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**Abstract**

In this study, we examine the reasons for and impact of recent changes in vertical transaction relationships in the Japanese automobile industry from 1994-2010. Our main results are the following: First, we find that buyer-supplier relationships in the automobile industry in Japan have become more open. Furthermore, productivity differences between suppliers with multiple clients and those with only one assembler client have widened gradually in recent years. Second, estimating a cost function, we find that supplier firms with a larger number of assembler clients tend to be less efficient, but the magnitude of this negative effect of the number of clients on production efficiency has been diminishing over time. Third, comparing the characteristics of suppliers with multiple assembler clients on the one hand those of suppliers with only one assembler client and second- or lower-tier suppliers, we find statistically significant differences not only in terms of basic firm characteristics such as firm size and foreign ownership rate, but also in terms of firm activities such as research and development (R&D) intensity and export orientation as well as business performance such as productivity, profitability, and survival rates.

Keywords: modularization; transaction relationships; open transaction
JEL classifications: L23, L62

## 1. Introduction

It has frequently been pointed out that Japan's automotive industry is characterized by close transaction relationships between final assemblers and parts makers to co-ordinate parts specifications, delivery schedules, and the like (see, e.g., Aoki 1990). However, in recent years, there have been major changes in the automotive industry in terms of both technology and transaction relationships. Specifically, the share of custom parts based on an "integral" product architecture, the continuity of transaction relationships, and the number of transaction partners have been gradually changing (Aoki and Ando, 2002; Konno, 2003). As seen in the electrical machinery industry, such changes lead to changes in corporate performance (productivity, etc.) and decisions regarding the location of production (through foreign direct investment, etc.) and have a major impact on the entire Japanese economy (Nobeoka et al., 2006; Kodama, 2011). Furthermore, such changes in technology and transaction relationships can be expected to advance also in other industries that rely on vertical transactions, and therefore will be more important issues in the future.

As highlighted by Lincoln and Shimotani (2009), interfirm cooperation through *keiretsu* transactions – a key characteristic of Japan's economy – worked well until the early 1990s, but the role of such transactions has declined through the 2000s. According to Lincoln and Shimotani (2009), there are several reasons for the decline of *keiretsu* links. The first set of reasons is related to economic globalization, changes in regulations, and changes in corporate governance. In particular the rapid increase in overseas production since the early 2000s and the increased capital participation by foreign car makers in their Japanese counterparts have a substantial impact on interfirm transaction relationships with regard to parts and components in the automotive industry (Toyota, 2003; Tange, 2011). The second set of reasons is related to technical changes. Particularly important are changes in production cost structures (that is, how much costs change in relation to changes in production volume, size, and scope) linked to the switch from integral architectures requiring customized parts and components to modular architectures based on product standardization and the utilization of common parts. This shift to modular architectures means that parts and components have become increasingly modular, with standardized interfaces between parts, making it possible to assemble the final product by combining independently developed parts (Baldwin and Clark, 2000; Aoki and Ando, 2002; Ikeda, 2005). Largely due to the digitization of parts and components, this shift to modular architectures has also advanced substantially in the automotive industry (Takeishi et al., 2001; Ku, 2004).

These changes in parts-related cost structures (as in the electrical machinery industry) are thought to have led to changes in vertical interfirm business relationships. Moreover, the division of labor with respect to development and production in vertical interfirm transaction relationships, which in the past had been regarded as providing a competitive edge to Japanese firms, may be forced to change. When interfaces to combine individual parts are developed at the same time as the parts are developed, close information exchange and mutual trust between firms are indispensable, so that long-term stable transaction relationships provide an advantage – a function fulfilled by *keiretsu* transactions (Aoki 1990).[1] However, the shift from integral to modular part design – in which the final product is made by combining individually developed parts – reflecting and resulting in changes in production cost structures and interfirm relationships with regard to design and production due to modularization, appears to have led to an opening-up of interfirm relationships (Fujimoto, 2003). For instance, using detailed microdata on interfirm transaction relationships in Japan's automotive parts industry, Nagaoka et al. (2008) examined the relationship between the technical characteristics of parts and the form that

[1] Explanations for the reliance on *keiretsu* transactions have focused on the risk sharing function they provide, on the spillover channel for technological knowledge they offer, and on the role of managerial capitalism (Lincoln and Shimotani 2009). For instance, Aoki (1984) formulated a model of risk sharing between upstream and downstream firms that represents Japanese firms. Meanwhile, Okamuro (2001), examining actual risk sharing in *keiretsu* transactions of Japanese firms, showed that the higher the dependence of a firm on a specific customer firm was, the more stable the firm's profits were.

interfirm transaction relationships take, and found that the lower the specificity and interdependency of a part or component, the higher was the probability that the part was not procured through *keiretsu* transactions or made internally by the final car assembler and that instead market procurement was chosen as the transactional form.[2] These preceding studies suggest that changes in cost structures with regard to the scale and scope of production and the opening-up of interfirm transaction relationships are closely linked.

Evidence that interfirm transaction relationship in the automobile industry have become more open in recent years is provided, for example, by Tokono (2015) using detailed data on automotive parts-related interfirm transaction relationships from the latter half of the 1980s to the 2000s. Meanwhile, Ito and Fukao (2001) and Ito (2002) and others empirically examined the link between transaction relationships and productivity in the automotive industry. However, there are no studies focusing on the impact of modularization and the opening-up of transaction relationships. Against this background, the aim of the present study is to examine the causes the opening-up of transaction relationships and its link with car part makers' behavior and performance in terms of their research and development (R&D), exports, etc. The main data used for analysis is the *Analysis of the Domestic Supply Matrix for Major Automotive Parts* (various years) by Sogo Giken containing detailed information on interfirm transactions in automobile parts in Japan, which we linked with microdata and establishment- and firm-level data from the *Basic Survey of Japanese Business Structure and Activities (BSBSA),* the *Census of Manufactures*, and the *Economic Census for Business Activity* (all compiled by the Ministry of Economy, Trade and Industry and provided by the Research Institute of Economy, Trade and Industry). Using these data, we analyze the interfirm transaction relationships and its link with productivity.

[2] In this context, modularization of part design can be regarded as a reduction of specificity and interdependency.

The remainder of this study is organized. Section 2 provides an outline of the data used in this study and presents an overview of how transaction relationships between final assemblers and parts makers in the Japanese automobile industry have changed from the 1990s through the 2000s. Specifically, it shows how interfirm transaction relationships have become more open and that there has been a growing productivity gap in recent years between parts makers that transact with a number of final assemblers and those that have continued to transact with just one final assembler.

Next, Section 3 examines the reasons why transaction relationships in the automotive industry are opening up. While a number of other factors – such as intensified competition among final assemblers due to globalization and the nonperforming loan problem following the collapse of the bubble economy – likely also play a role, the factor that we focus on here is the influence of changes in cost structures linked to production. Specifically, we estimate a cost function for parts makers to examine whether production efficiency is related to the number of transaction relationships with final assemblers.

Section 4 then examines differences in the characteristics of parts makers that transact with more final assemblers (that is, join more open transaction relationships) and those that do not. Specifically, we focus on differences in their R&D, productivity, export ratio, survival rate, etc. Finally, Section 5 summarizes the results of the analysis and discusses the policy implications.

## 2. Outline of data and overview of the opening-up of transaction relationships in the automotive industry

The data used for the analysis in this study are taken from the *Analysis of the Domestic Supply Matrix for Major Automotive Parts* by Sogo Giken, referred to as the *Supply Matrix* hereafter. The *Supply Matrix* has been published almost every year since 1989 and, for each year, focusing on more than 200 automotive parts and eleven domestic final assemblers, contains information on the parts makers (first-tier suppliers) supplying each specific part to each of the final assemblers. In this study, we use digitized data from the 1989, 1993, 1997, 2001, 2004, 2007, 2010 editions of the *Supply Matrix*.[3] Our analysis focuses only on parts makers delivering parts to passenger car manufacturers. For some items, information not only on whether a supplier transacted with a final assembler is available, but also on the quantity of parts supplied by the parts maker to the final assembler.

Now, Table 1 shows the total number of parts recorded in each edition of the *Supply Matrix* as well as the number of parts for which the quantity and/or value supplied is recorded. As can be seen, the percentage of parts for which such information is available has increased over time, and from the 2001 edition onward, the number of parts for which the [output value/value of parts supplied] is available exceeds 50% of the total number of parts. Next, Figure 1 shows the trends in the total nominal value of intermediate inputs procured by Japanese car makers from automotive parts makers and the total value of part supplies recorded in the *Supply Matrixes*. The figure indicates that from 2001 onward, the amount recorded in the *Supply Matrix* corresponds to more than 50% of total intermediate input of the automobile industry overall. Therefore, including parts for which the value supplied is not available, the *Supply Matrixes* can be regarded as covering an overwhelming share of major automotive parts.

**Table 1: Number of items included in the *Supply Matrixes***

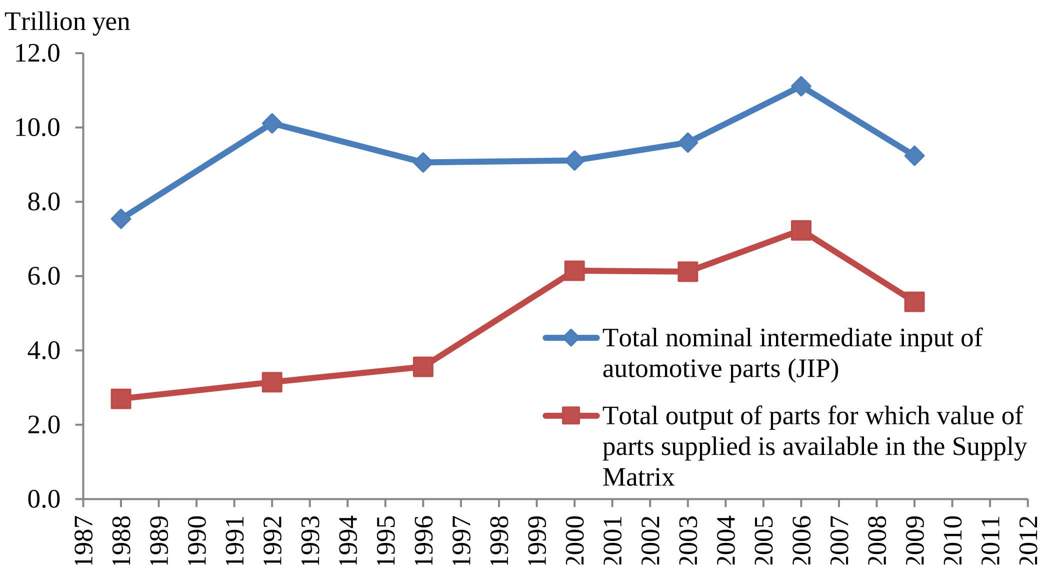
| Edition | Total number of parts | Number of parts for which quantity | Number of parts for which value of parts supplied is available |
|---|---|---|---|

[3] Each edition contains data for the previous year (for example, the 2010 edition contains information for 2009).

| | | | | | |
|---|---|---|---|---|---|
| | | supplied is available | | | |
| 1989 | 200 | 158 | 79% | 58 | 29% |
| 1993 | 225 | 197 | 88% | 90 | 40% |
| 1997 | 245 | 233 | 95% | 115 | 47% |
| 2001 | 256 | 240 | 94% | 132 | 52% |
| 2004 | 256 | 238 | 93% | 135 | 53% |
| 2007 | 256 | 247 | 96% | 158 | 62% |
| 2010 | 254 | 248 | 98% | 174 | 69% |

Source: *Supply Matrix* (various years).

**Figure 1: Intermediate input of automotive parts in the automobile industry and total value of parts for which the value of parts supplied is available in the *Supply Matrixes***




Sources: JIP Database 2013; *Supply Matrix* (various years).

Next, Table 2 provides an outline of the parts contained in the *Supply Matrixes*. The number of different parts included in the *Supply Matrix* was 194 in the 1989 edition, rising to 245 parts in the 2010 edition. In particular the number of electrical parts and components has increased substantially (from 36 parts in 1989 edition to 82 parts in 2010 edition). On the other hand, the number of parts makers (first-tier suppliers) that supplied major automotive parts to assemblers stood at 540 in the 1989 edition, but this number had decreased to 484 by the 2010 edition. More specifically, the table shows that the number of first-tier suppliers supplying engine parts and car body parts has decreased substantially.[4]

Next, using the Supply Matrixes, let us examine the opening-up of transactions, that is, whether the average number of final assemblers parts makers supply increased. Figure 2 shows the average number of final assemblers supplied by parts makers each year. As can be seen, the average number in the 1989 edition was 4.4 firms, but the number gradually increased, reaching 5.2 in the 2010 edition. Moreover, Figure 3 shows the distribution of parts makers in terms of the number of final assemblers they transact with. As can be seen, the share of parts maker supplying more than five final assemblers has been increasing. Next, Figure 4 shows the average number of final assemblers supplied by parts makers focusing on the type of parts supplied. The figure indicates that the opening-up of transactions can be observed for all types of parts. Moreover, it shows that the opening-up is particularly pronounced in the case of electrical parts and components as well as suspension and brake parts.

At the same time, the different types of parts handled by individual parts makers has also been increasing. Figure 5 shows the average number of different parts supplied by first-tier suppliers to one of the final assemblers (that is, degree of diversification). While the number was around 10 items around 1990, by the late 2000s this had increased to around 14.

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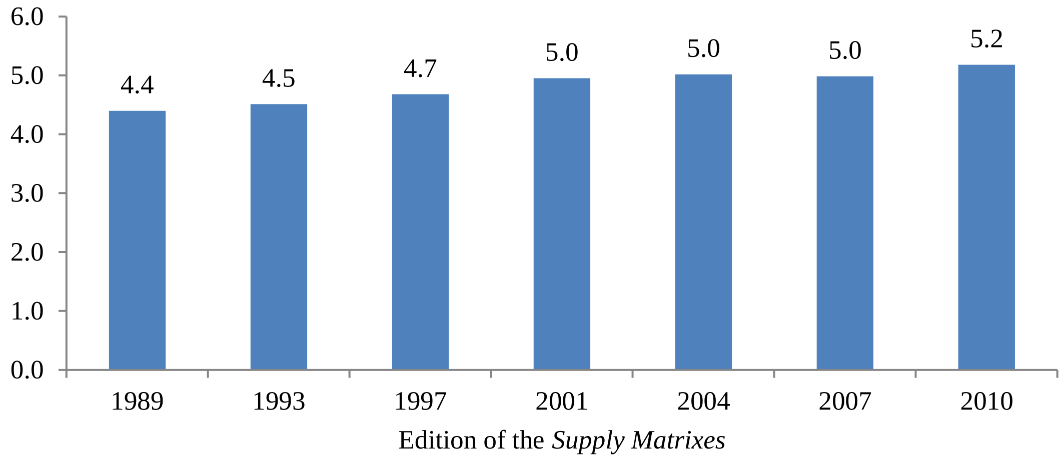
[4] According to the *BSBSA*, the number of automotive parts manufacturers did not decrease during this period.

**Table 2: Number of parts included and number of first-tier suppliers by type of parts**

| | Edition | All parts | Engine parts | Electrical parts and components | Driving and transmission parts | Suspension and brake parts | Body parts |
|---|---|---|---|---|---|---|---|
| Number of items included | 1989 | 194 | 69 | 36 | 36 | 19 | 34 |
| | 1993 | 218 | 73 | 58 | 36 | 18 | 33 |
| | 1997 | 241 | 78 | 66 | 37 | 20 | 40 |
| | 2001 | 249 | 79 | 71 | 39 | 20 | 40 |
| | 2004 | 248 | 79 | 72 | 39 | 22 | 36 |
| | 2007 | 246 | 78 | 73 | 37 | 22 | 36 |
| | 2010 | 245 | 73 | 82 | 37 | 20 | 33 |
| Number of first-tier suppliers | 1989 | 540 | 276 | 74 | 163 | 74 | 167 |
| | 1993 | 527 | 273 | 102 | 167 | 68 | 153 |
| | 1997 | 531 | 273 | 90 | 162 | 73 | 178 |
| | 2001 | 536 | 254 | 100 | 163 | 79 | 169 |
| | 2004 | 520 | 262 | 104 | 155 | 86 | 138 |
| | 2007 | 506 | 253 | 96 | 149 | 84 | 133 |
| | 2010 | 484 | 224 | 105 | 139 | 83 | 124 |

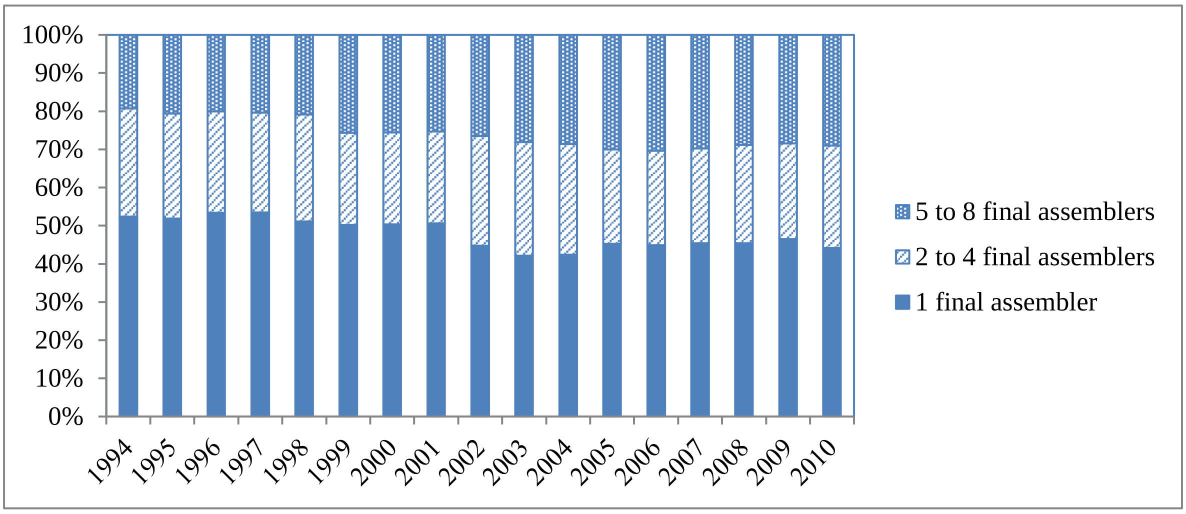
Source: *Supply Matrix* (various years).

**Figure 2: Average number of final assemblers supplied by parts makers (all parts)**



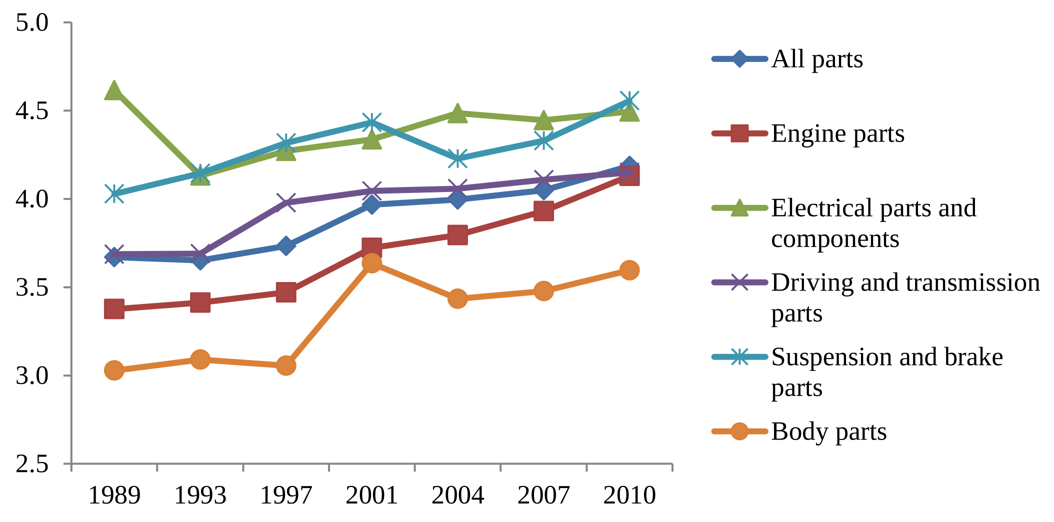

Source: *Supply Matrix* (various years).

**Figure 3: Number of final assemblers first-tier suppliers transact with**



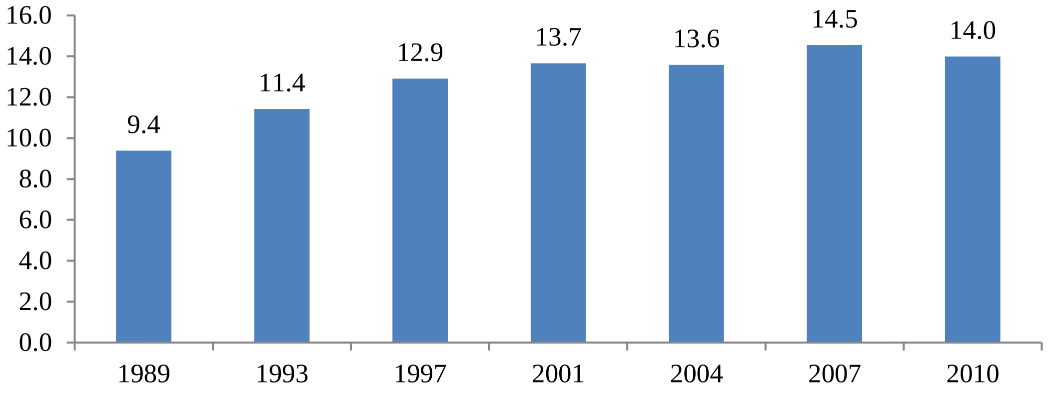

Source: *Supply Matrix* (various years) and the BSBSA.

**Figure 4: Average number of final assemblers supplied by parts makers, by type of parts**




Source: *Supply Matrix* (various years).

**Figure 5: Average number of parts supplied by parts makers per final assembler**

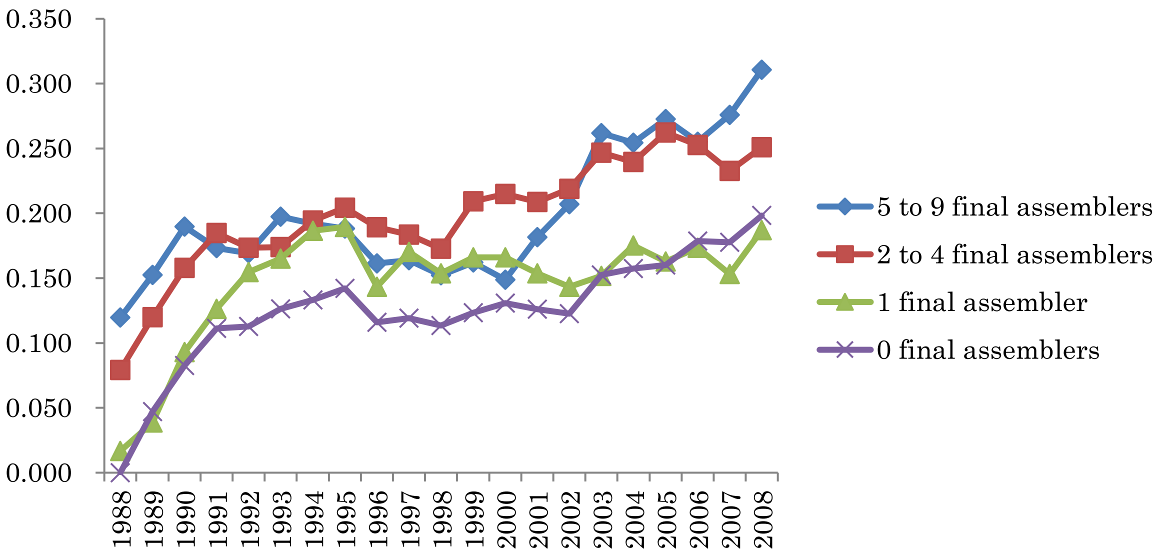



Source: *Supply Matrix* (various years).

Next, we merged the *Supply Matrix* data and the firm- and part-level microdata of the *Census of Manufactures*. To start with, we joined the data at the firm level using the company name, address, and information on paid-in capital. Moreover, since the classification of parts differs in the *Supply Matrix* and the *Census of Manufactures*, we unified the classifications. For the period from the 1997 edition onward, we were able to join the data for about 90% of the about 500 firms. Using the microdata of the *Census of Manufactures*, we estimated total factor productivity (TFP) at the establishment level and joined the estimates with the data from the *Supply Matrix*. Details of the approach we used to estimate establishment level TFP can be found in Fukao, Kim, and Kwon (2006).

Dividing parts makers into four groups in terms of the number of final assemblers they supply, we calculate the average TFP of establishments belonging to firms in each group using the merged data of the *Supply Matrix* and the *Census of Manufactures*. Developments in the TFP of the four groups of firms are shown in Figure 6. As can be seen, while the productivity of establishments of firms transacting with two or more final assemblers has been increasing from around 2000 onward, the productivity of establishments belonging to firms that are not first-tier suppliers (i.e., firms transacting with zero final assemblers) and of establishments belonging to firms transacting with only one final assembler has remained largely unchanged, so that productivity differences between the former and the latter have grown.[5]

**Figure 6: TFP index (in logarithm) of automotive parts makers grouped by number of final assemblers supplied**




Source: Authors' calculations based on merged data from the *Census of Manufactures* and the *Supply Matrix.*

Note: The figure shows the average TFP of establishments belonging to the automotive parts industry. The index is standardized using the average TFP in 1988 of establishments belonging to firms with no transactions with final assemblers.

[5] Aghion et al. (2005) suggest greater market competition tends to increase the technology gap across firms. One explanation for the increased productivity gap observed here therefore could be that the competitive environment may have changed as transaction relationships have become more open.

## 3. Modularization and the opening-up of transaction relationships

In this section, we examine the possibility that changes in parts-related cost structures may have played a role in the opening-up of transaction relationships by estimating a cost function for parts manufacturers. Assuming that the total costs of parts manufacturer $h$ in year $t$ are given by $C_{ht}$, the cost function is specified as follows:

$$\ln(C_{ht}/Y_{ht}) = \alpha_0 + \alpha_1 \ln(Y_{ht}) + \alpha_D f_{ht} + \alpha_I n_{Iht} + \alpha_J n_{Jht} + \sum_{i=1}^{I} \beta_i d_{hti} + \lambda_t + \varepsilon_{ht}$$

where the dependent variable on the left-hand side is the average cost of the parts maker obtained by dividing the total cost by output $Y_{ht}$, which we proxy using the parts maker's sales. $f_{ht}$ is the first tier supplier dummy which takes 1 if parts maker $h$ directly supplies at least a final assembler. $\alpha_D$ indicates the average difference in production efficiency between first tier suppliers and second or more tier suppliers. $n_{Iht}$ represents the number of different parts being produced, and $n_{Jht}$ represents the number of final assemblers being supplied. $d_{hti}$ represents a set of dummy variables for different parts and components that take 1 if a parts supplier produces part $i$ and 0 otherwise and that are added to take into account the effect of differences in production costs and prices for individual parts. $\lambda_t$ represents a set of year fixed effects in order to control for the impact of price shocks in the automotive parts industry.

When the product architecture is of the integral type, a close exchange of information between transaction partners is needed. Therefore, holding all else equal, the more final assemblers a parts maker supplies, i.e., the larger $n_{Jht}$, the higher the costs will be, so that $\alpha_J$ is expected to be positive. On the other hand, the more modular architectures are used, the more it becomes unnecessary to customize products for a transaction partner, so that $\alpha_J$ should approach zero. Therefore, if the estimation results of the cost function above show that $\alpha_J$ decreases over time, this indicates that the degree of customization has been declining.

To estimate the above cost function, we link the *Supply Matrix* data at the firm-level with *BSBSA* data for the period from 1994 to 2010. Matching was conducted using firms' name, address, and paid-in capital, and we were able to link about 90% of the firms in the *Supply Matrix*. We end up with an unbalanced panel spanning a period of 17 years covering about 800 firms belonging to the automotive industry. We assumed that firms in the *BSBSA* that we were not able to match with firms the *Supply Matrix* are second- or lower-tier suppliers that do not transact directly with final assemblers.

The estimation results of the cost function are shown in Table 3. Looking at the result of the baseline estimation shown in column (1), the coefficient on the first-tier suppler dummy is not statistically significant, indicating that there is no significant difference between the production efficiency of first-tier suppliers on the one hand and second- and lower-tier supplier on the other. On the other hand, the coefficient on the number of parts produced is positive and statistically significant, indicating that there are diseconomies of scope. In addition, the coefficient on the number of final assemblers supplied is also positive and statistically significant, indicating that production efficiency tends to decrease as the number of assemblers supplied increases, indicating that a certain degree of customization and coordination may be necessary.

Next, column (2) shows the results when we add an interaction term of the number of final assemblers supplied and a trend term to the explanatory variable to examine how the effect of the number of final assemblers supplied on costs has changed over time. The trend term is set to 0 for 1994. As seen in the table, the coefficient on the interaction term is negative and statistically significant, indicating that the effect that supplying a larger number of final assembler is associated with higher costs has been weakening over time. This suggests that changes in technology and production, such as the digitization of parts and components, standardization, the increased use of common components, and modular architecture have played a role, while the [role/importance] of customization in determining costs has been declining. Meanwhile, the size of the estimated coefficient indicates that the marginal (negative) effect of the number of final assembler supplied has fallen to almost zero in the second half of the 2000s.

**Table 3: Cost function estimation results**

| Dependent variable: Logarithm of average costs | (1) | (2) |
|---|---|---|
| Sales (log) | -0.0132*** | -0.0132*** |
| | (0.00136) | (0.00136) |
| First-tier supplier dummy | 0.00046 | 0.00029 |
| | (0.00321) | (0.00321) |
| Number of parts produced | 0.000846** | 0.00066 |
| | (0.000385) | (0.000485) |
| Number of final assemblers supplied | 0.00124* | 0.00272*** |
| | (0.000752) | (0.00103) |
| Number of parts supplied * Trend | | 0.000021 |
| | | (0.0000267) |
| Number of final assemblers supplied * Trend | | -0.000172** |
| | | (0.0000779) |
| Constant | 0.174*** | 0.173*** |
| | (0.0116) | (0.0116) |
| Year dummies | Yes | Yes |
| Parts dummies | Yes | Yes |
| No. of observations | 14,558 | 14,558 |
| $R^2$ | 0.372 | 0.372 |

Note: Analysis using linked data of firms belonging to the automotive parts industry from the *Supply Matrix* and the *BSBSA* for the period 1994–2010. Standard errors in parentheses.

***p<0.01, **p<0.05, *p<0.1.

## 4. What kind of parts makers have shifted to more open transaction relationships?

In this section, we examine differences between parts makers that have shifted to more open transaction relationships and other parts makers from a variety of angles. The data used for the analysis are the same panel data used in the previous section. For the analysis, we regress various variables such as firms' size, productivity, and R&D intensity on dummy variables representing the number of final assemblers supplied (using the same categories as in Figure 6). The estimation is conducted using ordinary least squares.

The results of the regression analysis are shown in Tables 4 to 6. Starting with Table 4, this shows the results of focusing on the link between the degree of openness of transaction relationships and parts maker characteristics. The results indicate that the larger a parts maker – as measured in terms of the number of employees and sales – the more open its transaction relationships tend to be (i.e., the more final assemblers it tends to supply). Next, to examine the capital tie, we used a dummy variable for suppliers that are subsidiaries of the other firms. The results indicate that parts makers supplying a larger number of final assemblers are more likely to independent. In addition, the last column of the Table shows that a higher foreign ownership ratio is also associated with greater openness as measured in terms of the number of final assemblers supplied. Overall, the results in the table indicate that larger firms – as measured in terms of their number of employees and sales – and firms that are independent from other domestic firms (as indicated by their capital ownership) tend to have more open transaction relationships. Moreover, firms with a high foreign ownership ratio are also likely to have more open transaction relationships. These results are in line with Toyoda's (2003) argument.

**Table 4: Openness of transaction relationships and parts maker characteristics**

| Dependent variable: | Number of employees (log) | Sales (log) | Subsidiary | Foreign ownership ratio |
|---|---|---|---|---|
| Number of final assemblers supplied = 1 firm | 0.795*** | 1.137*** | -0.0818*** | 1.105*** |
| | (0.0210) | (0.0266) | (0.0114) | (0.268) |
| Number of final assemblers supplied = 2–4 firms | 1.338*** | 1.762*** | -0.0743*** | 5.195*** |
| | (0.0272) | (0.0346) | (0.0148) | (0.348) |
| Number of final assemblers supplied = 5–8 firms | 2.116*** | 2.543*** | -0.132*** | 6.643*** |
| | (0.0276) | (0.0351) | (0.0150) | (0.353) |
| Constant | 5.188*** | 8.325*** | 0.284*** | 0.21000 |
| | (0.0310) | (0.0394) | (0.0169) | (0.397) |
| Year dummies | Yes | Yes | Yes | Yes |
| No. of observations | 14,656 | 14,656 | 14,656 | 14,656 |
| $R^2$ | 0.360 | 0.359 | 0.018 | 0.041 |

Note: Analysis using linked data of firms belonging to the automotive parts industry from the *Supply Matrix* and the *BSBSA* for the period 1994–2010. Standard errors in parentheses.

***p<0.01, **p<0.05, *p<0.1.

Next, in Table 5 we investigate the link with differences in firm activities by examining differences in parts makers' export ratio (direct exports divided by sales), R&D intensity ( R&D expenditure divided by sales), and patent intensity (number of patents held per employee). The results indicate that greater openness in transaction relationships tends to be associated with a higher export ratio and higher R&D

and patent intensities. These findings suggest that there is a positive correlation between more open transaction relationships and more active overseas activities and higher technological capabilities.

Finally, in Table 6 we focus on the link between the openness of transaction relationships and parts makers' business performance. The regression results indicate that parts makers with more transaction relationships tend to have higher productivity (TFP), higher profits (ROA and operating profit), and a higher survival rate (i.e. low hazard ratio). In other words, it is likely that parts makers that have not moved to more open transaction relationships cannot raise their business performance and are more likely at risk of being forced to exit the market.

**Table 5: Openness of transaction relationships and parts maker activities**

| Dependent variable: | Export ratio | R&D intensity | Patent intensity |
|---|---|---|---|
| Number of final assemblers supplied = 1 firm | 0.0131*** | 0.00625*** | 0.0301*** |
| | (0.00213) | (0.000371) | (0.00309) |
| Number of final assemblers supplied = 2–4 firms | 0.0387*** | 0.0138*** | 0.0827*** |
| | (0.00276) | (0.000483) | (0.00402) |
| Number of final assemblers supplied = 5–8 firms | 0.0769*** | 0.0244*** | 0.123*** |
| | (0.00280) | (0.000489) | (0.00407) |
| Constant | 0.00560* | 0.00281*** | 0.0288*** |
| | (0.00315) | (0.000550) | (0.00458) |
| Year dummies | Yes | Yes | Yes |
| No. of observations | 14,656 | 14,656 | 14,656 |
| $R^2$ | 0.066 | 0.178 | 0.080 |

Note: Analysis using linked data of firms belonging to the automotive parts industry from the *Supply Matrix* and the *BSBSA* for the period 1994–2010. Standard errors in parentheses.

***p<0.01, **p<0.05, *p<0.1.

**Table 6: Openness of transaction relationships and parts maker performance**

| Dependent variable: | TFP level (log) | TFP growth | ROA | Operating profit | Hazard rate |
|---|---|---|---|---|---|
| Number of final assemblers supplied = 1 firm | 0.0320*** | 0.001 | -0.002 | -0.00331*** | -0.00823** |
| | (0.00197) | (0.00134) | (0.00129) | (0.00115) | (0.00339) |
| Number of final assemblers supplied = 2–4 firms | 0.0530*** | 0.00233 | 0.00133 | 0.00244 | -0.0127*** |
| | (0.00256) | (0.00175) | (0.00168) | (0.00149) | (0.00440) |
| Number of final assemblers supplied = 5–8 firms | 0.0691*** | 0.00198 | 0.00396** | 0.0107*** | -0.0123*** |
| | (0.00257) | (0.00176) | (0.00171) | (0.00151) | (0.00446) |
| Constant | -0.0486*** | -0.00121 | 0.0202*** | 0.0347*** | 0.00329 |
| | (0.00329) | (0.00225) | (0.00191) | (0.00170) | (0.00502) |
| Year dummies | Yes | Yes | Yes | Yes | Yes |
| No. of observations | 12,838 | 12,838 | 14,612 | 14,651 | 14,656 |
| $R^2$ | 0.084 | 0.234 | 0.055 | 0.071 | 0.017 |

Note: Analysis using linked data of firms belonging to the automotive parts industry from the *Supply Matrix* and the *BSBSA* for the period 1994–2010. Standard errors in parentheses.

***p<0.01, **p<0.05, *p<0.1.

## 5. Summary of results and consideration of policy implications

In this study, we examined changes in transaction relationships in Japan's automotive industry and the impact of these changes on the behavior and performance of automotive parts makers using time-series data on transactions in parts and components between final assemblers and parts makers as well as business information on parts makers. We constructed a panel dataset by linking a unique dataset recording corporate information on the parts makers (first-tier suppliers) supplying parts to eleven individual domestic final assemblers for each of more than 200 individual automotive parts with firm- and establishment-level microdata from official statistics, and conducted a detailed analysis of transaction relationships.

Main results can be summarized as follows. First, transaction relationships in Japan's automotive industry are becoming more open. At the same time, there is a growing productivity gap between parts makers that supply two or more final assemblers and parts makers that supply only one assembler. Second, by estimating a cost function for parts makers, we found that the larger the number of final assemblers a parts maker supplies, the lower its production efficiency tends to be; however, the negative link between the number of final assemblers supplied and parts markers' production efficiency has weakened over time. And third, examining differences between parts makers that supply a large number of final assemblers and those that do not, we found that there were not only structural differences between them, for example in terms their size and foreign ownership ratio, but that they also differed substantially in their activities such as their R&D efforts and export orientation, as well as in their business performance, such as their productivity, profitability, and survival rates.

These results indicate that the gap between firms that have shifted to open transaction relationships and those that have not has been growing. This suggests that changes in the economies of scale and scope due to changes in production and technology in recent years have had a major effect.

The results of the analysis in this study have the following policy implications. First, due to technological innovations such as modularization and standardization, it can be expected that for some parts suppliers that assemblers directly transact with will be consolidated as transaction relationships become more open. In that case, it is likely that a small number of relatively large and productive parts makers will come to play a larger role in the automobile industry. An important policy issue in this context is how smoothly resources of firms left behind in this competition can be transferred to new growth fields. Of course, due to the importance of cost structures and customization, many parts makers will not be consolidated and will remain. In this context, a key question that needs to be investigated is what kinds of parts makers (in terms of their characteristics, parts supplied, etc.) will be consolidated. Second, the changes in cost structures and transaction structures in parts production may shift the distribution of value added between parts suppliers and final assemblers. As happened in the electrical machinery industry, profits may shift from final assemblers to parts makers. In any case, in order to ensure the Japanese automobile industry maintains and enhances its international competitive advantage, it is necessary to ascertain what kind of impact the changes in cost and transaction structures with regard to automotive parts has on the competitiveness of both final assemblers and parts makers.

Finally, it is worthwhile to point out some issues for future research. The first is that through the opening-up of transactions, communication between final assemblers and parts makers transacting with each other may be weakened, which in turn could weaken technology transfer and spillovers of technological knowhow between firms. Many studies have highlighted that so far product development through close coordination between customers and suppliers has been a key source of strength of Japan's manufacturing sector, and an important policy topic is to determine how the opening-up of transaction relationships affects such technology transfers and knowledge spillovers.

Second, a number of previous studies have highlighted that one of the functions of relational transactions, which is such a notable characteristic of Japanese firms including those in the automotive industry, is the role customer firms play in sharing some of the supplier's risk (Aoki, 1984; Okamuro, 2001). Against this background, another issue that needs to be investigated is whether the opening-up of transaction relationships in the car industry is leading to a weakening of this kind of risk-sharing.

And third, the cost structure of production is determined not only by parts makers, but also by final assemblers' strategy with regard to modularization and standardization and the characteristics of particular parts and components. Therefore, in order to obtain more effective policy implications, it is necessary to deepen the analysis and examine how differences in final assemblers' strategies and differences in parts characteristics affect transaction structures and parts makers' performance.

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