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Auto Parts Trade: Elasticity of Substitution in a Third Market

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Abstract:

This study attempts to examine whether an automobile part exported from Japan is a kind of special and hardly replaced by the *same* part exported from other countries by estimating the elasticity of substitution between Japan and competing countries in a third market. The recent literature on foreign outsourcing and incomplete contract suggests that international transaction of intermediate inputs take place through one or any combination of the following three forms: intra-firm trade, international outsourcing with a contract, or international outsourcing at arm’s length. I focus on the last two options in this paper, that is, a “how-to-buy” decision problem. In general, a maker would choose outsourcing with a contract over market purchases, when the desired part is specific enough to be assembled together with particular parts and components for a car. However, when there are other countries who can supply the same part at relatively lower cost, and a contract agreement with a supplier breaks down, a maker would outsource the part at arm’s length. Assuming the Armington’s hypothesis on the production location, one can postulate that lower elasticity of substitution for a part from a particular country should mean a higher level of uniqueness of that country’s part. I set up a regression model based on the two-level constant-elasticity-of-substitution (CES) production function and estimate it to examine how unique Japanese auto inputs are in a third market. It appears that some auto parts exported from Japan are less substitutable, explaining the temporal disruption of a global supply chain functioning for a motor vehicle industry, even causing a decline of U.S. automobile production right after the earthquake on March 11th., in 2011.

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1. Introduction

International trade in intermediate inputs is growing very fast. It accounts for about 40 percent of worldwide trade. A large part of the growth of such trade is due to an increase of international outsourcing and vertical foreign direct investment (FDI), which induces intra-firm trade as a result of extending production processes across many countries. Intra-firm trade now accounts for about one third of worldwide trade.

One of the economic impacts of the earthquake hitting the northern part of Japan on March 11th., 2011, was to create a considerable damage on parts factories of small-and-medium sized firms of this region. They produced parts and components of motor vehicles and various electronic products. Since they played an essential role as a global part supplier, the global supply chain was forced to be temporarily disrupted after the natural disaster[2]. The Ministry of Economy, Trade and Industry [METI], Japan, reports that due to this disruption, U.S. auto and auto-parts production leveled down by 8.9% in April 2011 (over previous month) (METI (2011)). They argue that in particular, many factories of a micro controller unit[3], one of the essential electric parts for motor vehicles, as well as for electronic products such as a mobile phone and remote controller of television set, were located in the region and severely damaged[4], naturally leading to the disruption of their part supply and reduction of auto production in the U.S.[5]

This incident motivated my current research asking whether and why such inputs exported from Japan are less substitutable in a third country. The literature on the firm's organization and incomplete contract provides an important idea about firm's make-and-buy (and how-to-buy) decision making in connection with the input trade. The theoretical argument has been developed on the factors for which vertical integration is preferred to international outsourcing (Grossman and Helpman (2003), Spencer (2005), Helpman (2006b), for example). For the explanation, contracting environment of a country and contractible activities in an input production are particularly focused on recently (Acemoglu, Antras, and Helpman (2007), Nunn (2007), and Nunn and Trefler (2008)).

Another focal point is about the model structure: technological complementarities.

[2] 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).
[3] On 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.).
[4] It is Ibaraki Prefecture.
[5] The METI also reports that the world share of this part by Japanese firms represents about 30%, but that the inventory ratio is very low as a motor vehicle production standard: only for 17 days.

Acemoglu, Antras, and Helpman (2007) introduced a model in which one can analyze the impact of contractual improvement on the elasticity of input substitution depending on the degree of technological complementarity. Such impact is higher when the degree of technological complementarity among inputs is greater. It is also explained by Helpman (2006a) that industries with low elasticities are more sensitive to the contract incompleteness. Based on those arguments, the current paper focuses on the substitutability of the same input from different countries with contracting enforceability taken account for.

As for empirical studies, only a few researches have been conducted. Head, Ries, and Spencer (2004) and studies by Nunn and Trefler are the most representative. As Helpman suggests, the direct testing of the hypothesis from the theory is difficult because of the data availability: we need transaction data classified for international outsourcing with and without a contract as well as FDI on a firm level[6]. 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. intra-firm trade is investigated by Nunn and Trefler (2008). Using the Census data, from which imports and exports by related-parties are available[7], they find that for industries with high level of headquarter intensity, intra-firm imports are positively related to contracting environment[8].

I set up a model in which an importer's production function depends on imported intermediate inputs that are assumed to be imperfectly substitute by the place of production (Armington's assumption). With the assumption of strong separability among inputs, I use the two-level constant-elasticity-of-substitution (CES) production function introduced by Sato (1967). It is also assumed that an input from each country is to some extent characterized by the degree of contracting environment of that country. An estimation using U.S. import data shows that for some parts, in fact, the micro-controller-included product category mentioned above represents lower elasticity of substitution and strong contract incompleteness effect. Thus, it appears that this kind of part exported from Japan is rather unique, compared to the *same* part from other countries probably because of its technical specificity.

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[6] 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.

[7] 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 the total goods trade in 2010.

[8] 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).

2. Exporter substitution in a third market: automobile parts and components

To examine the degree of substitutability for Japanese parts exports to a third market, I first directly estimate an elasticity of substitution for automobile part exports between Japan and competing countries in U.S., China, and world markets. The product categories used here are the ones generally considered to be used as parts and components for motor vehicle production, which are indicated under the Harmonized Commodity Description and Coding System (HS) 85 and 87 categories of the United Nations, *Commodity Trade Database* [UN *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.

$$\sigma = \frac{d\ln\left(x_J / x_c \right)}{d\ln\left(w_J / w_c \right)}, \quad (1)$$

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, 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,

$$ln\left(x_J / x_c \right) = \alpha + \sigma \cdot ln\left(w_J / w_c \right) + u. \quad (2)$$

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. It means that for a part with large elasticity, if the price of the part exported by a Japanese supplier is raised, its export is more likely replaced by the export of the same part by a supplier in the other country. If the elasticity is small, however, the price rise of the part is not likely to lead to the replacement with the competitor.

The *COMTRADE* database provides us with detailed trade data classified by-country-by-commodity import and export values and quantities. I collected export data of the 18 parts for 28 countries and area, which are designated to the U.S., China, and the world. A unit price of export is calculated simply by dividing the export value by the export quantity (numbers or weights (kilogram)). Japanese variable is taken as a numeraire, and so that, its relative ratio to each one of the 27 competing countries is only calculated.

Table 1 reports the estimation results[9]. The goodness of fit is generally better for the U.S. model than for the China's model. Thus I look at the results of the U.S. model. Concerning the magnitude of elasticities, it is found that they vary and mostly range from 1.76 (HS 851140, starter motors etc.) to nearly 4 (HS 870894, steering wheels etc.) in terms of absolute value. This suggests that technological characteristics of a part 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 the one of the lowest elasticity group among 18 parts. When this part is exported from Japan, it is very unlikely to be replaced by the same part exported from other countries.

The argument so far was made from an exporter's point of view. Since, to large extent, parts trade reflected a final-good maker's import decision rather than the exporters', I switch the viewpoint from that of exporters to that of importers in the next section. This is aimed at modeling input procurement options with the contract incompleteness as suggested by the literature.

3. Vertical networks and elasticity of substitution for auto parts

In the growing international input trade, vertical production networks play a significant role in determining the firm's decision-making on a make-and-buy and how-to-buy: this decision includes a firm's organizational choice problem, such as outsourcing versus vertical integration, or in particular, outsourcing to an insider versus outsourcing to an outsider. There are also other options: a maker could produce parts in-house rather than to outsource, or it could also choose outsourcing to domestic suppliers, or vertically integrate with domestic suppliers.

3.1 Outsourcing, relationship-specific investment, and incomplete contract

Among those several possible decision patterns, I focus on the insider-outsider model well explained in Head, Ries, and Spencer (2004). The model is the one where a maker decides whether to outsource a part to a (foreign) supplier who commits a relationship-specific investment (RSI) based on an incomplete contract (insider), or to outsource from an (foreign) independent supplier at arm's length (outsider). In this

[9] 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.

model the vertical integration through foreign direct investment (FDI) is not considered as a procurement option. The fact that it is not so often seen when Japanese parts suppliers are integrated with U.S. auto makers by FDI provides a good reason that vertical integration is not a very important option as far as imports from Japan are concerned.

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.[10] A maker prefers to outsource a part that would be expensive if it were made by themselves, to an independent supplier so as to reduce production cost. The important thing is that the RSI must be governed by a contract. It should be noted, however, that the contract is incomplete since whether the conditions are satisfied can't be immediately verified by either party (at the first stage of the game). Therefore, existence and availability of a third party for verification or reliable legal systems is particularly important in determining whether to outsource with a contract. The contractual part sourcing also suggests that the price of a part can be negotiated and renegotiated at the second stage (Feenstra and Spencer (2006)), and once it is set, the same price could last until the termination of the contract date comes.

The feature of my model relies on the two basic characteristics of the model with the RSI and incomplete contract. First, parts are classified and ordered according to the efficacy of RSI, which means an increment of rents generated by RSI on the supplier's side but obtained by a maker contributing to a decrease in its marginal cost of producing the part. The efficacy is specific to a part, and it would 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 RSI are likely to be used for a particular good such as a luxury passenger car, and to be used together with other parts and components to be assembled, like a cylinder and an engine.

A part required of more of RSI must be necessary for other particular parts to be used together and assembled as a car. It follows that the degree of complementarity between those parts should be very high (for example, the elasticity between a cylinder and an engine), and that the degree of substitutability for the part between suppliers with different countries of origin should be lower (for example, the elasticity between a cylinder imported from Malaysia and a cylinder imported from Japan can be different

[10] Asanuma (1989) termed the relationship-specific investment for 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 Japanese economy, which is detailed by Yamawaki (2007).

due to the technical specificity and its use in actual production in response to the requirement of the RSI by a maker).

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 countries 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 a car, and thus, the elasticity of substitution between parts should also 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.

3.2 Analytical framework

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

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

where

$$M_m = \left[\sum_{1}^{c} \beta_{\mathrm{mc}} \left(r_c \cdot x_{mc} \right)^{-\rho_m} \right]^{-\frac{1}{\rho_m}}. \quad (4)$$

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. $\alpha' s$ are distribution parameters. 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 the contracting enforceability is specific to each country, I assume that an import volume from a country be augmented by the degree of contracting environment of that country. This efficiency of RSI is captured by the following form: $r_c \cdot x_{mc}$, that is, an efficiency unit of imported part m from country c, where r_c represents the degree of contracting environment of country c. β_{mc} are the distribution parameter. ρ and ρ_m are the substitution parameters. The usual parameter conditions are also assumed:

$\alpha_L > 0$, $\alpha_K > 0$, $\alpha_m > 0$, $\rho > -1$, $1 < \sigma = 1/(1+\rho)$, 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 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 advantage of this function lies in the separability of optimization problems. At first stage a maker decides how many units of a particular input it uses solely based on the relative input price to the other input, and at the second stage, it decides how many units of the first input it imports from a particular country exclusively within the first input[11]. In our framework, with the total auto production held constant, an auto maker decides whether to outsource with a contract does not depend on the decision of how many units of the part is necessary.

We first consider the optimal condition at the second stage. The least cost condition must be satisfied for each pair of Japan and a competing country. 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.

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

Based on equation (4), we have the following condition.

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

Thus, for a part m, we have,

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

Defining $X_c = x_{mc}/x_{mJ}$, $B_c = \beta_{mc}/\beta_{mJ}$, $R_c = r_c/r_J$, and $\omega_c = w_{mc}/w_{mJ}$, rewrite the equation.

[11] Sato (1967) describes for this advantage "the choice of the cost-minimizing factor combination is effectively separated into two stages."

$$X_c = B_c^{\sigma_m} \cdot R_c^{\sigma_m - 1} \cdot \omega_c^{-\sigma_m}. \quad (7)$$

Taking a natural logarithm of equation (7), a reduced form of the estimation 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 $\ln \omega_c$ in equation (8).

Next, the optimality condition at the first stage is derived as follows. The least cost condition must hold for each pair of the parts, m and n.

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

where p_m and p_n are the prices of parts m and n, respectively.

Based on equation (3), we obtain

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

Defining $M = M_n / M_m$ and $P = p_n / p_m$, and taking a natural logarithm, then, a reduced form estimation equation becomes,

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

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).

3.3 Estimation and Data

The empirical application using 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 two-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, different from this study.

U.S. parts import data are obtained again from the United Nations, *COMTRADE* database. I collected import values and quantities for the same 18 HS-6-digit products as the previous section, which are considered to be used for motor vehicles production.

The import data is bilateral with all countries from which the U.S. imported a particular part in 2010, and imports from Japan are recorded for all of the 18 parts.

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 the 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 divide it by 5). This data is for 2008.

The ratios in estimation equations (8) are defined as the competing country over Japan. The estimate of a_1 in equation (8) is of importance in the sense that it implies the effect of the contracting environment on the part import. We can argue on this point based on the Proposition (1) described in sub-section 3.1. The estimate of a_2 in equation (8), 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 provides the *inter*-class elasticity of substitution for each pair of two parts, as suggested in Proposition (3).

3.4 Estimation results

The estimation results are reported in Table 2. Unlike the previous estimation, the number of parts had to be reduced to five from 18. This is primarily because the unit price calculated from the U.N. database does not provide enough variations, and the virtually constant unit price across countries seems to come from the trade-volume (or value) estimation method conducted by the U.N. As a result, I estimated the model for the five parts only, whose unit price has an enough variation[12].

Without the contract variable, the intra-class elasticity estimates are negative and significant for the three out of five 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 also 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 in the U.S. When the contracting environment variable is included in estimation, the magnitude of the elasticity becomes slightly even smaller (-1.43) with a statistically and significantly positive estimate of the contracting variable. If the competing country is characterized by a worse contracting environment relative to Japan, the part import from Japan would increase.

[12] Those five 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 rest of products, but unit price of this product group shows more variation, whose reason is not yet figured out.

The elasticity estimated for the starter motors etc. (HS 851140) is -1.86, and it is -1.88 when the contracting environment variable is included in estimation. The magnitude is slightly higher than that of the estimate for the 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 the safety seat belts etc. is obtained to be -2.39 and -2.64 for models without and with the contracting environment variable, respectively. There is some difference between the two estimates, however, the estimate of the 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 are 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 particularly, significantly depend on the contracting enforceability of the source countries. It follows that for those parts the relationship-specific investment (RSI) is more required and therefore, the countries with better contracting environment and with best production technique, like Japanese suppliers, are given greater advantage in the U.S., raising the degree of uniqueness of their product.

On the right hand side of Table 2 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 are in the same range (-1.62 ~ -1.95), and relatively low. That is, the parts considered are used complementary in auto production as indicated in Proposition (3). It should be noticed that the estimate for electronic integrated circuits shows the lowest magnitude and that only this part estimate shows the intra-class elasticity of substitution lower than the inter-class elasticity of substitution. This might again fortify the implication for the industry, namely the RSI is important since both elasticity are low, and once the investment is committed, it is specific with other parts as well as to an auto, and hence, the part is less substitutable.

4. Conclusion

This study tried to investigate how unique Japanese auto parts and components are in a third market. The simple regression estimation results suggest that the magnitude of the estimated elasticities varies across 18 inputs and among three destination markets. Some parts have higher elasticity of substitution, and others have lower elasticity of substitution. For those inputs with lower elasticity, one could say that Japanese exports are less likely replaced by exports from other countries. But from this exporter's viewpoint, we do not really know about why some parts are less substitutable.

Then, I estimated the elasticity of substitution with a model from outsourcing, relationship-specific investment (RSI), and incomplete contract theory. The degree of substitutability depends on the degree of contractible activities of the production in association with the commitment of RSI on a supplier's side, and all of these make a particular part more unique (specific). Thus, the contract model is supposed to be better explaining the pattern of intermediate input trade as long as the uniqueness of the input is concerned. Using the two-level CES production function, I estimated the elasticity of substitution incorporated with the degree of contracting environment. 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 RSI is important and commitment of the investment by suppliers of a country with better contract enforceability makes the part special for makers, but if the part supply were disconnected, the entire auto production process would have to be stopped. This story seems consistent with the Japanese experience after the natural disaster on March, 2011.

The estimation was conducted for the two levels: one is for intra-class, and the other is for inter-class. The two elasticities are separately estimated, but whether the difference between the two estimates is statistically significant or not was not tested in this study. It is particularly necessary when arguing on the complementarity among inputs in terms of comparison with the 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 be probably very important especially when investigating the contracting nature of intermediate input trade, as well as just for the purpose of making larger sample. Thus, the analysis using a panel data set will also be a next step.

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Table 1. Elasticity of Exporter Substitution between Japan and Competing Countries: 18 Auto Parts in U.S., China, and World Markets, 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. The asterisks "**" show the 1% significance level, and an asterisk "*" shows the 5% significance level. The 28 countries and area are: Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Luxembourg, Malaysia, Mexico, 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.

Table 2. Elasticity of Substitution for Imported Auto Inputs: 5 HS 6-digit U.S. Imports, 2010

Regression Model		Intra-class elasticity of substitution						Inter-class elasticity of subsitution			
	HS 6-digit	*elas. of sub.* (σ_m)		*contracting environment*		Adjusted		*elas. of sub.* (σ)			
	Code No.	$\ln(W_{mc}/W_{mJ})$	t-value	$\ln(R_c/R_J)$	t-value	R-Squared	No. of Obs.	$\ln(P_n/P_m)$	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 to the five parts out of 18 in Table 2. Estimation includes a constant term. The asterisks "**" show the 1% significance level, and an asterisk "*" shows the 5% significance level.

Appendix Table to Tables 1 and 2: HS 6-digit Classification Codes and Product Names (UN, *COMTRADE* Database)

850300: "Parts suit. for use solely/principally with the machines of 85.01/85.02","Parts suitable for use solely or principally with the machines of heading 85.01 or 85.02.",1,6,"8503"

851140: "Starter motors & dual purp. starter-generators","- Starter motors and dual purpose starter-generators",1,6,"8511"

851290: "Parts of the equip. of 85.12","- Parts",1,6,"8512"

854231: Electronic integrated circuits, processors & controllers, whether/not combined with memories, converters, logic circuits, amplifiers, clock & timing circuits,/other circuits

870600: "Chassis fitted with engines, for the motor vehicles of 87.01-87.05","Chassis fitted with engines, for the motor vehicles of headings 87.01 to 87.05.",1,6,"8706"

870810: "Bumpers & parts thereof of the motor vehicles of 87.01-87.05","- Bumpers and parts thereof",1,6, "8708"

870821: "Safety seat belts of the motor vehicles of 87.01-87.05","-- Safety seat belts",1,6, "8708"

870829: "Parts & accessories of bodies (incl. cabs) of the motor vehicles of 87.01-87.05, n.e.s. in 87.08","-- Other" ,1,6,"8708"

870830: "Brakes & servo-brakes; parts thereof, of the motor vehicles of headings 87.01 to 87.05.","- Brakes and servo-brakes; parts thereof",1,6,"8708"

870840: "Gear boxes & parts thereof, of the motor vehicles of headings 87.01 to 87.05.","- Gear boxes and parts thereof",1,6,"8708"

870850: "Drive-axles with differential, whether/not provided with other transmission components, & non-driving axles; parts thereof of the motor vehicles of headings 87.01 to 87.05.", - Drive-axles with differential, whether or not provided with other transmission components, and non-driving axles; parts thereof,1,6,"8708"

870870: "Road wheels & parts & accessories thereof for the motor vehicles of 87.01-87.05","- Road wheels and parts and accessories thereof",1,6,"8708"

870880: "Suspension systems & parts thereof (incl. shock-absorbers) ,of the motor vehicles of headings 87.01 to 87.05", - Suspension systems and parts thereof (including shock-absorbers),1,6,"8708"

870891: "Radiators & parts thereof for the motor vehicles of 87.01-87.05","-- Radiators and parts thereof",1,6,"8708"

870892: "Silencers (mufflers) & exhaust pipes; parts thereof for the motor vehicles of 87.01-87.05","-- Silencers (mufflers) and exhaust pipes; parts thereof",1,6,"8708"

870893: "Clutches & parts thereof for the motor vehicles of 87.01-87.05","-- Clutches and parts thereof",1,6,"8708"

870894: "Steering wheels, steering columns & steering boxes; parts thereof for the motor vehicles of 87.01-87.05", -- Steering wheels, steering columns and steering boxes; parts thereof,1,6,"8708"

870899: "Other parts & accessories for the motor vehicles of 87.01-87.05, exclud. 8708.91/92/93/94/95.","-- Other",1,6,"8708"