countries, capital is negative and significant. The coefficient on energy is significantly negative for the net exports and exports to the world and the developing countries.

In 1975, Japan exported capital intensive goods to both developing and OECD countries, while Japan imported unskilled labor intensive goods from the world and especially from the developing countries. Japan imported skilled labor intensive goods from the OECD countries, but she imported less of them from the developing countries. Less energy intensive goods were exported to the world and the developing countries in three areas in 1975, whereas they are significantly higher for net exports to the world and developing countries in that year. The changes in coefficients on capital and energy are generally not significant, except that the coefficient on energy declined significantly for net exports to the world and developing countries in that year. The changes in coefficients on skilled labor and energy are generally not significant, except that the coefficient on energy declined significantly for net exports to the world and developing countries. In short, Japanese trade changed substantially during the 1967-75 period. In order to examine the importance of changes in the coefficients on independent variables, a series of dummy variables (which take the value of unity for 1975 and zero for 1967) are introduced into the estimated equations. Table 3 shows the results. \(DUL, DSL, DCA\) and \(DEN\) are dummy variables for \(UL, SL, CA\) and \(EN\), respectively.

Compared to 1967 values, the coefficients on unskilled labor in 1975 are significantly lower for net exports and exports to all three regions, while they are significantly higher for imports from the world and developing countries. The opposite picture emerges for the changes in coefficients on capital. The coefficients on capital are significantly lower for imports from all three areas in 1975, whereas they are significantly higher for net exports to the world and developing countries in that year. The changes in coefficients on skilled labor and energy are generally not significant, except that the coefficient on energy declined significantly for net exports to the world and developing countries. In short, Japanese exports shifted from unskilled labor intensive goods to capital intensive goods, while imports showed the opposite shift from capital intensive goods to unskilled labor intensive goods.

An analysis of the changes in factor usage may help explain the shift in Japanese trade structure. Table 4 shows the changes in factor intensity with respect to unskilled labor for manufacturing industries in Japan.

\[\text{Table 3. Estimates of Regression Equations for the 1967-75 Period: Skill Measure}\]

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Independent Variables</th>
<th>Equation Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>(NX) by (1967)</td>
<td>(1967)</td>
</tr>
<tr>
<td></td>
<td>(1975)</td>
<td>(1975)</td>
</tr>
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<td></td>
<td>(1967)</td>
<td>(1975)</td>
</tr>
<tr>
<td>(C)</td>
<td>(UL)</td>
<td>(UL)</td>
</tr>
<tr>
<td>(DUL)</td>
<td>(SL)</td>
<td>(SL)</td>
</tr>
<tr>
<td>(DSL)</td>
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<td>(CA)</td>
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<tr>
<td>(DCA)</td>
<td>(EN)</td>
<td>(EN)</td>
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<tr>
<td>(DEN)</td>
<td>(\bar{R}^2)</td>
<td>(\bar{R}^2)</td>
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<tr>
<td>(R^2)</td>
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</table>

Notes: C should be interpreted as \(V_2^{-1/2}\) in all equations except 3.3 and 3.6, where it should be interpreted as \((19.542 + 0.721 V_2^{1/2})^{-1}\) and \((14.324 + 0.359 V_2^{1/2})^{-1}\) respectively. t-values are in parentheses.

Significant at the 1% level.
Significant at the 5% level.
Significant at the 10% level.

A similar trend regarding unskilled labor and human capital has been observed for the U.S. manufacturing trade (see Maskus (1981)).
the United States, and Korea between 1967 and 1975. Figures for the United States and Korea are reasonable approximations of those for the OECD and developing country groups since their trade shares with Japan are the largest within the respective groups. Table 4 illustrates that Japan's capital-unskilled labor intensity increased more than that of the United States and Korea, while the skilled labor-unskilled labor intensity also increased, albeit less markedly.12 The observation regarding changes in the capital-unskilled factor intensity for Japan agrees with the shift in the Japanese trade structure.13 Although energy usage increased most among the factor inputs in Japan, Japan exported less energy intensive goods to the developing countries in 1975 than in 1967. One possible reason for this is that Korea may not represent a significant portion of developing countries' trade with Japan in energy intensive goods. In other words, if the factor usage pattern of the oil producing trading partners such as Indonesia were included, this apparent paradox might disappear.

The analysis above indicates that the changes in the Japanese trade structure between 1967 and 1975 broadly reflected the shift in factor usage with respect to trading partners for both unskilled labor and capital.

12 Jorgenson and Nishimizu (1978) and Bowen (1981) also found the gap in capital-labor ratios between the United States and Japan becoming smaller over the 1967–75 period. However, unlike our finding, Bowen found that the capital-labor ratio in Korea increased faster than that in Japan between 1963 and 1975. This difference may be attributed to the differences in sectoral coverage of the sample. Our study only examines the manufacturing sector, whereas Bowen's figure seems to include other sectors such as agriculture and mining. Capital formation in those sectors in Korea in those periods might have been higher than that in Japan.

13 Heller (1976) found this relation in his analysis of the Japanese trade between 1955 and 1968. However, Heller did not consider the changes in factor usage of Japan's trading partners explicitly. Bowen (1981) also found this association between trade structure and resource structure from a sample of thirty-four countries.


