Vertical Intra-Industry Trade, Unit Values of Commodities, and Factor Contents: An Empirical Analysis Based on Micro-Data of the *Census of Manufactures*

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1. Introduction

Recent studies on intra-industry trade (IIT) have brought to light rapid increases in vertical IIT (VIIT), i.e., intra-industry trade where goods are differentiated by quality. Falvey (1981) pointed out in his seminal theoretical paper that commodities of the same statistical group but of different quality may be produced using different mixes of factor inputs. Based on this idea, empirical studies have typically used information on the unit value of commodities as a proxy for product quality and, employing such unit value data, have examined patterns of IIT or the international division of labor (e.g., Greenaway et al. 1994, Fontagné et al., 1997). Research has also shown that developed economies tend to export commodities at higher prices than developing economies (Schott, 2004, Hummels and Klenow, 2005, etc.). These studies suggest that an increase in VIIT may have a large impact on factor demand and factor prices in both developed and developing countries if there exists a positive relationship between commodity prices or quality and physical and human capital-intensities. For example, Widell (2005), addressing this issue, and calculated the factor contents of Swedish trade, adjusting for difference between export unit values and import unit values.[1]

On the other hand, many studies have investigated the impact of increasing imports from developing countries on developed countries, focusing on issues such as domestic skill-upgrading, capital deepening, firm dynamics, and so on (Feenstra and Hanson, 1999, 2001, etc.). Although such studies do not rely on unit value or price information, their ideas are founded on the assumption that developed economies export physical and human capital-intensive products of high quality and import unskilled labor-intensive products of low quality from developing economies. Thus, many theoretical and empirical studies have in common that they take the positive relationships between commodity prices or quality and physical and human capital-intensities as given. Yet, to the best of our knowledge, there are no studies that have empirically examined the relationship between unit values of commodities and their factor contents at the commodity level.

Against this background, in this study, using micro-data of the *Census of Manufactures* (CM) for Japan and comparing the factor inputs of factories producing the same goods, we

[1] There are increasing number of studies which use unit value information as a proxy for product quality. For example, Baldwin and Harrigan (2007) find that export unit values are positively related to distance, which is consistent with the prediction of their quality heterogenous-firms model where only firms with sufficiently high-price/high-quality goods find it worthwhile to see to distant markets. Kugler and Verhoogen (2008) find that output and input prices are positively correlated with plant size within industries and that exporters tend to have higher output and input prices, using Colombian manufacturing plants data. Their interpretation of the results is that input quality and plant productivity are complementary in generating output quality. Hallak and Sivadasan (2009), using manufacturing establishment datasets for India, the U.S., Chile, and Colombia, show that conditional on size, exporters are predicted to sell products of higher quality and at higher prices, pay higher wages and use capital more intensively.

estimate the relationship between the unit values of gross output and factor contents and test whether factories that produce goods with a higher unit value tend to input more skilled labor and capital stock services. To do so, we treat factories producing the same commodity according to detailed commodity classifications as producing the "same" goods. Although we should use information on commodity-level factor intensities ideally, we use factory-level factor intensity information as a proxy for the commodity-level factor intensity information because the commodity-level factor intensities are not available. Using the results of the relationship between unit values and factor intensity, we then estimate the factor contents of Japan's trade with the rest of the world. For the analysis, we use micro-data of the CM and Japanese trade statistics. Factor intensities such as capital-labor ratios and skilled-unskilled labor ratios are calculated at the 6-digit commodity-level using the micro-data of the CM, an establishment-level annual survey conducted by the Ministry of Economy, Trade and Industry. Commodity-level unit values for products made domestically are calculated using the micro-data of the CM, while unit values for exports and imports are calculated using Japan's trade statistics. Then, we match such commodity-level information calculated from the CM with that calculated from the trade statistics. Using this matched dataset, we can measure the factor contents of trade, taking account of differences in unit values of shipments of a particular product by establishments in Japan, of exports, and of imports.

The remainder of the paper is organized as follows. In Section 2, we present a simple theoretical model for the estimation and in Section 3, we describe the data sources for our variables and how our dataset is constructed. In Section 4, we provide econometric evidence on the relationship between output unit values and factor intensities, while in Section 5, we estimate the factor contents of Japan's VIIT. Section 6 concludes the paper.

2. Theoretical Analysis of Factor Contents in VIIT

In this section, we present a simple theoretical model to examine factor contents in vertical intra-industry trade. We begin by providing a model in which factories, in order to produce commodities of a high quality, engage in production processes that are intensive in both skilled labor and capital. Next, using this framework, we derive an econometric model to estimate the relationship between output unit values and factor contents. Finally, we estimate factor contents in Japan's vertical intra-industry trade with the rest of the world.

We assume the existence of four factors, skilled (white-collar) labor (L_S), unskilled (blue-collar) labor (L_U), capital (K) and intermediate input (M).[2] We focus on a certain

[2] In the *Census of Manufactures*, data on the number of skilled and unskilled workers are not available. What are available, however, are data on the number of non-production and production workers. Since non-production workers tend to be more highly educated and in charge of relatively sophisticated tasks, such

manufacturing industry, such as the electrical and precision machinery or the general machinery industry. Suppose that N commodities are produced in this industry. For each commodity, there is a continuum of different qualities $[\underline{q}, \overline{q}]$. We assume that each "commodity" in our model corresponds to one product item in the most detailed commodity classification of production and trade statistics and that products that differ only in quality are not recorded as different products in the statistics.

Each commodity is produced by a Leontief-type constant-returns-to-scale production function. We examine the profit maximization behavior of factory i in year t, which produces commodity (n, q), that is, commodity n of quality q. The production function of this factory is defined by

$$Y_{q,i,t} = \frac{a_{i,t} c_{n,t}}{e(q_{i,t})} \min\left[\frac{L_{U,q,i,t}}{\alpha}, \frac{L_{S,q,i,t}}{\beta f(q_{i,t})}, \frac{K_{q,i,t}}{\gamma g(q_{i,t})}, \frac{M_{q,i,t}}{\delta h(q_{i,t})} \right] \tag{3.1}$$

where $L_{U,q,i,t}$, $L_{S,q,i,t}$, $K_{q,i,t}$ and $M_{q,i,t}$ denote blue-collar labor, white-collar labor, capital, and intermediate input. $Y_{q,i,t}$ denotes the gross output of factory i. $a_{i,t}$ denotes factory i's total factor productivity (TFP) level in comparison with the industry average TFP level in year t. To simplify our notation, we omit suffix n for variables except for the commodity-specific term $c_{n,t}$. We normalize values $a_{i,t}$ and $c_{n,t}$ so that the average value of $\ln(a_{i,t})$ across all factories producing commodity n is zero for any t. The parameters α, β, γ and δ are constant positive values satisfying $\alpha + \beta + \gamma + \delta = 1$, and do not depend on n.

In order to raise output quality, factories need to change their amount of factor inputs. The relationship between output quality and factor inputs is determined by four functions, $e(q_{i,t})$, $f(q_{i,t})$, $g(q_{i,t})$, and $h(q_{i,t})$. These functions are continuously differentiable in q, take positive values for any $q \in [\underline{q}, \overline{q}]$, $0 < \underline{q} < 1 < \overline{q}$, and satisfy $e(1)=1$, $f(1)=1$, $g(1)=1$ and $h(1)=1$. What is of key interest in our analysis are the signs of $f'(q_{i,t})$ and $g'(q_{i,t})$. If these derivatives are positive, we will have the relationship that as $q_{i,t}$ approaches $\overline{q}$, the commodity becomes more white-collar labor and physical-capital intensive. To simplify our analysis, we also assume that the elasticities of these functions in $q_{i,t}$ are constant. We express these elasticity values by $\eta_Y=(q_{i,t}\, de(q_{i,t}))/(e(q_{i,t})\, dq_{i,t})$, $\eta_S=(q_{i,t}\, df(q_{i,t}))/(f(q_{i,t})\, dq_{i,t})$, $\eta_K=(q_{i,t}\, dg(q_{i,t}))/(g(q_{i,t})\, dq_{i,t})$, $\eta_M=(q_{i,t}\, dh(q_{i,t}))/(h(q_{i,t})\, dq_{i,t})$, respectively.

We assume that all factories are price takers in factor markets. Let $w_{U,t}$, $w_{S,t}$, r_t and $p_{M,t}$

as management, monitoring of production processes, planning, and research and development (R&D), we use the ratio of non-production to production workers as a proxy for ratio of skilled to unskilled workers and refer to this variable as the white-collar/blue-collar labor ratio.

denote the wage rate for blue-collar workers, the wage rate for white-collar workers, the cost of capital, and the price of intermediate input in year *t*. From cost minimization conditions, we have the following relationships:

$$\frac{L_{S,q,i,t}}{L_{U,q,i,t}} = \frac{\beta}{\alpha} f(q_{i,t}) \tag{3.3}$$

$$\frac{K_{q,i,t}}{L_{U,q,i,t}} = \frac{\gamma}{\alpha} g(q_{i,t}) \tag{3.4}$$

$$\frac{M_{q,i,t}}{L_{U,q,i,t}} = \frac{\delta}{\alpha} h(q_{i,t}) \tag{3.5}$$

From the above relationships and our production function, we have the following factor demand functions:

$$\frac{L_{U,q,i,t}}{Y_{q,i,t}} = \frac{\alpha}{a_{i,t} c_{n,t}} e(q_{i,t}) \tag{3.6}$$

$$\frac{L_{S,q,i,t}}{Y_{q,i,t}} = \frac{\beta}{a_{i,t} c_{n,t}} e(q_{i.t}) f(q_{i,t}) \tag{3.7}$$

$$\frac{K_{q,i,t}}{Y_{q,i,t}} = \frac{\gamma}{a_{i,t} c_{n,t}} e(q_{i,t}) g(q_{i,t}) \tag{3.8}$$

$$\frac{M_{q,i,t}}{Y_{q,i,t}} = \frac{\delta}{a_{i,t} c_{n,t}} e(q_{i,t}) h(q_{i,t}) \tag{3.9}$$

We assume monopolistic competition. The price elasticity of demand for each factory's output in this industry is constant and takes the same value for all factories producing commodity *n*. This means that the mark-up ratio will be the same for all factories and we will have the following relationship between factory *i*'s unit production cost, $u_{q,\,i,\,t}$, and the unit value of its output, $p_{q,\,i,\,t}$:

$$p_{q,i,t} = (1 + \lambda_n) u_{q.i,t} \tag{3.10}$$

Unit production cost is determined by

$$
\begin{aligned}
u_{q,i,t} &= w_{U,t}\frac{L_{U,q,i,t}}{Y_{q,i,t}} + w_{S,t}\frac{L_{S,q,i,t}}{Y_{q,i,t}} + r_t\frac{K_{q,i,t}}{Y_{q,i,t}} + p_{M,t}\frac{M_{q,i,t}}{Y_{q,i,t}} \\
&= \frac{e(q_{i,t})}{a_{i,t}c_{n,t}}\left(\alpha w_{U,t} + \beta f(q_{i,t})w_{S,t} + \gamma g(q_{i,t})r_t + \delta h(q_{i,t})p_{M,t}\right)
\end{aligned} \tag{3.11}
$$

We assume that most of the four elasticity parameters, η_Y, η_S, η_K, η_M, do not take large negative values, so that $u_{q,i}$ is an increasing function of q.

If we take the logarithm of both sides of the above equation and use equation (3.10), we obtain

$$
\begin{aligned}
\ln\left(p_{q,i,t}\right) = \ln\left(e\left(q_{i,t}\right)\right) + \ln\left(\alpha w_{U,t} + \beta f(q_{i,t})w_{S,t} + \gamma g(q_{i,t})r_t + \delta h(q_{i,t})p_{M,t}\right) \\
- \ln\left(a_{i,t}\right) - \ln\left(c_{n,t}\right) + \ln\left(1+\lambda\right)
\end{aligned} \tag{3.12}
$$

We make a linear approximation of each term on the right-hand side of the above equation around a certain value of q_t, which we denote by q_t *. If we subtract the average values of each term of equation (3.12) across all factories from both sides of equation (3.12), we obtain

$$
\begin{aligned}
&\ln\left(p_{q,i}\right) - \overline{\ln\left(p_t\right)} = \\
&\left(\eta_Y + \frac{\beta f(q_t{*})w_{S,t}\eta_S + \gamma g(q_t{*})r_t\eta_K + \delta h(q_t{*})p_{M,t}\eta_M}{\alpha w_{U,t} + \beta f(q_t{*})w_{S,t} + \gamma g(q_t{*})r_t + \delta h(q_t{*})p_{M,t}}\right)\left(\ln\left(q_{i,t}\right) - \overline{\ln\left(q_t\right)}\right) \\
&- \ln\left(a_{i,t}\right)
\end{aligned} \tag{3.13}
$$

Variables with upper bars denote average values. To derive the above equation, we used the fact that the average value of $\ln(a_{i,t})$ is equal to zero as a result of our normalization of $a_{i,t}$ and $c_{n,t}$.

By making a linear approximation of equation (3.3) and subtracting average values across all factories from both sides of the equation, we have

$$
\ln\left(\frac{L_{S,q,i,t}}{L_{U,q,i,t}}\right) - \overline{\ln\left(\frac{L_{S,t}}{L_{U,t}}\right)} = \eta_S\left(\ln\left(q_{i,t}\right) - \overline{\ln\left(q_t\right)}\right) \tag{3.14}
$$

From equations (3.13) and (3.14), we obtain the relationship between the unit value of a product and its white-collar labor intensity:

$$\ln\left(\frac{L_{S,q,i,t}}{L_{U,q,i,t}}\right)-\overline{\ln\left(\frac{L_{S,t}}{L_{U,t}}\right)}=\theta_S\left(\ln\left(p_{q,i,t}\right)-\overline{\ln\left(p_t\right)}\right)+\theta_S\ln\left(a_{i,t}\right) \tag{3.15}$$

By using equation (3.13) and one of the equations (3.4), (3.5) or (3.6), we also obtain the following equations:

$$\ln\left(\frac{K_{q,i,t}}{L_{U,q,i,t}}\right)-\overline{\ln\left(\frac{K_{t}}{L_{U,t}}\right)}=\theta_K\left(\ln\left(p_{q,i,t}\right)-\overline{\ln\left(p_t\right)}\right)+\theta_K\ln\left(a_{i,t}\right) \tag{3.16}$$

$$\ln\left(\frac{M_{q,i,t}}{L_{U,q,i,t}}\right)-\overline{\ln\left(\frac{M_{t}}{L_{U,t}}\right)}=\theta_M\left(\ln\left(p_{q,i,t}\right)-\overline{\ln\left(p_t\right)}\right)+\theta_M\ln\left(a_{i,t}\right) \tag{3.17}$$

$$\ln\left(\frac{L_{U,q,i,t}}{Y_{q,i,t}}\right)-\overline{\ln\left(\frac{L_{U,t}}{Y_{t}}\right)}=\theta_Y\left(\ln\left(p_{q,i,t}\right)-\overline{\ln\left(p_t\right)}\right)+\theta_Y\ln\left(a_{i,t}\right)-\ln\left(a_{i,t}\right) \tag{3.18}$$

where

$$\theta_S=\frac{\eta_S}{\left(\eta_Y+\dfrac{\beta f(q_t*)w_{S,t}\eta_S+\gamma g(q_t*)r_t\eta_K+\delta h(q_t*)p_{M,t}\eta_M}{\alpha w_{U,t}+\beta f(q_t*)w_{S,t}+\gamma g(q_t*)r_t+\delta h(q_t*)p_{M,t}}\right)}$$

$$\theta_K=\frac{\eta_K}{\left(\eta_Y+\dfrac{\beta f(q_t*)w_{S,t}\eta_S+\gamma g(q_t*)r_t\eta_K+\delta h(q_t*)p_{M,t}\eta_M}{\alpha w_{U,t}+\beta f(q_t*)w_{S,t}+\gamma g(q_t*)r_t+\delta h(q_t*)p_{M,t}}\right)}$$

$$\theta_M=\frac{\eta_M}{\left(\eta_Y+\dfrac{\beta f(q_t*)w_{S,t}\eta_S+\gamma g(q_t*)r_t\eta_K+\delta h(q_t*)p_{M,t}\eta_M}{\alpha w_{U,t}+\beta f(q_t*)w_{S,t}+\gamma g(q_t*)r_t+\delta h(q_t*)p_{M,t}}\right)}$$

$$\theta_Y=\frac{\eta_Y}{\left(\eta_Y+\dfrac{\beta f(q_t*)w_{S,t}\eta_S+\gamma g(q_t*)r_t\eta_K+\delta h(q_t*)p_{M,t}\eta_M}{\alpha w_{U,t}+\beta f(q_t*)w_{S,t}+\gamma g(q_t*)r_t+\delta h(q_t*)p_{M,t}}\right)}$$

These are the four equations that we estimate in order to examine the relationship between output unit values and factor contents. Since we assume constant returns to scale and a constant mark-up ratio, we have the following identity among the coefficients of (3.15)-(3.18):

$$\theta_Y + \frac{\beta f(q_t^*) w_{S,t}}{\alpha w_{U,t} + \beta f(q_t^*) w_{S,t} + \gamma g(q_t^*) r_t + \delta h(q_t^*) p_{M,t}} \theta_S$$
$$+ \frac{\gamma g(q_t^*) r_t}{\alpha w_{U,t} + \beta f(q_t^*) w_{S,t} + \gamma g(q_t^*) r_t + \delta h(q_t^*) p_{M,t}} \theta_K \qquad (3.19)$$
$$+ \frac{\delta h(q_t^*) p_{M,t}}{\alpha w_{U,t} + \beta f(q_t^*) w_{S,t} + \gamma g(q_t^*) r_t + \delta h(q_t^*) p_{M,t}} \theta_M = 1$$

This constraint means that a one percent increase in the unit price of output corresponds to a one percent increase in the unit production cost.

We estimate equations (3.15)-(3.18) under the constraint (3.19). For the constraint (3.19), we use the sample average cost share of white-collar workers as the value of $\beta f(q_t^*)w_{S,t}/\{\alpha w_{U,t}+\beta f(q_t^*)w_{S,t}+\gamma g(q_t^*)r_t+\delta h(q_t^*)p_{M,t}\}$. We also use the sample average cost share of capital service input as the value of $\gamma g(q_t^*)r_t/\{\alpha w_{U,t}+\beta f(q_t^*)w_{S,t}+\gamma g(q_t^*)r_t+\delta h(q_t^*)p_{M,t}\}$ and the sample average cost share of intermediate input as the value of $\delta h(q_t^*)p_{M,t}/\{\alpha w_{U,t}+\beta f(q_t^*)w_{S,t}+\gamma g(q_t^*)r_t+\delta h(q_t^*)p_{M,t}\}$.

3. Data

The core empirical part of this paper estimates the relationship between output unit values and factor intensities, and calculates the factor contents embodied in Japan's VIIT using this relationship. We first describe the data sources for our variables and then explain how our dataset was constructed.

As a first step, using micro-data of the *Census of Manufactures* for Japan and comparing the factor inputs of factories producing the same good, we estimate the relationship between the unit value of gross output and factor intensities based on commodity- and factory-level data. The CM is an annual survey conducted by the Ministry of Economy, Trade and Industry. We use the establishment-level data of the *Larger Establishment Sample* of the CM that covers all manufacturing establishments with 30 or more employees.[3] The CM includes information on shipments by commodity for each establishment as well as other

[3] The CM consists of two samples, the *Larger Establishment Sample* and the *Smaller Establishment Sample*, which includes data on factories with less than 30 employees. Because data on the number of white-collar and blue-collar workers are not available in the *Smaller Establishment Sample*, we use the data of the *Large Establishment Sample* for the analysis in this paper. Moreover, in the *Smaller Establishment Sample*, tangible assets data are missing for many establishments.

establishment-level data such as the book value of capital, intermediate input, the number of production and non-production workers, the wage bill, and so on. Using the micro-data of the CM, we calculate factor intensities at the establishment level such as the white-collar/blue-collar labor ratio, the capital/blue-collar labor ratio, the intermediate input/blue-collar labor ratio, and the blue-collar labor/output ratio.[4] Moreover, using the information on a 6-digit commodity classification basis, we select only single-product establishments, which we define as establishments where one commodity accounts for more than 60 percent of total shipments. In the CM, there are approximately 2,000 commodities, out of which quantity information is available for approximately 800 commodities. Based on the 60 percent threshold, we calculate the unit value of a commodity (commodity-level shipments divided by quantity) and various factor intensities at the establishment level. As a result, we obtain information both on unit values and factor intensities for approximately 500+ commodities for each year. However, data on the number of production and non-production workers are available only for 1981, 1984, 1987, and 1990, and we cannot distinguish between production and non-production workers after 1990. Therefore, in this paper, we mainly use the micro-data of the CM for these four years to estimate the relationship between the unit value of output and factor intensities. By estimating equations (3.15)-(3.18), we can derive the relationship between the unit value of output and factor intensities. For the estimation, we employ seemingly unrelated regression (SUR) estimations subject to the constraint expressed by equation (3.19). The estimation results will be presented in Section 4.

After obtaining the relationship between the unit value of output and factor intensities, we calculate the factor contents of Japan's VIIT by matching the trade statistics with the commodity-level unit value and factor intensity data taken from the CM. In the case of Japan's trade statistics, classification at the 9-digit commodity level is available, which is

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[4] Some people may argue that the production- and non-production-job category does not appropriately capture skill levels of workers. Some production workers with a long working experience may be much more skilled than non-production workers with less working experience. Or, education level may determine skills of workers to some extent. However, data on working experience or education levels are not available in the CM and only available data are number of production workers and non-production workers. More disaggregated job categories are not available in the CM. According to the *Basic Survey on Wage Structure* for Japan, production workers are clearly less educated than non-production workers. In the manufacturing sector in 1990, 96 percent of the production workers received only primary and secondary education while 42 percent of the non-production workers received tertiary education. Moreover, average hourly wage for male non-production workers with secondary education was 36 percent higher than that for male production workers with secondary education in the manufacturing sector in 1990. Comparing hourly wages for male workers with approximately 14 years experience in the company, non-production workers received 23 percent higher hourly wage than production workers on average. Therefore, we interpret that the production-non-production-job category can be a proxy for skill levels and we use this job category in the empirical anaylysis in this paper.

much more detailed than the commodity classification for the CM.[5] Therefore, we match the trade statistics with the CM data at the CM's 6-digit commodity level. We do so for 1990, because at this stage, the commodity-level correspondence between the trade statistics and the CM is available only for 1990.[6] Using the trade statistics, we calculate the unit values for Japan's export and import commodities and then match the commodity-level unit value data for exports and imports with the commodity-level unit value data and factor intensity data taken from the CM. We should note that the matched data are limited to commodities for which the unit of quantity is the same in both the CM and the trade statistics.[7] As a result, for the year 1990, we obtain unit value and factor intensity data for 635 commodities from the CM, out of which 354 commodities have export unit value information while 336 commodities have import unit value information.

4. Empirical Results on the Relationship between Output Unit Values and Factor Intensities

In this section, we report our estimation results on the relationship between output unit values and factor intensities. We estimate the system of equations (3.15)-(3.18) under the constraint expressed by equation (3.19), using SUR techniques. In order to take account of the possibility that factor intensities and production technologies may differ across industries, we estimated the system of equations separately for the following ten manufacturing subsectors: food, textiles, wood, chemicals, ceramics, metals, general machinery, electrical and precision machinery, transportation equipment, and miscellaneous products. A full set of year dummies is included in order to capture industry-level productivity shocks over time.

The estimation results are reported in Table 1. The most important result is that in the case of the relationship between unit values and the white-collar/blue-collar labor ratio, the coefficient was positive for all ten subsectors and statistically significant for eight. That is, to produce high unit-value products, factories need a high white-collar/blue-collar labor ratio. White-collar labor tends to be more abundant and therefore relatively cheap in developed economies, so that developed economies are expected to have a comparative advantage in white-collar labor intensive products. Our finding that more expensive products are more white-collar labor intensive is consistent with the well known stylized fact that developed

[5] For example, for 1990, we identified 6,716 export commodities and 8,744 import commodities at the 9-digit commodity level in the Trade Statistics compared with only 1,853 commodities at the 6-digit level in the CM.

[6] We hope to construct correspondence tables for other years and extend our analysis in the near future.

[7] There are various quantity units reported in the CM and the Trade Statistics. In the case of the Trade Statistics, approximately 90 percent of commodities with quantity information are reported in terms of kilograms or tons. However, in the case of the CM, the unit "number" is the most frequent quantity unit, although there are also many commodities that are reported in terms of tons.

economies tend to export products with higher unit values and import products with lower unit values (Fukao et al., 2003; Schott 2004).

Insert Table 1

The relationship between the capital/blue-collar labor ratio and unit values and that between the intermediate input/blue-collar labor ratio and unit values differ across subsectors. For example, the unit value coefficient in the capital/blue-collar labor ratio equation is positive in six subsectors (textiles, chemicals, general machinery, electrical and precision machinery, transportation equipment, and miscellaneous products) but negative in the other four subsectors.

It is interesting to note that the coefficient in the blue-collar labor/gross output ratio equation is greater than 0.9 in all subsectors. This result implies that in order to raise the unit value of their output by 10 percent, factories need to increase their blue-collar labor input per output by more than 9 percent. In other words, in order to produce higher unit value products, an increase only of white-collar labor input or of capital is not sufficient. Our estimation results show that even if factories increase their white-collar/blue-collar labor ratio, they also need to increase the input/output ratio for all other inputs simultaneously.[8]

In order to check the robustness of our results, we also estimate the system of four equations (3.15)-(3.18) without the constraint (3.19). The results are reported in Table 2. The results are very similar to those in Table 1 in most of the subsectors.[9]

Insert Table 2

One caveat regarding the CM data is that they do not cover the activities of headquarters if these are not located in the same place as the factory. This means that headquarter activities, such as research and development, design, and advertising, which tend to be white-collar labor and capital-intensive and are necessary to produce and sell

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[8] From equations (3.17) and (3.18), we have the following relationship:

$$\ln\left(\frac{K_{U,q,i,t}}{Y_{q,i,t}}\right)-\overline{\ln\left(\frac{K_{U,t}}{Y_t}\right)}=(\theta_K+\theta_Y)\theta_Y\left(\ln\left(p_{q,i,t}\right)-\overline{\ln(p_t)}\right)+\theta_K\ln\left(a_{i,t}\right)+\theta_Y\ln\left(a_{i,t}\right)-\ln\left(a_{i,t}\right)$$

Taking the electrical machinery industry as an example, this implies that in order to raise the unit value of output by 10 percent, factories need to increase their capital input per output by 1.62+9.29=10.91 percent (see column (9) in Table 1).

[9] We should note that high output prices may reflect high mark-ups rather than high product quality. We jointly estimated equations (3.15)-(3.18), using unit production costs instead of unit output prices. We obtained very similar results to those in Tables 1 and 2. Therefore, we interpret that high output prices should reflect high product quality.

high-quality products, are included for some observations but not for others. This means that the coefficients in the regressions for the white-collar/blue-collar labor ratio and the capital/blue-collar labor ratio may be biased. Another potential problem of our estimation is that the unit value of output could be arbitrary and not convey meaningful information if the output is traded within the firm. In order to examine whether our estimates are affected by these potential issues, we re-estimate the system of four equations (without the constraint) using only data of factories belonging to firms with no additional factory and whose headquarters are located in the same place. As Table 3 shows, the results are largely similar to those in Tables 1 and 2.

Insert Table 3

5. Factor Contents in Japan's VIIT

In this section we estimate the factor contents of Japan's VIIT. We first present our theoretical framework and then, using concrete examples, show how we obtain the necessary data for the factor content analysis. Finally, we calculate the factor contents.

We can derive factor contents of international trade from our estimators of elasticity values as well as the factor demand functions. We assume that $a_{i,t}$ is close to one for any i and any t. Using equations (3.15) and (3.18), we can express the ratio of the white-collar labor input to the output quantity for a factory which produces commodity (n, q) as follows:

$$\frac{L_{S,n,t}(p_t)}{Y_{n,t}(p_t)} = c'_{n,t} p_t^{\theta_S + \theta_Y} \tag{3.20}$$

where $c'_{n,t}$ denotes a commodity- and year-specific constant term.

Let $\varphi_{D,n,t}(p_t)$ denote the distribution function of output quantity by all the factories producing commodity n in Japan over unit value p. Then, we can derive the following equation from (3.20):

$$L_{S,D,n,t} = Y_{D,n,t} c'_{n,t} \int_{p_t=0}^{+\infty} p_t^{\theta_S + \theta_Y} \varphi_{D,n,t}(p_t) dp_t \tag{3.21}$$

where $L_{S,D,n,t}$ denotes the total input of white-collar labor in products made in Japan of n and $Y_{D,n,t}$ denotes the total domestic output quantity of n. Finally, white-collar labor embodied in Japan's exports of commodity n, $L_{S,E,n,t}$, and imports, $L_{S,I,n,t}$, is given by

$$L_{S,E,n,t} = Y_{E,n,t} \frac{L_{S,D,n,t}}{Y_{D,n,t}} \frac{\int_{p_t=0}^{+\infty} p_t^{\theta_S+\theta_Y} \varphi_{E,n,t}(p_t)dp_t}{\int_{p_t=0}^{+\infty} p_t^{\theta_S+\theta_Y} \varphi_{D,n,t}(p_t)dp_t} \tag{3.22}$$

$$L_{S,I,n,t} = Y_{I,n,t} \frac{L_{S,D,n,t}}{Y_{D,n,t}} \frac{\int_{p_t=0}^{+\infty} p_t^{\theta_S+\theta_Y} \varphi_{I,n,t}(p_t)dp_t}{\int_{p_t=0}^{+\infty} p_t^{\theta_S+\theta_Y} \varphi_{D,n,t}(p_t)dp_t} \tag{3.23}$$

where $Y_{E,n,t}$ and $Y_{I,n,t}$ denote the total export volume and total import volume of commodity n. $\varphi_{E,n,t}(p_t)$ and $\varphi_{I,n,t}(p_t)$ denote the distribution functions of export and import quantity over unit value. Usually, we do not know these distribution functions. But we do know the average unit value of exports and imports:

$$p_t^E = \int_{p_t=0}^{+\infty} p_t \varphi_{E,n,t}(p_t)dp_t \tag{3.24}$$

$$p_t^I = \int_{p_t=0}^{+\infty} p_t \varphi_{I,n,t}(p_t)dp_t \tag{3.25}$$

If we assume that $\varphi_{E,n,t}(p_{n,t})$ and $\varphi_{I,n,t}(p_t)$ follow a log normal distribution and their standard deviations are, say, one half of $\varphi_{D,n,t}(p_t)$, we can derive $L_{S,E,n,t}$ and $L_{S,I,n,t}$.

By using equations (3.16)-(3.18), we also obtain the following equations:

$$K_{E,n,t} = Y_{E,n,t} \frac{K_{D,n,t}}{Y_{D,n,t}} \frac{\int_{p_t=0}^{+\infty} p_t^{\theta_K+\theta_Y} \varphi_{E,n,t}(p_t)dp_t}{\int_{p_t=0}^{+\infty} p_t^{\theta_K+\theta_Y} \varphi_{D,n,t}(p_t)dp_t} \tag{3.26}$$

$$K_{I,n,t} = Y_{I,n,t} \frac{K_{D,n,t}}{K_{n,t}} \frac{\int_{p_t=0}^{+\infty} p_t^{\theta_K+\theta_Y} \varphi_{I,n,t}(p_t)dp_t}{\int_{p_t=0}^{+\infty} p_t^{\theta_K+\theta_Y} \varphi_{D,n,t}(p_t)dp_t} \tag{3.27}$$

$$L_{U,E,n,t} = Y_{E,n,t} \frac{L_{U,D,n,t}}{Y_{D,n,t}} \frac{\int_{p_t=0}^{+\infty} p_t^{\theta_Y} \varphi_{E,n,t}(p_t)dp_t}{\int_{p_t=0}^{+\infty} p_t^{\theta_Y} \varphi_{D,n,t}(p_t)dp_t} \tag{3.28}$$

$$L_{U,I,n,t} = Y_{I,n,t} \frac{L_{U,D,n,t}}{Y_{D,n,t}} \frac{\int_{p_t=0}^{+\infty} p_t^{\theta_Y} \varphi_{I,n,t}(p_t)dp_t}{\int_{p_t=0}^{+\infty} p_t^{\theta_Y} \varphi_{D,n,t}(p_t)dp_t} \tag{3.29}$$

Next, using concrete examples, we show how we obtain the necessary data for our factor content analysis, such as the unit value of the shipments of a particular product by firms in Japan, of exports and of imports of that product, and the standard deviation of the unit values of shipments of that product. [10]

Table 4 provides summary information of our unit value analysis for the case of "cotton tubular knit fabric," a category at the most disaggregated, 6-digit commodity category level of the CM. We can calculate unit values and factor contents for 14 factories for 1990. The average unit value of the gross output of these single-product factories is 1.36 million yen per ton. The standard deviation of the natural log of unit values across factories is 0.607. "Cotton tubular knit fabric" cover three commodity categories in the 9-digit commodity classification of the Harmonized System (HS) in the case of Japan's exports and six commodity categories in the case of Japan's imports.

Insert Table 4

It is interesting to note that the unit value of Japan's exports (2.48 million yen per ton), which is calculated as the total value of exports over the total volume of exports, is more than 50 percent higher than the unit value of total shipments by single-product factories (1.36 million yen per ton). Probably, two factors contribute to this gap in unit values. One is that among factories in Japan, only those factories that are white-collar labor-intensive and producing output with a high unit value may be engaged in exporting. The other factor is that the observations for our unit value analysis consist only of single-product factories, which may be less white-collar labor-intensive and produce cheaper products than the average factory in Japan. On the other hand, the unit value of Japan's imports (1.34 million yen per ton) is almost the same as the unit value of the total shipments by single-product factories.

Next, Table 5 provides summary information of our unit value analysis for the case of "light and small passenger cars," another category at the 6-digit commodity level of the CM. We can calculate unit values and factor contents for 9 factories for 1990. The average unit value of the gross output of these single-product factories is 0.943 million yen per unit, and the standard deviation of the natural log of unit values across factories is 0.237. "Light and

[10] In the CM, we cannot distinguish between shipments for the domestic market and shipments for the export market. Moreover, there is no information on exports by each establishment and we cannot distinguish whether an establishment is involved in exporting/importing or not. In 2001, however, a question was added in the CM asking for the export-shipment ratio of each establishment. Thus, for years after 2001, it may be possible to distinguish between the unit value of products made and sold in Japan and the unit value of products made in Japan but exported.

small passenger cars" cover seven commodity categories in the 9-digit commodity classification of the Harmonized System (HS) in the case of Japan's exports and five commodity categories in the case of Japan's imports.

Insert Table 5

In the case of this type of cars, the unit value of Japan's exports (0.981 million yen unit) is almost equal to the unit value of all shipments by single-product factories in Japan (0.943 million yen per unit). On the other hand, the unit value of Japan's imports (2.66 million yen per unit) is much higher than the unit value of all shipments by single-product factories and the unit value of exports. A probable reason is that Japan imports mainly luxury cars.

Using such unit value information taken from the CM and the trade statistics as well as data on factor intensities for each commodity, we estimate the factor contents of Japan's VIIT based on equations (3.22), (3.23) and (3.26)-(3.29). For p_t, we use the log of the unit value of all shipments by single-product factories. For p_t^E and p_t^I, we use the log of the unit value of Japan's exports and the log of the unit value of Japan's imports, respectively.[11] We also obtain from the CM factor inputs and the total domestic output quantity for each commodity, $L_{S,D,n,t}$, $K_{D,n,t}$, $L_{U,D,n,t}$, $Y_{D,n,t}$, while total export and import volumes for each commodity, $Y_{E,n,t}$ and $Y_{I,n,t}$, are obtained from the trade statistics.

As already mentioned, we do not know the distribution functions of export and import quantities over unit values, $\varphi_{E,n,t}(p_t)$ and $\varphi_{I,n,t}(p_t)$, but we do know the average unit value of exports and imports. Therefore, we assume that $\varphi_{E,n,t}(p_{n,t})$ and $\varphi_{I,n,t}(p_t)$ follow a log normal distribution and their standard deviations are equal to: (1) the standard deviation of the distribution function of output quantity by all the factories producing commodity n in Japan over unit value p, $\varphi_{D,n,t}(p_t)$; (2) one half of the standard deviation of $\varphi_{D,n,t}(p_t)$; or (3) twice the standard deviation of $\varphi_{D,n,t}(p_t)$. If we assume that $\varphi_{E,n,t}(p_{n,t})$ and $\varphi_{I,n,t}(p_t)$ follow a log normal distribution, we can simplify equations (3.22), (3.23) and (3.26)-(3.29). For example, equation (3.22) can be rewritten as:

$$L_{S,E,n,t} = Y_{E,n,t} \frac{L_{S,D,n,t}}{Y_{D,n,t}} \exp\left\{ (\theta_S + \theta_Y)(\mu_E - \mu_D) + \frac{1}{2}(\theta_S + \theta_Y)^2 (\sigma_E^2 - \sigma_D^2) \right\} \tag{3.22'}$$

[11] In the case of the log of the unit value of all shipments by single-product factories, the log of the unit value is the simple mean of factory-level unit values in logarithm for each 6-digit commodity in the CM. In the case of the log of the unit value of Japan's exports and imports, we calculate the log of the sum of exports (imports) in the 9-digit commodities in the trade statistics corresponding to the 6-digit commodity category in the CM divided by the sum of the quantities in the 9-digit commodities in the trade statistics.

where μ_E and μ_D denote the log of the unit value of Japan's exports and the average of the factory-level unit values in logarithm, respectively, for commodity n. σ_E and σ_D denote the standard deviation of the distribution functions of exports and of all shipments by single-product factories, respectively, for commodity n. For σ_D, we use the standard deviation calculated from the unit value data of the CM. For σ_E, we assume above three cases. Similarly, we can rewrite equations (3.23) and (3.26)-(3.29) using $\mu_{E,}$ $\mu_{I,}$ $\mu_{D,}\sigma_{E,}$ $\sigma_{I,}$ *a*nd σ_D.

We calculate the factor contents of exports or imports for 1990 at the 6-digit commodity level for commodities for which unit value information can be calculated and the CM data and the trade statistics can be matched.[12] The values are then aggregated at the broad industry level and the results shown in Table 6. We find, first, that estimated factor contents vary depending on our assumption with regard to the standard deviation, suggesting that finding a plausible assumption regarding the standard deviation is one of the key issues for improving our factor contents estimation. Second, we were not able to obtain a unit value and match the CM data with the trade data for many commodities. Therefore, the estimated factor contents of trade shown in Table 6 are subject to serious underestimation. In fact, as shown in Table 7, the coverage ratios of the matched commodities are not very high. The first column of Table 7 shows the coverage ratio based on the shipment value taken from the CM. The coverage ratio is defined as sum of shipments of matched commodities divided by total domestic shipments. The second and third columns of Table 7 show the coverage ratio calculated from the trade statistics as the amount of exports (imports) of matched commodities divided by total amount of exports (imports). The coverage ratio for all manufacturing sectors together is 10.4 percent based on shipments, 32.0 based on exports, and 21.6 percent based on imports. Although the coverage ratios for some industries, such as metals and transportation equipment, are relatively high, those for general machinery and electrical and precision machinery are extremely low.

In fact, VIIT is most prominent in the machinery industries in Japan and East Asia.[13] Therefore, in order to improve our estimation, it is critical to find a way to estimate factor contents of VIIT for the machinery industries. Moreover, given the fact that VIIT in East Asia increased rapidly in the 1990s, an urgent task is to apply our methodology to data for later years, for example 2000 or 2005, in order to examine the impact of increasing VIIT on

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[12] In Japan's Trade Statistics, exports are recorded on an f.o.b. basis while imports are on c.i.f. basis. Moreover, insurance and freight cannot be separated from the cost of imported goods. Therefore, if the value of imports is simply divided by the quantity of imports, import unit values will be overestimated. In order to mitigate this problem, we subtract 10 percent from all import values, a percentage that is approximately equivalent to the cost of insurance and freight, as suggested by Fukao et al. (2003), who estimate the difference between c.i.f. and f.o.b. values and report that the difference is 12.35 percent in the case of electrical machinery.

[13] See Fukao et al. (2003), for example.

changes in the factor content of Japan's trade.

Insert Tables 6 & 7

6. Conclusion (Tentative)

This paper aimed to contribute to the development of a new analytical framework for the empirical study of factor contents of VIIT. To this end, we first examined whether or not the widely used assumption of a positive relationship between unit values and human- or physical-capital intensities holds.

We found significant and stable relationships between factor intensities and unit values for many industries. As for the relationship between the unit value of a product and its white-collar labor intensity, the significant and positive relationship we found is important empirical evidence which supports the assumption widely used in theoretical models that commodities with higher prices are of higher quality and more human capital-intensive. On the other hand, we found that the relationship between the unit value of a product and its capital intensity is not always positive and that the relationship is significantly negative in some sectors. That is, we find that the widely used assumption that commodities with higher prices are more physical capital-intensive does not always hold.

After confirming the significant relationships between unit values and factor intensities, we tried to estimate the factor contents of trade, taking account of differences in unit values of shipments of a particular product by establishments in Japan, of exports, and of imports. However, at this stage, we face the following difficulties. First, estimated factor contents varied depending on our assumption with regard to the standard deviation of distribution functions of export and import quantities over unit values. This suggests that finding a plausible assumption regarding the standard deviation is one of the key issues for improving our factor contents estimation. Second, we were not able to obtain a unit value and match the CM data with the trade data for many commodities. Particularly, the coverage problem is serious in the machinery industries where VIIT is most prominent in East Asia. We need to find a way to estimate factor contents of VIIT for the machinery industries. Third, the factor contents analysis is limited to the year 1990. Extending our analysis to 2000 or 2005 onwards certainly is an urgent task to capture the rapid increase in VIIT in the 1990s.

If we can resolve some of the difficulties we are currently facing, our methodology may enable us to conduct various pioneering analyses on VIIT and factors embodied in trade. Given that in many parts of the world, intra-industry trade is more prominent than traditional inter-industry trade, there is an urgent need to develop a new research framework to gain a better and more detailed understanding of the impact of intra-industry trade.

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Table 1. Relationship between factor intensity and unit price: Seemingly Unrelated Regression estimations with constraint

Equation number	Dependent variable	Food (1)	Textiles (2)	Wood (3)	Chemicals (4)	Ceramics (5)	Metals (6)	General machinery (7)	Electrical and precision machinery (8)	Transpor-tation equipment (9)	Miscellane-ous products (10)
(3.15)	dvlnWBratio	0.144***	0.108***	0.057	0.161***	0.087**	0.044**	0.119***	0.138***	0.010	0.259***
		(0.040)	(0.016)	(0.033)	(0.022)	(0.027)	(0.015)	(0.015)	(0.022)	(0.025)	(0.056)
(3.16)	dvlnKBratio	-0.245***	0.066***	-0.069	0.048	-0.005	-0.094***	0.058***	0.162***	0.066	0.151*
		(0.043)	(0.017)	(0.047)	(0.028)	(0.031)	(0.020)	(0.016)	(0.027)	(0.036)	(0.068)
(3.17)	dvlnMBratio	-0.283***	0.116***	-0.028	-0.061**	-0.064**	-0.177***	0.081***	0.070***	0.032	0.058
		(0.033)	(0.017)	(0.032)	(0.019)	(0.021)	(0.015)	(0.013)	(0.019)	(0.027)	(0.041)
(3.18)	dvlnBYratio	1.212***	0.909***	1.022***	1.031***	1.035***	1.132***	0.928***	0.929***	0.972***	0.938***
		(0.028)	(0.013)	(0.027)	(0.016)	(0.016)	(0.012)	(0.010)	(0.016)	(0.022)	(0.032)
	Number of observations	3006	6712	1942	4334	5515	8270	2267	1736	906	1074

Notes:
1. The dependent variables are factor intensities expressed in logarithmic form (deviation from the commodity-year mean).
2. Standard errors are in parentheses, with ***, ** and * indicating significance at the 1, 5 and 10 percent level, respectively.
3. Constant terms and year dummies are included, but estimated coefficients are not reported.
4. For the estimation, pooled data of factories with 30 or more employees in 1981, 1984, 1987, 1990 were used.

Table 2. Relationship between factor intensity and unit price: Seemingly Unrelated Regression estimations without constraint

Equation number	Dependent variable	Food (1)	Textiles (2)	Wood (3)	Chemicals (4)	Ceramics (5)	Metals (6)	General machinery (7)	Electrical and precision machinery (8)	Transpor-tation equipment (9)	Miscellane-ous products (10)
(3.15)	dvlnWBratio	0.098*	0.112***	0.057	0.162***	0.097***	0.046**	0.119***	0.143***	0.011	0.284***
		(0.040)	(0.016)	(0.033)	(0.022)	(0.027)	(0.015)	(0.015)	(0.022)	(0.025)	(0.056)
(3.16)	dvlnKBratio	-0.212***	0.065***	-0.073	0.045	-0.021	-0.091***	0.057***	0.176***	0.065	0.162*
		(0.043)	(0.017)	(0.047)	(0.028)	(0.032)	(0.020)	(0.016)	(0.027)	(0.036)	(0.068)
(3.17)	dvlnMBratio	-0.202***	0.109***	-0.028	-0.072***	-0.021	-0.176***	0.081***	0.066***	0.031	0.038
		(0.034)	(0.017)	(0.032)	(0.019)	(0.022)	(0.015)	(0.013)	(0.019)	(0.027)	(0.041)
(3.18)	dvlnBYratio	0.967***	0.895***	1.004***	0.978***	0.895***	1.107***	0.920***	0.902***	0.962***	0.856***
		(0.033)	(0.013)	(0.030)	(0.018)	(0.021)	(0.013)	(0.011)	(0.017)	(0.024)	(0.036)
	Number of observations	3006	6712	1942	4334	5515	8270	2267	1736	906	1074

Notes:
1. The dependent variables are factor intensities expressed in logarithmic form (deviation from the commodity-year mean).
2. Standard errors are in parentheses, with ***, ** and * indicating significance at the 1, 5 and 10 percent level, respectively.
3. Constant terms and year dummies are included, but estimated coefficients are not reported.
4. For the estimation, pooled data of factories with 30 or more employees in 1981, 1984, 1987, 1990 were used.

Table 3. Relationship between factor intensity and unit price: Seemingly Unrelated Regression estimations without constraint, based on data of factories belonging to firms with no additional factory and whose headquarters are located in the same place

		Food	Textiles	Wood	Chemicals	Ceramics	Metals	General machinery	Electrical and precision machinery	Transpor-tation equipment	Miscellane-ous products
Equation number	Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(3.15)	dvlnWBratio	0.157**	0.114***	-0.003	0.226***	0.163***	0.067**	0.120***	0.116***	-0.001	0.190**
		(0.058)	(0.022)	(0.042)	(0.037)	(0.045)	(0.022)	(0.019)	(0.035)	(0.030)	(0.073)
(3.16)	dvlnKBratio	-0.186**	0.058*	-0.040	0.005	-0.128*	-0.046	0.044*	0.075	0.015	0.215*
		(0.063)	(0.023)	(0.057)	(0.046)	(0.055)	(0.029)	(0.021)	(0.042)	(0.050)	(0.091)
(3.17)	dvlnMBratio	-0.187***	0.081***	-0.045	-0.041	-0.001	-0.144***	0.093***	0.022	-0.027	0.013
		(0.048)	(0.022)	(0.044)	(0.035)	(0.038)	(0.023)	(0.018)	(0.029)	(0.035)	(0.052)
(3.18)	dvlnBYratio	1.039***	0.912***	1.041***	0.951***	0.870***	1.105***	0.904***	0.962***	1.002***	0.881***
		(0.047)	(0.018)	(0.040)	(0.028)	(0.036)	(0.020)	(0.015)	(0.027)	(0.030)	(0.046)
	Number of observations	1578	3548	963	1452	2245	3766	1050	601	468	561

Notes:
1. The dependent variables are factor intensities expressed in logarithmic form (deviation from the commodity-year mean).
2. Standard errors are in parentheses, with ***, ** and * indicating significance at the 1, 5 and 10 percent level, respectively.
3. Constant terms and year dummies are included, but estimated coefficients are not reported.
4. For the estimation, pooled data of factories with 30 or more employees in 1981, 1984, 1987, 1990 were used.

Table 4. Summary table of the unit value analysis: The case of cotton tubular knit fabric

Unit value data of the *Census of Manufactures 1990*

Commodity classification name in the *Census of Manufactures*	Cotton tubular knit fabric
Commodity code	1451-11
Number of factories whose data were used	14
Number of white-collar workers per one million yen gross output	0.0066
Number of blue-collar workers per one million yen gross output	0.0167
Capital stock (in million yen) per one million yen gross output	0.1257
Average unit value (million yen per ton)	1.3571
Standard deviation of unit value (million yen per ton)	1.6016
Average of natural log of unit value	0.0393
Standard deviation of natural log of unit value	0.6073

Corresponding Trade Statistics for 1990

Exports

HS 9-digit code	HS 9-digit name			
600210190	Knitted or crocheted fabrics of a width not exceeding 30 cm, containing by weight 5% or more of elastomeric yarn or rubber thread, made of cotton			
	Unit value of exports (million yen per ton)	2.240	Quantity of exports (ton)	15.497
	Value of exports (million yen)	34.709		
600220190	Knitted or crocheted fabrics of a width not exceeding 30 cm, made of cotton, other than those of heading 600210			
	Unit value of exports (million yen per ton)	2.583	Quantity of exports (ton)	13.849
	Value of exports (million yen)	35.768		
600230190	Knitted or crocheted fabrics of a width exceeding 30 cm, containing by weight 5% or more of elastomeric yarn or rubber thread, made of cotton			
	Unit value of exports (million yen per ton)	2.527	Quantity of exports (ton)	52.484
	Value of exports (million yen)	132.633		
Total value of exports (million yen)		203.110	Total volume of exports	81.830
Total value of exports/total volume of exports (million yen)		2.482		
Weighted average of unit value of exports (weight: value of exports)		2.488		

Imports

HS 9-digit code	HS 9-digit name			
600210031	Knitted or crocheted fabrics of a width not exceeding 30 cm, containing by weight 5% or more of rubber thread, not figured, made of cotton			
	Unit value of imports (million yen per ton)	1.903	Quantity of imports (ton)	7.579
	Value of imports (million yen)	14.423		
600210092	Knitted or crocheted fabrics of a width not exceeding 30 cm, containing by weight 5% or more of elastomeric yarn, not figured, made of cotton			
	Unit value of imports (million yen per ton)	n.a.	Quantity of imports (ton)	0
	Value of imports (million yen)	0.000		
600220022	Knitted or crocheted fabrics of a width not exceeding 30 cm, not figured, made of cotton, other than those of heading 600210			
	Unit value of imports (million yen per ton)	0.731	Quantity of imports (ton)	32.095
	Value of imports (million yen)	23.469		
600230031	Knitted or crocheted fabrics of a width exceeding 30 cm, containing by weight 5% or more of rubber thread, not figured, made of cotton			
	Unit value of imports (million yen per ton)	5.614	Quantity of imports (ton)	0.057
	Value of imports (million yen)	0.320		
600230092	Knitted or crocheted fabrics of a width exceeding 30 cm, containing by weight 5% or more of elastomeric yarn, not figured, made of cotton			
	Unit value of imports (million yen per ton)	9.790	Quantity of imports (ton)	0.200
	Value of imports (million yen)	1.958		
600292020	Knitted or crocheted fabrics, not figured, made of cotton, other than those of heading 600210, 600220, and 600230			
	Unit value of imports (million yen per ton)	1.382	Quantity of imports (ton)	364.215
	Value of imports (million yen)	503.195		
Total value of imports (million yen)		543.365	Total volume of imports (ton)	404.146
Unit value (Total value of imports/total volume of imports, million yen per to		1.344		
Weighted average of unit value of imports (weight: value of imports)		1.400		

Table 5. Summary table of the unit value analysis: The case of light and small passenger cars

Unit value data of the *Census of Manufactures 1990*

Commodity classification name in the *Census of Manufactures*	Light and small passenger cars, less than 2000ml cylinder capacity, including chassis
Commodity code	3111-11
Number of factories whose data were used	9
Number of white-collar workers per one million yen gross output	0.0024
Number of blue-collar workers per one million yen gross output	0.0065
Capital stock (in million yen) per one million yen gross output	0.0824
Average unit value (million yen per unit)	0.9431
Standard deviation of unit value (million yen per unit)	0.2069
Average of natural log of unit value	4.5229
Standard deviation of natural log of unit value	0.2374

Corresponding Trade Statistics for 1990

Exports

HS 9-digit code	HS 9-digit name			
870321910	Passenger automobiles, with spark-ignition internal combustion reciprocating piston engine, of a cylinder capacity not exceeding 550cc, excluding knock down products			
	Unit value of exports (million yen per unit)	0.302	Quantity of exports (unit)	12,730
	Value of exports (million yen)	3,848		
870321920	Passenger automobiles, with spark-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 550cc and not exceeding 1,000cc, excluding knock down products			
	Unit value of exports (million yen per unit)	0.587	Quantity of exports (unit)	215,033
	Value of exports (million yen)	126,218		
870322900	Passenger automobiles, with spark-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 1,000cc and not exceeding 1,500cc, excluding knock down products			
	Unit value of exports (million yen per unit)	0.814	Quantity of exports (unit)	1,027,269
	Value of exports (million yen)	836,088		
870323910	Passenger automobiles, with spark-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 1,500cc and not exceeding 2,000cc, excluding knock down products			
	Unit value of exports (million yen per unit)	1.152	Quantity of exports (unit)	1,589,365
	Value of exports (million yen)	1,831,106		
870331910	Passenger automobiles, with compression-ignition internal combustion reciprocating piston engine, of a cylinder capacity not exceeding 1,000cc, excluding knock down products			
	Unit value of exports (million yen per unit)	0.679	Quantity of exports (unit)	2,688
	Value of exports (million yen)	1,826		
870331920	Passenger automobiles, with compression-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 1,000cc and not exceeding 1,500cc, excluding knock down products			
	Unit value of exports (million yen per unit)	0.769	Quantity of exports (unit)	2,425
	Value of exports (million yen)	1,866		
870332910	Passenger automobiles, with compression-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 1,500cc and not exceeding 2,000cc, excluding knock down products			
	Unit value of exports (million yen per unit)	0.929	Quantity of exports (unit)	79,611
	Value of exports (million yen)	73,921		
Total value of exports (million yen)		2,874,872	Total volume of exports	2,929,121
Total value of exports/total volume of exports (million yen)		0.981		
Weighted average of unit value of exports (weight: value of exports)		1.021		

Imports

HS 9-digit code	HS 9-digit name			
870321000	Passenger automobiles, with spark-ignition internal combustion reciprocating piston engine, of a cylinder capacity not exceeding 1,000cc			
	Unit value of imports (million yen per unit)	0.842	Quantity of imports (unit)	17,974
	Value of imports (million yen)	15,140		
870322000	Passenger automobiles, with spark-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 1,000cc and not exceeding 1,500cc			
	Unit value of imports (million yen per unit)	1.064	Quantity of imports (unit)	9,300
	Value of imports (million yen)	9,895		
870323000	Passenger automobiles, with spark-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 1,500cc and not exceeding 3,000cc			
	Unit value of imports (million yen per unit)	2.951	Quantity of imports (unit)	171,001
	Value of imports (million yen)	504,628		
870331000	Passenger automobiles, with compression-ignition internal combustion reciprocating piston engine, of a cylinder capacity not exceeding 1,500cc			
	Unit value of imports (million yen per unit)	1.772	Quantity of imports (unit)	3
	Value of imports (million yen)	5		
870332000	Passenger automobiles, with compression-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 1,500cc and not exceeding 2,500cc			
	Unit value of imports (million yen per unit)	2.044	Quantity of imports (unit)	2,740
	Value of imports (million yen)	5,600		
Total value of imports (million yen)		535,269	Total volume of imports (unit)	201,018
Unit value (Total value of imports/total volume of imports, million yei		2.663		
Weighted average of unit value of imports (weight: value of imports)		2.847		

Table 6. Estimated factor contents of trade: Matched commodities

(a) Assumption 1: $\sigma_E=\sigma_I=\sigma_D$

	EXPORTS			IMPORTS			NET EXPORTS		
Industry	L_S	L_U	K	L_S	L_U	K	L_S	L_U	K
1 Food	232	701	6,185	1,794	3,443	53,854	-1,562	-2,742	-47,669
2 Textiles	2,327	8,923	46,755	1,299	7,160	44,153	1,028	1,764	2,602
3 Wood	568	1,634	58,805	3,039	7,264	132,163	-2,471	-5,630	-73,358
4 Chemicals	8,716	12,833	301,346	5,930	15,242	211,145	2,787	-2,409	90,201
5 Ceramics	2,186	5,233	74,253	706	1,411	23,469	1,481	3,821	50,785
6 Metals	10,447	27,516	393,667	4,851	11,652	306,520	5,596	15,864	87,147
7 General machinery	1,614	2,370	15,556	117	166	1,070	1,497	2,204	14,485
8 Electrical & precision machinery	13,789	15,658	182,639	2,246	588	36,034	11,543	15,070	146,605
9 Transportation equipment	32,487	82,460	414,535	2,169	7,704	44,542	30,318	74,756	369,993
10 Miscellaneous products	28	108	544	1	12	44	27	96	500
Manufacturing total	72,395	157,436	1,494,285	22,152	54,642	852,995	50,243	102,794	641,290

(b) Assumption 2: $\sigma_E=\sigma_I=0.5*\sigma_D$

	EXPORTS			IMPORTS			NET EXPORTS		
Industry	L_S	L_U	K	L_S	L_U	K	L_S	L_U	K
1 Food	215	670	6,011	1,557	3,127	51,277	-1,342	-2,458	-45,266
2 Textiles	2,093	8,365	42,169	1,172	6,650	40,401	921	1,714	1,768
3 Wood	522	1,511	55,455	2,731	6,342	126,097	-2,209	-4,830	-70,643
4 Chemicals	7,435	11,293	270,394	5,072	14,117	193,581	2,363	-2,824	76,813
5 Ceramics	1,905	4,609	68,014	612	1,240	21,226	1,293	3,369	46,789
6 Metals	9,105	24,123	359,715	4,605	11,108	300,332	4,500	13,016	59,383
7 General machinery	1,233	1,899	12,051	75	120	738	1,158	1,779	11,313
8 Electrical & precision machinery	9,978	12,821	130,676	1,292	399	20,263	8,686	12,422	110,413
9 Transportation equipment	27,372	70,149	369,135	1,964	6,831	42,996	25,408	63,318	326,139
10 Miscellaneous products	22	93	479	1	10	34	21	84	446
Manufacturing total	59,881	135,534	1,314,098	19,082	49,944	796,944	40,798	85,590	517,154

(c) Assumption 3: $\sigma_E=\sigma_I=2*\sigma_D$

	EXPORTS			IMPORTS			NET EXPORTS		
Industry	L_S	L_U	K	L_S	L_U	K	L_S	L_U	K
1 Food	339	864	6,994	3,399	5,317	66,195	-3,060	-4,453	-59,201
2 Textiles	4,091	12,303	78,725	2,143	9,896	66,202	1,947	2,407	12,523
3 Wood	874	2,430	77,422	5,356	13,847	169,824	-4,482	-11,417	-92,402
4 Chemicals	47,300	37,579	800,787	38,856	35,291	520,583	8,444	2,288	280,204
5 Ceramics	4,336	9,437	115,376	1,501	2,712	39,514	2,835	6,725	75,862
6 Metals	21,814	55,081	638,835	6,526	15,335	339,962	15,288	39,746	298,873
7 General machinery	6,350	6,726	51,294	784	657	5,182	5,566	6,069	46,112
8 Electrical & precision machinery	67,628	39,691	989,147	20,770	2,990	367,900	46,858	36,701	621,248
9 Transportation equipment	71,224	171,718	793,460	3,497	13,423	52,899	67,727	158,296	740,561
10 Miscellaneous products	84	207	1,028	5	26	129	79	181	899
Manufacturing total	224,039	336,036	3,553,068	82,836	99,493	1,628,391	141,203	236,543	1,924,677

Notes: σ_E: standard deviation of log of unit value for exports; σ_I: standard deviation of log of unit value for imports.

σ_D: standard deviation of log of unit value for domestically produced goods.

L_s: white-collar labor (number of workers) embodied in trade.

L_u: blue-collar labor (number of workers) embodied in trade.

K: Capital stock (million yen) embodied in trade.

Table 7. Coverage ratio for the matched commodities

(%)

Industry	*Census*	*Trade Statistics*	
	Domestic shipments	Exports	Imports
1 Food	14.8	16.2	8.0
2 Textiles	6.0	25.9	9.8
3 Wood	6.9	30.8	34.0
4 Chemicals	12.4	33.0	30.6
5 Ceramics	14.9	38.6	19.5
6 Metals	21.2	67.1	41.6
7 General machinery	1.1	2.2	0.9
8 Electrical & precision machinery	4.0	10.4	4.4
9 Transportation equipment	13.3	67.6	51.9
10 Miscellaneous products	0.4	0.2	0.0
Manufacturing total	10.4	32.0	21.6

Notes: The coverage ratio calculated from the *Census* data is defined as shipments of matched commodities divided by total domestic shipments.

The coverage ratio calculated from the *Trade Statistics* is defined as exports (imports) of matched commodities divided by total exports (imports).