Uniqueness of Japanese Auto Inputs:

An Investigation by the Concept of Incomplete Contract and the Elasticity of Substitution [1)]

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Abstract

The earthquake and subsequent tsunami and nuclear power plant accidents in March 2011 in Japan caused a temporal disruption of part supply for motor vehicle production. It is also said that because of the disruption even U.S. automobile production was scaled down, since most makers source parts and components from Japanese suppliers. This implies how important, or *unique*, Japanese parts are for auto makers in the U.S., or raises a question of why those makers within the U.S. were not simply able to change suppliers.

This study investigates the question using an incomplete contract model, in which the situation can be seen as a hold-up problem. A maker contracts out production of a specific part with a particular supplier, but because of the technological importance it has to rely on the supplier. To investigate, I estimate and compare the degree of the import elasticity of substitution between countries for parts to the U.S. With the Armington's assumption, a regression model derived from the two-level constant-elasticity-of-substitution (CES) production function, augmented by a rule of law index, is estimated. It is shown that a part category such as integrated circuits, including micro-controller units, in fact has relatively *lower* degree of the elasticity of substitution than other parts. Therefore, it might be inferred that regardless of whether firms belong to a vertical production network, it is technologically necessary to procure some parts from Japanese part suppliers. (JEL Classification Numbers: F12, F14, F23, L23, L24)

Keywords: trade in intermediate inputs, elasticity of substitution, incomplete contract, hold-up problem, U.S. auto parts imports

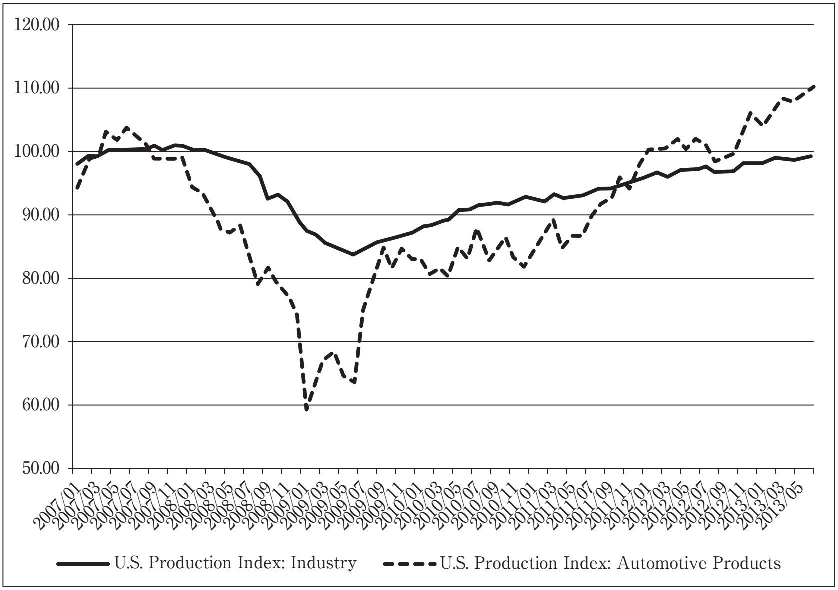
1. Introduction

International trade in intermediate inputs has been growing very fast. It accounts for about 40 percent of worldwide trade at present. A large part of the growth of such trade is mainly due to the expansion of *vertical* foreign direct investment (FDI) and international outsourcing. The more multinational enterprises engage in FDI, the more they trade parts and components within the firm. The intra-firm trade has expanded as a result of spreading stages of the production process over countries, and is now accounting for about a third of worldwide trade. International outsourcing, on the other hand, more often reflects the characteristics of parts, such as the degree of specificity.

One of the economic impacts of the earthquake hitting the northern part of Japan on March 11th, 2011 was concerning these types of trade. There was considerable damage to parts factories in the region. Since they were an important supplier producing and exporting parts and components of motor vehicles, as well as various electronic products, their supply chain was temporarily disrupted right after the natural disaster.[3] The Ministry of Economy, Trade and Industry [METI], Japan, reports that due to this disruption, as Figure 1 shows, U.S. auto production decreased by 8.9% in April 2011 (over previous month) (METI (2011)). They argue that many factories producing micro controller units[4] were located in the region,[5] and the damage of factories stopped the supply, leading to the reduction of auto production in the U.S.[6] James (2011) also points out that the impact is not limited to the Japanese firms, but for non-Japanese automakers as well, the disruption of supply chain affected their production schedules since most automakers source parts and components from Japanese suppliers.

This incident motivated my current research asking whether the production disruption was caused simply by the shortage of parts in storage, or more fundamentally could be attributed to technological irreplaceability. Firm's organizational choices for part production can be commonly described by a 4 dimensional table as in Feenstra (2010, p.5). With factor prices and technologies different across countries, a firm would choose foreign outsourcing over integration for some part production. In this case, the firm has to make a decision further on which part it should outsource and to which country. This is a choice between in-house production abroad versus international outsourcing, where characteristic differences of parts are considered. To deal with this decision-making process, I use the two-level constant-elasticity-of-substitution (CES) production function, incorporating the choice problems of source countries and parts separately. Estimation results with U.S. import data show that for some parts, in fact, the micro-controller-included product category represents a lower degree of elasticity of substitution as well as strong contracting environment effects. It appears that this kind of part exported from Japan is rather technologically more *unique* compared to the *same* part from other countries, and thus it had a more direct impact on U.S. auto production than others.

Figure 1. U.S. Production Index: January 2007 – June 2013, 2007 = 100



Sources: FRB and CEIC database.
Note: Data are seasonally adjusted.

2. Literature review

The literature on a firm's organization and incomplete contract theory provides an important idea about input trade in line with a firm's make-and-buy decision making. The arguments have been developed on factors for which vertical integration is preferred to international outsourcing or vice versa (Grossman and Helpman (2003), Spencer (2005), Helpman (2006b), for example). Among the various factors, contracting environment of a country and contractible activities in input production have been particularly focused on recently (Acemoglu, Antras, and Helpman (2007), Nunn (2007), and Nunn and Trefler (2008)).

Another focal point is about model structure: technological complementarities. Acemoglu, Antras, and Helpman (2007) introduced a model in which one can analyze the relationship between the degree of contractual incompleteness, the elasticity of input substitution, and productivity of a firm's profit function. They show that the productivity impact is higher as contractual incompleteness improves like improvement of legal institutions, but such effect is greater when the degree of technological complementarity among inputs is higher. Helpman (2006a) explains that industries with lower elasticity of substitution are more sensitive to contract incompleteness. Based on these arguments, the current paper focuses on the substitutability of an input from various countries with different degrees of contracting enforceability.

As for empirical studies, Head, Ries, and Spencer (2004) and studies by Nunn and Trefler are the most representative. As Helpman suggests, however, the direct testing of the hypothesis from theory is difficult because of data availability; we need transaction data classified into international outsourcing or FDI on a firm level.[7] Thus, industry data are more often used to investigate whether the resulting trade pattern reflects such factors as contracting environment. Case in point, the share of U.S. intrafirm trade is investigated by Nunn and Trefler (2008). Using Census data, from which data on imports and exports by related-parties are available,[8] they find that for industries with a high level of headquarter intensity, intra-firm imports are positively related to contracting environment.[9]

3. Elasticity of substitution in a third market: from the exporters' perspective

To examine the degree of substitutability of Japanese parts, first I estimate the elasticity of substitution for automobile parts exported from Japan and a competing country to the U.S., China, and the world. The product categories are the ones considered as parts and components of motor vehicles, indicated under the Harmonized Commodity Description and Coding System (HS) 85 and 87 product categories of the United Nations, *Commodity Trade Database* [*COMTRADE*]. I selected 18 6-digit auto parts. These HS code numbers and their product names are listed in Appendix Table.

The exporter elasticity of substitution (σ) is defined as follows.

$$\sigma = \frac{d \ln \left(x_J / x_C \right)}{d \ln \left(w_J / w_C \right)}, \qquad (1)$$

where x_J represents Japanese export quantity of a part to a third country, x_C is the competing country's export quantity of the same part to the same country, and w_J and w_C are the prices of the part exported from Japan and from the competing country, respectively. The part is assumed to be imperfectly substituted. The simple way to obtain the elasticity of substitution is to regress the numerator on the denominator of equation (1). That is,

$$ln \left(x_J / x_C \right) = \alpha + \sigma \cdot ln \left(w_J / w_C \right) + u, \; J = Japan, \; c = 1, 2, \cdots, C. \qquad (2)$$

An error term u is added to describe an estimation model in equation (2). The estimate of the coefficient on the relative price term shows the elasticity estimated (σ). The sign of σ is defined as negative, which means that for a part with large elasticity, if the price of the part exported from Japan is raised, its export is more likely replaced by the export of the *same* part from the other country. If the elasticity is small, however, rise in price of the part will not likely lead to replacement by the competitor's exports.

The *COMTRADE* database provides us with detailed trade data for by-country-by-commodity import and export values and quantities. I collected export data of the 18 parts for 28 countries designated to the U.S., China, and the world. A unit price of export is calculated simply by dividing the

Table 1. Elasticity of Exporter Substitution between Japan and Competing Countries: 18 Auto Parts to the U.S., China, and the World, 2010

		Destination U.S.			China			World		
	HS 6-digit Code No.	sigma (σ)	t-value	R-Squared	sigma (σ)	t-value	R-Squared	sigma (σ)	t-value	R-Squared
1	850300	-2.58**	-4.202	0.482	-1.91	-1.942	0.173	-1.49	-1.812	0.147
2	851140	-1.76**	-4.946	0.527	-0.82	-0.926	0.048	-4.33**	-3.883	0.376
3	851290	-1.45	-1.708	0.127	0.18	0.322	0.005	-1.88**	-2.989	0.263
4	854231	-1.99**	-5.802	0.754	0.30	0.292	0.008	-1.65*	-2.365	0.318
5	870600	-2.20**	-3.530	0.509	1.08	0.552	0.027	0.92	1.539	0.086
6	870810	-2.83**	-5.090	0.564	-1.15	-1.748	0.127	-0.58	-0.700	0.019
7	870821	-0.17	-0.155	0.002	-0.44	-0.445	0.016	-2.00*	-2.234	0.166
8	870829	-1.56	-1.409	0.076	0.77	1.022	0.047	0.31	0.381	0.006
9	870830	-2.88**	-3.029	0.338	-1.02	-1.538	0.129	-2.81*	-2.504	0.248
10	870840	-2.04**	-2.857	0.262	-1.31	-1.159	0.066	0.68	0.840	0.027
11	870850	-3.32**	-3.366	0.362	-1.67	-1.789	0.151	-2.12*	-2.062	0.145
12	870870	-2.68*	-2.261	0.176	-1.89*	-2.663	0.252	-0.59	-0.471	0.009
13	870880	-2.58**	-4.708	0.491	-1.40	-1.644	0.119	-1.24	-1.530	0.086
14	870891	-3.37**	-3.797	0.385	-0.62	-0.889	0.040	-2.98**	-4.060	0.397
15	870892	-3.13**	-3.317	0.344	-1.19	-1.938	0.165	-0.48	-0.497	0.010
16	870893	-2.49*	-2.721	0.261	-2.56**	-4.089	0.443	-2.25*	-2.372	0.184
17	870894	-3.97**	-3.559	0.355	0.05	0.059	0.0002	-2.87*	-2.519	0.202
18	870899	-3.38**	-5.180	0.528	-2.60**	-3.020	0.275	-0.34	-0.417	0.007

Data Source: United Nations, *COMTRADE Database* (downloaded from the web site: http://comtrade.un.org/db/ce/ceSearch.aspx).

Notes: The elasticity of exporter substitution is the estimated coefficient on ln (WJ/Wc) by OLS with a constant term. Two asterisks "**" show the 1% significance level, and an asterisk "*" shows the 5% significance level. The 28 countries and areas are: Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Luxembourg, Malaysia, Mexico, the Netherlands, New Zealand, Norway, Portugal, Russia, Singapore, South Africa, Spain, Switzerland, Thailand, the U.K., and the U.S. The number of observations varies from 13 to 26 for the U.S. and China, and 14 to 27 for the World.

export value by the export quantity (numbers or weights (kilogram)). The Japanese variable is taken as a numeraire, and so, its relative ratio to each one of the 27 competing countries is calculated.

Table 1 reports the estimation results.[10] The goodness of fit is generally better for the U.S. model than for China's or the world's. Thus I focus on the results of the U.S. model only. Concerning the magnitude of the elasticities, I found that they vary from 1.76 (HS 851140, starter motors etc.) to nearly 4 (HS 870894, steering wheels etc.) in terms of absolute value. This suggests that the part's characteristics and other factors give rise to the different degree of export competition. As for the product category HS 854231, the product category including micro-controller units, the elasticity is estimated to be -1.99, which is one of the lowest elasticities among the 18 parts. Even when the price of this part exported from Japan rises, it would be very unlikely to be replaced by the *same* part exported from other countries. Moreover, when the supply of the part is disrupted, it would be hard to find a replacement.

The argument so far was made from an exporter's point of view. Since the trade of a specific part requires a contract between a buyer and a supplier, it is necessary to explicitly consider the buyer's (importer's) behavior. In the next section, I consider an analytical framework from the importer's perspective.

4. Vertical networks, outsourcing, and elasticity of substitution for an auto part

4.1 Vertical integration versus international outsourcing in the Japanese auto industry

In the growing international trade of inputs, vertical production networks play a significant role. For producing auto parts, Japanese multinational enterprises commonly engage in vertical integration. Table 2 shows the regional decomposition of procurement by Japanese affiliates in the U.S. In the transportation equipment sector the share of imports from Japan is 22.8%, of which the share of intra-firm imports accounts for 22.6%. It is reasonable to assume that Japanese affiliates mostly procure parts from their parent firm back in Japan.

Table 2. Regional Decomposition of Sourcing by Japanese Affiliates in the U.S.: Electrical Machinery and Transportation Equipment Sectors, 2009 Fiscal Year, %

Japanese affiliates in the U.S.	Decomposition of purchases of Japanese affiliates located in the U.S.: By source, %					
	Imports from Japan	of which, from parent firms	Local Purchases	of which, from Japanese firms	Imports from the rest of the world	Total
Manufacturing Total	29.06	28.10	61.47	32.69	9.48	100.0
Electrical machinery	57.73	52.49	33.81	2.09	8.46	100.0
Transportation equipment	22.77	22.57	67.42	47.62	9.81	100.0

Source: METI, *Basic Survey of Overseas Business Activities* (downloaded from the web site: http://www.meti.go.jp/english/statistics/tyo/kaigaizi/index.html).

Considering the fact that the production share of Japanese affiliates comprises only a part of total U.S. auto production, one should take into account patterns of part sourcing of non-Japanese auto makers in the U.S. Particularly for those parts that are technologically important, it might be possible that U.S. or non-Japanese automakers also import some parts from Japanese suppliers, regardless of whether they belong to any production networks or vertical *keiretsu*. Table 3 reports the regional share of intra-firm exports of Japanese auto and auto part firms.[11] To North America, 91.4% of exports are designated to their affiliated firms. The volume of the transaction is not significant here, but rather specificity is. As long as the part is specific, there could potentially be a big effect on non-Japanese makers in the event of disruption of the import suppply.

Table 3. Share of Intra-firm Exports from Japan: Electric Parts, Devices, and Integrated Circuits, and Motor Vehicles and Their Parts, 2010, (%)

Industry	No. of exporting firms (responded)	Share of intra-firm exports by region (%)		
		North America	Europe	Asia
Electric Parts, Devices, and Integrated Circuits	321	66.7	63.8	57.9
Motor Vehicles and Their Parts	338	91.4	74.4	70.2

Source: METI, *Basic Survey of Japanese Business Structure and Activities 2010*, Volume 2, October 2011.

4.2 Outsourcing, relationship-specific investment, and incomplete contracts

To set up an analytical framework, I focus on the insider-outsider model, which is well explained in Head, Ries, and Spencer (2004) and Feenstra and Spencer (2006). In this model, a maker decides whether to outsource to a (foreign) supplier who commits to a relationship-specific investment (an *insider*), or to purchase a generic version of the part from an (foreign) independent supplier at arm's-length (an *outsider*).

In the model, the relationship-specific investment (RSI) plays a central role. It is viewed that such investment is required for part-suppliers to manufacture high-quality parts, or parts used only for specific models.[12] A maker prefers to outsource a part that would be expensive to make in-house, and for which the RSI generates rent for the maker so as to reduce actual production cost to below the marginal cost. Even when transaction price between the maker and the insider supplier is higher than the marginal cost at which the maker could purchase a generic version of the part from an outsider, the net cost incurred by the maker becomes lower than the marginal cost price because of rent. The important feature is that the

RSI must be governed by a contract. However, the contract is incomplete since whether or not the conditions have been satisfied cannot be immediately verified by either party at the first stage of the game between the maker and the supplier. Therefore, existence and availability of a third party for verification or a reliable legal system is particularly important for the firm in determining a location to outsource with a contract. The contractual part sourcing also suggests that the price of a part can be negotiated then renegotiated at the second stage, and once it is set, the same price could last in a longer term.

The feature of my model relies on two basic characteristics. First, parts are classified and ordered according to the efficacy of RSI. The efficacy of RSI means the degree of the increment of rents generated by RSI contributing to a decrease in the maker's net cost of producing the part. The efficacy is specific to each part, and can also be affected by other factors such as business networks, like Japanese *keiretsu*, through which information may be easily exchanged, contract enforceability because of the nature of the contract incompleteness, and so on. Second, parts that require more of the RSI are likely to be used for a particular good, such as a luxury passenger car. This implies that more or less one specific part has to be used together with the other specific parts and components to be assembled, like a cylinder and engine for Lexus.

It follows that the degree of complementarity between parts for luxury cars should be very high (for example, the elasticity of substitution between a brake and an engine for Lexus could be lower), and that the degree of substitutability for the part between suppliers of different countries with different contract enforceability should be lower (for example, the elasticity of substitution between a cylinder imported from Malaysia and a cylinder imported from Japan could be lower).

The following proposition summarizes the arguments:

Proposition

When the relationship-specific investment is important for a particular part production,

(1) the part is likely to be produced by a supplier located in a country with a relatively better contracting environment,

(2) if it is imported by a third country, the elasticity of substitution for the part between exporters should be low (*intra*-class elasticity of substitution), and

(3) since the part is technically specific to a particular car, it must be used with other specific inputs to assemble the car, and thus, the elasticity of substitution between parts should be low (*inter*-class elasticity of substitution).

In the next sub-section, I discuss an analytical framework by which the above proposition can be examined.

4.3 Analytical framework

Auto producers in the U.S., who import parts and components from Japan, are supposed to be any of U.S., European, or Korean makers as well as Japanese makers. Although they trade intermediate inputs mainly within the firm, when it comes to specific parts, they might choose to outsource to a particular supplier in a particular country, regardless of the production network. Thus, I assume that an auto maker could come from any nation.

Let us assume that a representative auto maker produces an automobile only by using imported intermediate inputs. These imports are also distinguished by the country of production, as suggested by Armington, and thus, they are assumed to be imperfect substitutes for each other. With the assumption of strong separability among inputs, production technology can be represented by the following two-level constant-elasticity-of-substitution (CES) production function.

$$q=\left[\sum_{1}^{M}\alpha_m M_m^{-\rho}\right]^{-\frac{1}{\rho}},\ M_m=M_1, M_2, \cdots, M_M, \quad (3)$$

where

$$M_m=\left[\sum_{1}^{C}\beta_{mc}\ (r_c \cdot x_{mc})^{-\rho_m}\right]^{-\frac{1}{\rho_m}},\ x_{mc}=x_{m1}, x_{m2}, \cdots, x_{mC}. \quad (4)$$

In the production function of the final good (equation (3)), q is the auto output, which depends on m kinds of imported parts, M_m. The part m production function (M_m) is given by equation (4), which depends on x_{mc}, the part m imported from country c. To the extent that contracting enforceability is specific to each country, I assume that import volume from a country is augmented by the degree of contracting environment of that country. The efficacy of the RSI is captured by r_C, $r_C \in [0, 1]$, which represents the degree of contracting enforceability of country c. Therefore, the interacted term, $r_C \cdot x_{mc}$, shows efficiency units of part m imported from country c. α_m and β_{mc} are distribution parameters, and ρ and ρ_m are the substitution parameters. The usual sign conditions are assumed:

$$\alpha_m>0,\ \rho>-1,\ 1<\sigma=1/(1+\rho),\ \text{and}\ \beta_m>0,\ \rho_m>-1,\ 1<\sigma_m=1/(1+\rho_m).$$

We call σ the *inter*-class elasticity of substitution, while σ_m is the *intra*-class elasticity of substitution.

This functional form is first introduced by Sato (1967) and proved to preserve the constancy feature of the elasticity. The strong separability among inputs means that the advantage of this function lies in the separability of optimization problems. At the first stage, a maker decides on how many units of a particular input it will use solely based on the relative input price to the other inputs, and at the second stage, the maker decides on how many units of the first input it will import from a particular country exclusively within the first input.[13)] In my framework, with the total auto production held constant, the maker decides to which country to outsource, with or without a contract, independent of the decision of how many units of the part is necessary.

First, I consider the optimal condition at the second stage, that is, the maker's decision of how many units of a part from each country. The separable optimization suggests that the least cost condition be satisfied for each pair of countries. The ratio of marginal product of a part from country c relative to that of the same part imported from Japan, must be equated to the ratio of the unit import prices, country c over Japan. For part m,

$$\frac{\partial q}{\partial x_{mc}} \cdot \left(\frac{\partial q}{\partial x_{mJ}}\right)^{-1} = \frac{w_{mc}}{w_{mJ}} \cdot$$

Based on equation (4), the following condition is obtained.

$$\frac{w_{mc}}{w_{mJ}} = \frac{\beta_{mc}}{\beta_{mJ}} \cdot \left(\frac{r_C}{r_J}\right)^{-\rho_m} \cdot \left(\frac{x_{mc}}{x_{mJ}}\right)^{-\rho_m - 1} . \quad (5)$$

Thus,

$$\left(\frac{x_{mc}}{x_{mJ}}\right) = \left(\frac{\beta_{mc}}{\beta_{mJ}}\right)^{\sigma_m} \cdot \left(\frac{r_C}{r_J}\right)^{\sigma_m - 1} \cdot \left(\frac{w_{mc}}{w_{mJ}}\right)^{-\sigma_m} . \quad (6)$$

Defining $X_C = x_{mc}/x_{mJ}$, $B_C = \beta_{mc}/\beta_{mJ}$, $R_C = r_C/r_J$, and $\omega_C = w_{mc}/w_{mJ}$, the equation is rewritten as

$$X_C = B_C^{\sigma_m} \cdot R_C^{\sigma_m - 1} \cdot \omega_C^{-\sigma_m}. \quad (7)$$

Taking a natural logarithm of equation (7) on both sides, a reduced form of the estimation equation is obtained as

$$ln\ X_C = a_0 + a_1\ ln\ R_C + a_2\ ln\ \omega_C + u_C, \quad (8)$$

where $a_0 = \sigma_m\ ln\ B_C$, $a_1 = \sigma_m - 1$, and $a_2 = -\sigma_m$.

The *intra*-class elasticity of substitution (σ_m) can be obtained as an estimate of the coefficient on ln ω_C in equation (8).

The next step is to derive the optimality condition at the first stage. The least cost condition for the pair of parts, m and n, is

$$\frac{\partial q}{\partial x_n} \cdot \left(\frac{\partial q}{\partial x_m}\right)^{-1} = \frac{p_m}{p_n},$$

where p_m and p_n are the prices of parts m and n, respectively.
Based on equation (3), the following condition is obtained.

$$\left(\frac{M_n}{M_m}\right) = \left(\frac{\alpha_n}{\alpha_m}\right)^{-\sigma} \cdot \left(\frac{p_n}{p_m}\right)^{-\sigma}. \quad (9)$$

Defining $M = M_n/M_m$ and $P = p_n/p_m$, and taking a natural logarithm on both sides, a reduced form estimation equation is obtained as

$$ln\ M = b_0 + b_1\ ln\ P + u, \quad (10)$$

where $b_0 = -\sigma\ ln\left(\frac{\alpha_n}{\alpha_m}\right)$, and $b_1 = -\sigma$.

The *inter*-class elasticity of substitution (σ) can be obtained as an estimate of the coefficient on ln P in equation (10).

4.4 Estimation and Data

The empirical application of the two-level CES production function can be seen in the literature. Saito (2004) is one of the studies, in which she estimated both *inter*- and *intra*- group elasticities of substitution for 2-digit industries to argue on the plausibility of the use of bilateral trade data for testing the Armington hypothesis. Her estimation of the *intra*-group elasticity consists of each combination of bilateral trade and price ratios, that is, they are not limited to the ratio of import volume or price relative to Japan, which is different from my study.

To estimate the *intra*-class elasticity of substitution, data on U.S. part imports are obtained, again, from the United Nations, *COMTRADE* database. I collected import values and quantities for the same 18 HS-6-digit products as in the previous section. The import data is on a bilateral basis with every country from which the U.S. imported a particular part in 2010. Imports from Japan are recorded for all of the 18 parts. To estimate the *inter*-class elasticity of substitution, import value and quantity from the world are used for each part. Data on 17 parts are available.[14] The relative price and quantity are calculated as each of 5 parts to be a numeraire in turn.

The data on contracting environment does not exist as such, but very often in the literature, the rule of law index by Kaufmann, Kraay, and Mastruzzi (2009) is used as a proxy. Following Nunn and Trefler (2008), I collected the indices for all available countries with the index ranging from -2.5 to +2.5, and modified them so that the index lies between 0 and 1 (by adding 2.5 and dividing by 5). This data is for 2008.

The ratios in estimation equation (8) are all defined as the competing country over Japan. The estimate of α_1 is of importance since it implies the effect of a country's contracting environment on the U.S. part import from that country. We can argue on this point based on the Proposition (1) described in sub-section 4.2. The estimate of α_2 in the equation, on the other hand, shows the magnitude of the *intra*-class elasticity of substitution between Japan and the competing country for a particular part, as summarized in Proposition (2). Finally, the estimate of b_1 in equation (10) provides the *inter*-class elasticity of substitution for each pair of 2 parts, as suggested in Proposition (3).

Table 4. Elasticity of Substitution for Imported Auto Parts: 5 HS 6-digit U.S. Imports, 2010

Regression Model	HS 6-digit Code No.	Intra-class elasticity of substitution: *elas. of sub.* (σ_m) $\ln\left(\frac{W_{mc}}{W_{mJ}}\right)$	t-value	*contracting environment* $\ln\left(\frac{R_c}{R_J}\right)$	t-value	Adjusted R-Squared	No. of Obs.	Inter-class elasticity of subsitution: *elas. of sub.* (σ) $\ln\left(\frac{P_n}{P_m}\right)$	t-value	R-Squared	No. of Obs.
2	851140	-1.884 **	-8.67	1.912 *	2.37	0.558	62	-1.645 **	-11.70	0.907	16
		-1.858 **	-8.25			0.524	62				
4	854231	-1.429 **	-10.68	3.702 **	3.38	0.648	82	-1.621 **	-11.49	0.904	16
		-1.536 **	-11.12			0.602	82				
5	870600	-0.289	-1.37	1.180	1.10	0.136	13	-1.953 **	-4.03	0.537	16
		-0.339	-1.62			0.120	13				
7	870821	-2.640 **	-2.90	1.920	0.82	0.211	25	-1.662 **	-14.19	0.935	16
		-2.386 *	-2.80			0.222	25				
11	870850	-2.879	-1.98	1.786	1.59	0.077	48	-1.651 **	-11.74	0.908	16
		-2.680	-1.82			0.047	48				

Data Source: United Nations, *COMTRADE* Database (downloaded from the web site: http://comtrade.un.org/db/ce/ceSearch.aspx).

Notes: Due to the data estimation problem by the UN, we do not have an enough variation of unit prices among countries based on the calculation by the value-divided-by-quantity method. Those products with a virtually fixed unit price are excluded in this analysis, limiting the sample to 5 parts out of the 18 in Table 2. Estimation includes a constant term. Two asterisks "**" show the 1% significance level, and an asterisk "*" shows the 5% significance level.

4.5 Estimation results

The estimation results are reported in Table 4. Unlike the previous estimation (Table 1), the number of parts had to be reduced to 5 from 18. This is primarily because the unit price calculated from the U.N. database does not provide enough variations. This virtually constant unit price across countries seems to come from the estimation method of trade-volume (or value) conducted by the U.N. As a result, I had to limit the sample to 5 parts only, whose unit price has an enough variation.[15)]

Without the contract variable, the *intra*-class elasticity estimates are negative and significant for the 3 out of 5 parts, ranging from -1.54 (HS 854231, electronic integrated circuits etc.) to -2.39 (HS 870821, safety seat belts etc.). The elasticity estimated for the integrated circuits, which includes micro-controllers, shows the lowest magnitude. The low elasticity of substitution for the part clearly indicates that the part imported from Japan is less substitutable by the *same* part from other countries. When the contracting environment variable is included in estimation, the magnitude of the elasticity becomes even slightly smaller (-1.43) with a statistically and significantly positive estimate of the contracting variable. If the competing country is characterized by worse contracting enforceability than Japan, volume of import from Japan would increase.

The elasticity estimated for starter motors etc. (HS 851140) is -1.86, and it becomes -1.88 when the contracting environment variable is included in estimation. The magnitude is slightly higher than that of the estimate for integrated circuits. It shows that there is no big difference between the estimation with and without the contracting variable, though the estimate of the variable itself is positive and statistically significant at the 5 % level.

The estimate for safety seat belts etc. is obtained to be -2.39 and -2.64, without and with the contract variable respectively. There is some difference between the two estimates. However, the estimate of the contract variable itself is not statistically significant, though positive. Since the magnitude of the elasticity is relatively high, it might be inferred that the part provided by Japanese suppliers is not so different from the part provided by other countries.

These estimation results imply that U.S. imports of some auto parts, electronic integrated circuits and starter motors in particular, significantly depend on the contracting enforceability of the source country. It follows that for those parts the relationship-specific investment (RSI) is more required and, therefore, countries with a better contracting environment and the best production technique, like Japanese suppliers, are given greater advantage in the U.S., raising the degree of *uniqueness* of their product.

The right hand side of Table 4 shows the estimation results for the elasticity of substitution between parts (like safety seat belts and starter motors). The estimates are negative and statistically significant. The magnitudes of the estimates range from -1.62 to -1.95, which is relatively low. That is, the parts considered are used complementarily in auto production as indicated in Proposition (3). It should be noted that the estimate for electronic integrated circuits shows the lowest magnitude, and that only this part estimate shows an *intra*-class elasticity of substitution lower than the *inter*-class elasticity of substitution. This might again fortify the implication for the industry, namely that RSI is important since both elasticity are low, because the investment is committed, the relationship becomes specific each other among parts, hence the part is less substitutable.

5. Conclusion

This study has tried to examine how *unique* Japanese auto parts and components are viewed in a third market. The regression result using export data suggests that the magnitude of the estimated elasticities varies across 18 inputs and among 3 destinations. For those inputs with lower elasticity, one could say that Japanese exports are less likely replaced by exports from other countries. But from an exporter's viewpoint, one does not really know about why some parts are less substitutable.

Then, I estimated the elasticity of substitution incorporated with the degree of contracting enforceability, using the two-level CES production function. For the micro controller-included product categories, the estimate of the contracting environment is positive and significant, and the magnitude of the *intra*-class elasticity of substitution is lowest. It follows that for this part the relationship-specific investment is important, and commitment to the investment by a supplier from a country with better contracting enforceability makes the part special for the maker, but consequently, if the part supply were disrupted, the entire auto production process would have to be stopped. This explanation seems consistent with the Japanese and world experience after the natural disaster occurring in March, 2011.

It can also be inferred that some auto parts are traded between non-related firms, unlike under the Japanese *keiretsu* membership often cited as a major source of trade patterns in the past. Part sourcing is still dominated by intra-firm trade for Japanese affiliates in the U.S. The importance of outsourcing has been increasing, however. Schaede (2009) discusses that as modularization becomes a significant way of part sourcing, first tier suppliers are becoming closer to makers while second and third tier suppliers are gradually being faced with a difficult business situation. This indicates a change in transactions occurring through a *keiretsu* relationship to ones with any firms that can meet the demand of buyers, which can be seen as an important feature recently. The case of inputs like micro-controller units evidenced in this study confirms this trend. The temporal decrease of auto production in the U.S. implies that there are some parts traded outside vertical production networks or *keiretsu* memberships because of technological specificity in production, and buyers in the U.S., whether Japanese or non-Japanese, do not simply buy from a new source.

The estimation was conducted for 2 levels: *intra*-class and *inter*-class. The 2 elasticities are separately estimated, but whether the difference be-

Appendix Table. HS 6-digit Classification Code Numbers and Product Names (From UN, COMTRADE Database)

HS 6-digit Code No.	Product description
850300	Parts for use solely/principally with the machines of 85.01/85.02, 8503
851140	Starter motors and dual purpose starter-generators
851290	Parts of the equip. of 85.12
854231	Electronic integrated circuits, processors & controllers
870600	Chassis fitted with engines, for the motor vehicles
870810	Bumpers & parts thereof of the motor vehicles
870821	Safety seat belts of the motor vehicles
870829	Parts & accessories of bodies (incl. cabs)
870830	Brakes & servo-brakes; parts thereof
870840	Gear boxes & parts thereof the motor vehicles
870850	Drive-axles with differential, non-driving axles; parts thereof of the motor vehicles of headings 87.01 to 87.05, 8708
870870	Road wheels & parts & accessories
870880	Suspension systems & parts thereof (incl. shock-absorbers)
870891	Radiators & parts thereof for the motor vehicles
870892	Silencers (mufflers) & exhaust pipes; parts thereof for the motor vehicles
870893	Clutches & parts thereof for the motor vehicles
870894	Steering wheels, steering columns & steering boxes; parts thereof for the motor vehicles of 87.01-87.05, parts thereof 8708
870899	Other parts & accessories for the motor vehicles

tween the 2 estimates is statistically significant or not was not tested in this study. It is particularly necessary when arguing on the complementarity among inputs compared with *intra*-class elasticity. Thus, this test should be conducted as soon as possible. The current study also primarily conducted a cross-country analysis. Since time-series data adds historical information, such data would probably be very important, especially when investigating the contracting nature of intermediate input trade. Thus, an analysis using a panel data set will also be the next step.

Notes

1） The early version of this paper was presented at the EEA annual meetings in Boston and at the Global Economy International Conference in Seattle, in March 2012, and at the WEAI annual meetings in San Francisco in July 2012. The author appreciated very useful comments from the participants of these conferences.

2） I am grateful for the comments from an anonymous referee. I would like to acknowledge the financial support (Grants-in-Aid for Scientific Research) from the Japan Society for the Promotion of Science (JSPS, #23530286). The content of this study does not represent the JSPS's viewpoint, but author's alone. All remaining errors are in author's responsibility.

3） In part, disruption of the global supply chain had been already observed before the earthquake happened as one of the factors of "the great trade collapse, and as one of the major impacts of global financial crisis and great recession" after the Lehman Brothers incident of 2008, according to Feenstra (2011). However, the current study does not consider this point to keep analysis simple.

4） At the HS 9-digit classification, micro-controller units are under the line of "854231992", that is, a part of the 6-digit "854231" product group (electronic integrated circuits etc.).

5） It is Ibaraki Prefecture.

6） The METI also reports that while world share of this part by Japanese firms represents about 30%, the inventory ratio is very low compared to the motor vehicle production standard: only for 17 days.

7) In addition, the incompleteness of a contract and the portion of contractible activities for input production are theoretically of importance, for which acquiring data might be even more difficult in reality.

8) According to *U.S. Census Bureau News* by the U.S. Department of Commerce, in the U.S. the share of trade by related-party accounted for 40.8% of total goods traded in 2010.

9) Since improvement of the contracting environment is more likely to increase outsourcing with a contract, their result can be interpreted as the case where the “surprise effect” (slightly) dominates the “standard effect” (Nunn and Trefler (2008), p.75).

10) The number of observations varies from 13 to 26 for the U.S. and China’s model, and 14 to 27 for the World model, depending on how many of the 27 competing countries actually exported.

11) More direct data should be used for the analysis. It is difficult, however, to find data on U.S. firms’ outsourcing to Japanese suppliers or data on Japanese suppliers who are outsourced by firms in the U.S.

12) Asanuma (1989) termed relationship-specific investment as the investment in skills that “require...the supplier to respond efficiently to the specific needs of the core firm.” Prevalence of this kind of investment and subcontracting is a well-known business system among keiretsu members, especially during the high-growth period of the Japanese economy, which is detailed by Yamawaki (2007).

13) Sato (1967) describes this advantage, “the choice of the cost-minimizing factor combination is effectively separated into two stages.”

14) For the product, HS 850300 (“Parts for use solely with the machines of 85.01 etc.”), quantity data is not available and thus it is eliminated from the sample.

15) Those 5 parts are: HS code, 851140, 854231, 870600, 870821, and 870850. For the last product group, the same estimation method is applied as the one that makes less variation for the eliminated products, but the calculated price actually has variation, the reason for which is unknown.

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