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Enhancement of the advanced R&D cooperation between automakers and suppliers in the Japanese automobile industry

Hosei University
Yoshinori Konno

March 2007

東京大学21世紀COE（センター・オブ・エクセレンス）
ものづくり経営研究センター

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1. Introduction

In many industries, global competition has grown fiercer, technologies have been more complicated, market needs have further upgraded, the variety of goods and services have increased substantially and product lifecycles have been shortened. Companies in these industries are now required not only to improve the speed and quality of product development projects but also to lower development costs (e.g., Wheelwright and Clark, 1992). Also knowledge for researching, developing and commercializing new goods or services has increased explosively (e.g., Badaracco, 1991). Consequently it is no longer realistic for any company alone to cover all product development processes, and it is now essential for all companies to cooperate with others in order to survive fierce competition (e.g., Henderson and Cockburn, 1994).

Japanese auto sector is one of the industries where inter-firm cooperation in product development processes is playing a key role. The typical passenger car contains 20,000 to 30,000 components. As much as 70% of these components come from outside suppliers. These outside suppliers are often involved in design as well as manufacturing, and may account for 50% or more of engineering costs.

In addition, a car is a typical product for integral architecture. Functional and structural interdependency is complicated between components comprising a car. Interfaces between these components are not standardized. It is difficult to make any excellent car without knowledge about the entire car or individual components (Takeishi, 2003). In the Japanese auto industry, automakers accumulate knowledge about the whole of vehicles while automotive suppliers store knowledge about individual components. When new technologies or new-concept components are developed, automakers and suppliers must make joint development arrangements in order to integrate their knowledge.

In this respect, a great number of studies at home and abroad since the mid-1980s have drawn a conclusion (e.g., Womack et al., 1990; Clark and Fujimoto, 1991; Cusumano and Takeishi, 1991; Nishiguchi, 1994; Dyer, 1996; Sako, 1996; Sako and Helper, 1998; Wasti and Liker, 1999): "Japanese automakers have maintained their respective long-term cooperative business relations with limited number of suppliers and are conducting close information exchanges and coordination with them, based on their strong mutual trust. Very close cooperation between automakers and their respective suppliers have covered even product development processes. This is a source of the Japanese auto industry's international competitiveness." As vehicle development lead times have shortened, research and development cooperation between automakers and their respective suppliers have reportedly been enhanced further (e.g., Konno, 2002).

However, vehicle development projects are not limited to improvements of existing technologies. They may include development of advanced technologies regarding new-concept automotive components and new elemental technologies (e.g., materials). This kind of technology development is called "advanced research and development." Advanced research and development of new technologies may precede or be integrated with new vehicle development projects.

Many studies have mentioned that automakers and their respective suppliers cooperate closely even in such advanced research and development activities (e.g., Ueda, 1995). But most of earlier studies analyzed individual product development projects respectively and discussed factors affecting such as development lead times, development man-hours and product quality, therefore failing to cover cooperation between automakers and their respective suppliers in the development of advanced technologies. Some studies that covered such cooperation were limited to qualitative analyses, lacking quantitative analyses.

This paper is designed to analyze the realities of recent cooperation between Japanese automakers and their respective suppliers in the development of advanced technologies as quantitatively as possible. A conclusion of this paper is that as cooperation between automakers and their respective suppliers has been expanding into the development of advanced technologies, suppliers that have the capability to participate in such development activities have had closer relations with automakers than others.

Section 2 analyzes data concerning automakers' joint patent applications in order to specify cooperation in the development of advanced technologies. Section 3 analyzes the relationship between such cooperation and business relations, based on questionnaire survey data. Section 4 covers the conclusion and discussions.

2. Analysis of Automakers' Joint Patent Applications

This section looks into cooperation between automakers and their respective suppliers in the development of advanced technologies through an analysis of automakers' joint patent applications.

2.1. Source

Subjected to the analysis were nine Japanese automakers' patent applications that were filed over 12 years between 1993 and 2004 and released on the official patent gazette issued by Japan's Patent Office. The nine automakers are Toyota Motor Corp., Nissan Motor Co., Honda Motor Co., Mitsubishi Motors Corp., Mazda Motor Corp., Suzuki Motor Corp., Daihatsu Motor Co., Fuji Heavy Industries Ltd. and Isuzu Motors Ltd. Specifically, applicants (multiple applicants for one patent application are all counted as applicants), publication numbers, application dates, names, international patent classification (first invention information subclasses), inventors and other patent application data were entered into spreadsheet software. Then, we conducted a patent map analysis of joint patents, or patents for which applications were filed jointly by automakers and their suppliers.

The joint patent applications are those for which both automakers and their respective suppliers are applicants in connection with the development of advanced technologies that can be identified as novel or inventive. The joint patents thus represent inventions to which both automakers and their suppliers have contributed[1]. Therefore, the joint patents may be utilized as an indicator of successful

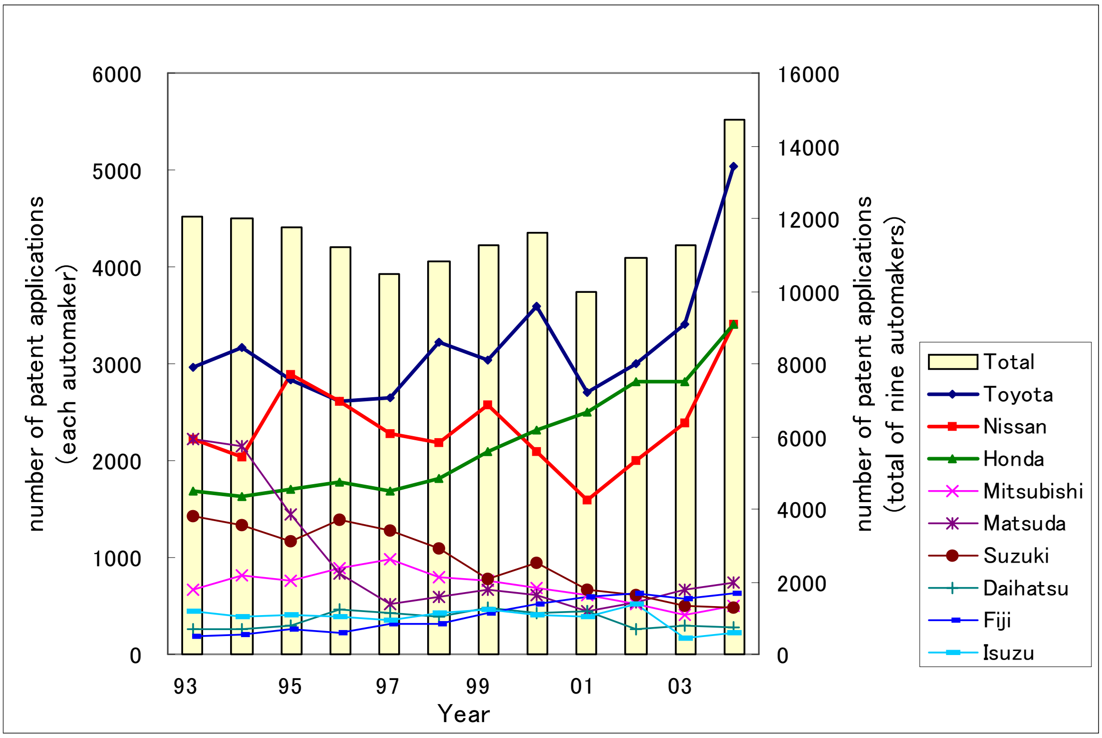
[1] Inventions subjected to patent applications may be published in the official gazette one year and a half after these applications are filed with the Patent Office. Applications may enter an examination process only if applicants pay examination fees and request examination. If novelty or inventiveness is identified in inventions, patents may be awarded.

This means that patents are awarded for only a minor portion of patent applications. Many cooperation in the development of advanced technologies[2].

2.2. Overview of Automakers' Patent Applications

First, we would like to review the overall trend. Figure 1 indicates the total number of patent applications for the nine automakers and each of them between 1993 and 2004.

Figure 1: Patent Applications



The figure shows that the nine automakers' total patent applications began to increase around

applications are filed for defensive purposes. Manufacturing know-how and other technologies that may be difficult to imitate for rivals are not necessarily subjected to patent applications. There are thus various constraints on patent data. However, no alternative objective indicators exist for successful advanced technology development. As far as patent applications are filed at some cost, technologies subjected to patent applications should have been screened by applicants and can be expected to feature some novelty or inventiveness. In this sense, patent data may be allowed to be utilized as an indicator of successful advanced technology development.

[2] Multiple applicants for a single patent may not necessarily have made the same contributions to a relevant invention. The multiple applicants may assess their respective contributions to an invention subject to their patent application and agree on how to share gains from the patent. Such agreement may not be reflected in patent applications, but all applicants should have made some contributions to the invention. In this sense, there may be no problem with utilization of joint patent applications as an indicator of cooperation in the development of advanced technologies.

2002 and scored a sharp increase in 2004. Breaking down these patent applications by automaker, we find that Toyota, Nissan and Honda account for a dominant share of the total. Roughly, the three firms accounted for 60-70% of the nine's total patent applications. In 2004, the three's share rose to 80%. Patent applications from the others have been falling or leveling off. Effectively, Toyota, Nissan and Honda have been leading the development of advanced technologies in the Japanese auto industry.

2.3. Overview of Automakers' Joint Patent Applications

Next, we would like to review the overall trend of patent applications filed jointly by automakers and their respective suppliers. Figure 2 indicates the total number of joint patent applications for the nine automakers and their share of their total patent applications between 1993 and 2004.

Figure 2: Joint Patent Applications and Their Share of Total

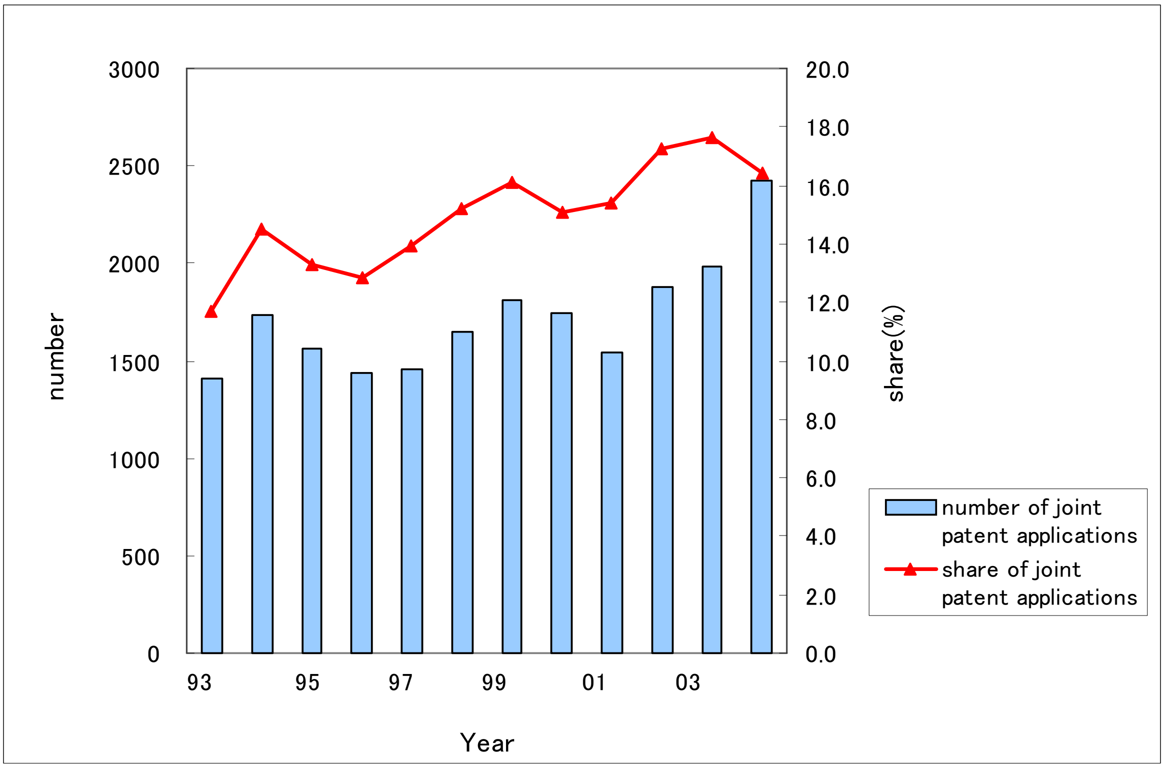
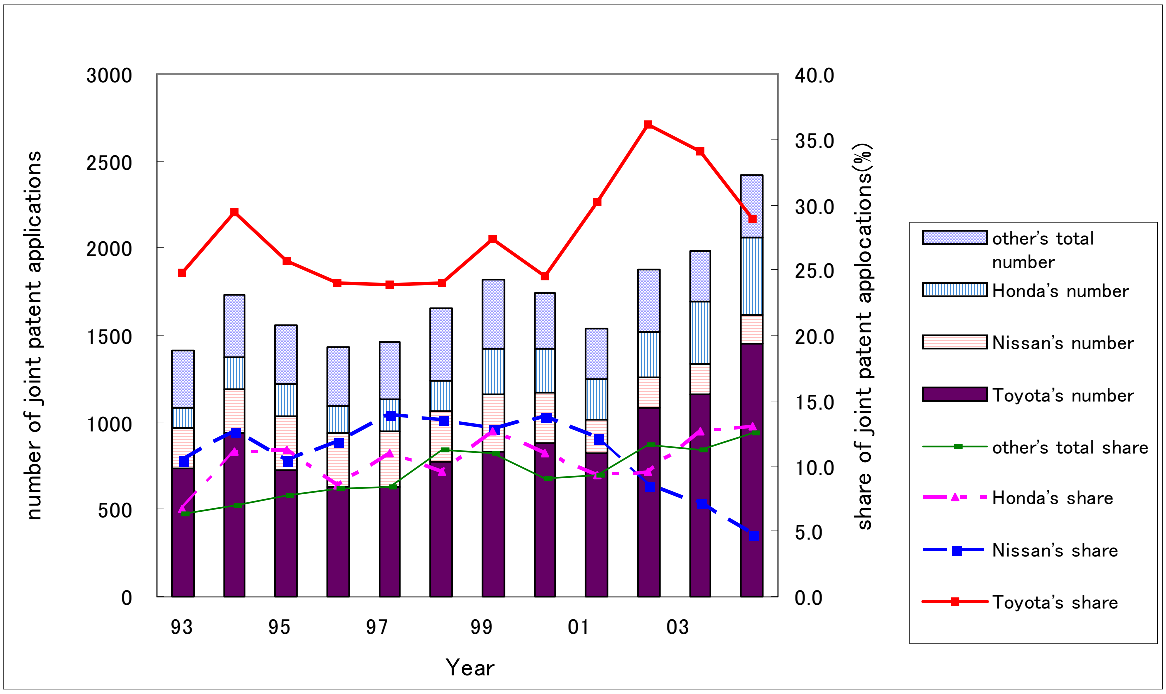


Figure 2 shows that the total number of joint patent applications and their share of total patent applications have continued a rough upward trend, although some fluctuations were seen for some years. Particularly, joint patent applications have increased apparently since the nine's total patent applications began to rise in 2002. Joint patent applications' share of the total also indicates a rough upward trend.

Figure 3 indicates the number of joint patent applications and their share of the total for the three largest Japanese automakers – Toyota, Nissan and Honda – between 1993 and 2004. This figure shows that Toyota features a greater number of joint patent applications and a higher share of the total patent applications than at the other two[3].

Figure 3: Joint Patent Applications and Their Share of Total for Each Automaker

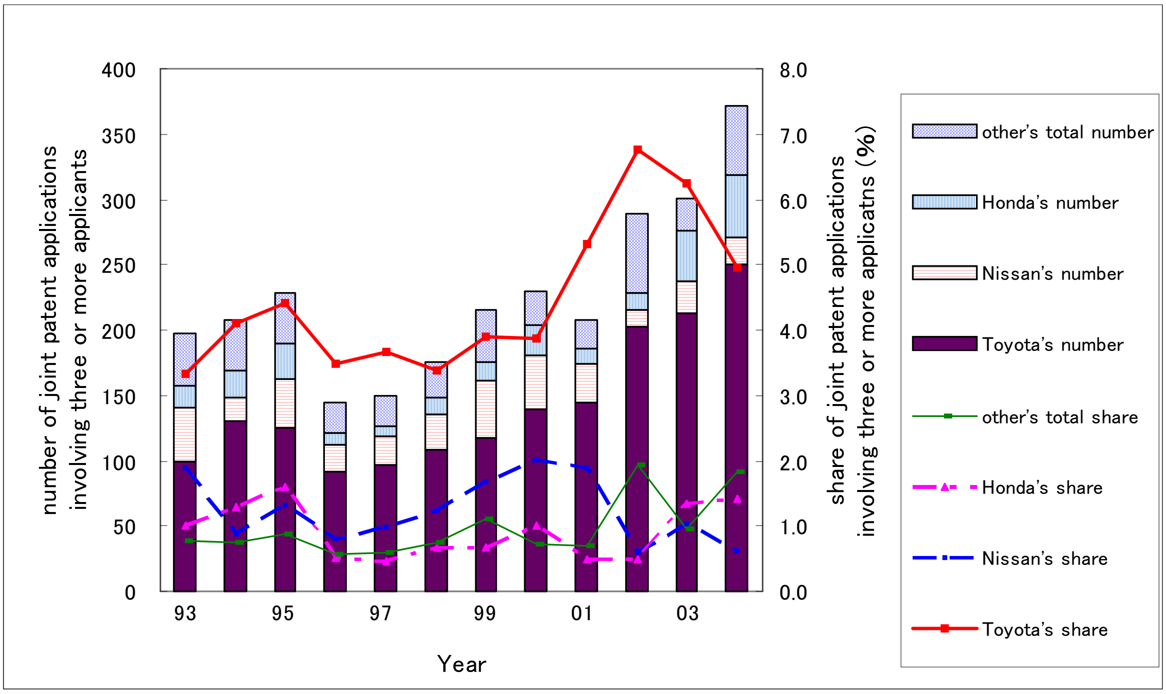


For each of the three largest automakers, Figure 4 indicates the number and percentage share of patent applications that it filed jointly with two or more suppliers. A patent application filed by three or more companies may represent not only dyad cooperation between an automaker and one of its suppliers but also horizontal cooperation between suppliers. The number and percentage share of

[3] Figures 3 and 4 don't make adjustments for Toyota's joint patent applications with Toyota Central R&D Labs. Inc. and Honda's joint applications with Honda R&D Co., although these R&D firms have personnel exchanges with their respective parent companies and are positioned as consolidated subsidiaries forming component of their respective parents' R&D divisions. This means there is some upward bias for these companies. Even if such adjustments are made, however, a conclusion here may remain unchanged.

such patent applications can be utilized as an indicator of advanced R&D cooperation.

Figure 4: Joint Patent Applications Involving 3 or More Applicants for Each Automaker



This figure shows that Toyota features a far higher number and percentage share than the others for joint patent applications involving three or more applicants. Joint patent applications for Toyota mainly involve Toyota-affiliated suppliers including Toyota Central R&D Labs. Inc., Denso Corp. and Aisin Seiki Co. However, Toyota's R&D cooperation partners have not been limited to its affiliates. For example, Toyota filed a joint patent application for some telecommunications technologies in 1999 with five others – Aisin AW Co., Denso, Fujitsu Ten Ltd., Pioneer Corp. and Matsushita Electric Industrial Co. We have found many large-scale R&D projects that Toyota has arranged with a wider range of suppliers.

Japanese automakers have thus expanded cooperation with their respective suppliers into the development of advanced technologies. Amid such general trend, Toyota has also made aggressive efforts to coordinate the joint-style advanced technology development projects which include two or more suppliers (which include horizontal cooperation between suppliers). In terms of quantitative achievements through such cooperation, Toyota has gone far ahead of other Japanese automakers.

3. Analyzing Questionnaire Survey of Supplier

As indicated in the previous section, automakers' cooperation with their respective suppliers in the development of advanced technologies has been expanding in the Japanese auto industry. How have business relations between automakers and their respective suppliers changed in line with such expanding cooperation?

In a bid to look into such changes, we would like to analyze a questionnaire survey of first-tier automotive suppliers, that was conducted in November 2003 jointly with Mr. Takahiro Fujimoto, a professor of Tokyo University, and Mr. Ku Seunghwan, then assistant professor at Kyoto Sangyo University .

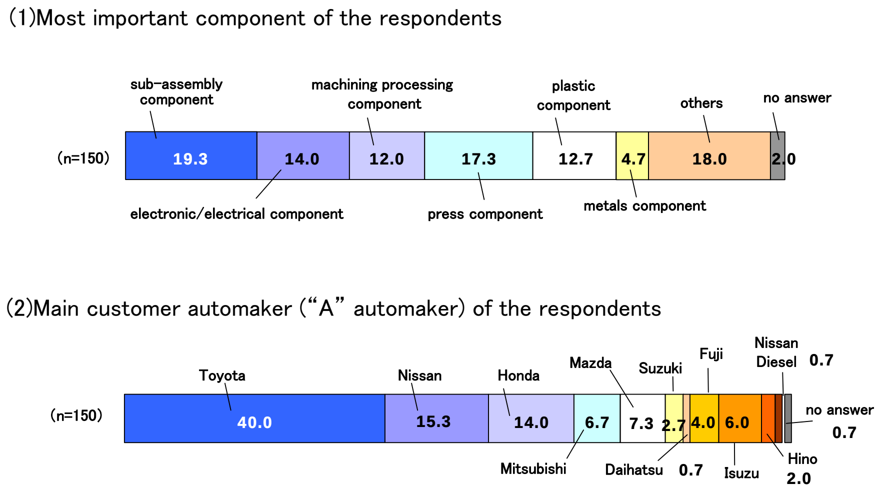
3.1. Survey Data Sources and Outline

In the above questionnaire survey, we sent questionnaires to 340 first-tier automotive suppliers among the members of the Japan Auto Components Industries Association. Of them, 150 firms sent back responses, resulting in about 44.1% response rate. In the questionnaire, the suppliers were first asked to select its most important product (component). Then they were asked about its business relations with a main customer automaker regarding the most important product (component).

Note that the components chosen as the most important spread over 7 categories; sub-assembly components, electronic / electrical components, machining processing components, press components, plastic components, metals (molding / casting) components, and others. Of the total, subassembly components accounted for 19%, press components for 17%, and electronic and electrical components for 14%. The main customer automaker mentioned by the questionnaire respondents were Toyota 40%, Nissan 15%, Honda 14%, Mitsubishi 7%, Matsuda 7%. These percentages roughly represent their respective domestic auto production shares.

One question in the survey asked a supplier about the number of competing suppliers to the respondent's main customer automaker. Those citing the number as two to four including the respondent itself accounted for 70% of the total respondents. And 27% of the respondents answered that the number has increased in the last four years (but 62% saw no change). On the number of Japanese automakers they are dealing with as customers, responses ranged from one to 11 firms. And 24% of the respondents said that the number has increased over the last four years (but 68% saw no change). Thus, these results show that both automakers and suppliers have remained unchanged or increased slightly their customer / supplier bases.

Figure 5: Outline of Components Transactions (1)



Of the suppliers, 58% said that they "undertook more than half of the development workload themselves. Asked on the change in the percentage over the past four years, 56% answered that they saw an upward trend. These results show that many suppliers are responsible for quite a high ratio of the component development.

Of suppliers' transactions with automakers, 69% belonged to 'the approved drawing components[4]', 17% belonged to 'the assigned drawing components[5]' and 10% belonged to 'the detailed-controlled drawing components[6]'. 'Supplier proprietary components' were subjected to 3% of these transactions. These data indicate that suppliers participated in detailed engineering as part of

[4] Under 'the approved drawing components' practice, a supplier conducts detailed engineering based on rather rough specifications provided by the customer automaker. After the automaker approves the drawings, the supplier owns the final drawings, and produces components based on it for delivery to the automaker. See Asanuma(1989) and Fujimoto(1999).

[5] Under 'the assigned drawing components' practice, a supplier conducts detailed engineering based on the customer automaker's basic drawing. The automaker owns the final drawing. This type of components is positioned between the approved drawing components and the detailed-controlled drawing components. See Fujimoto(1999).

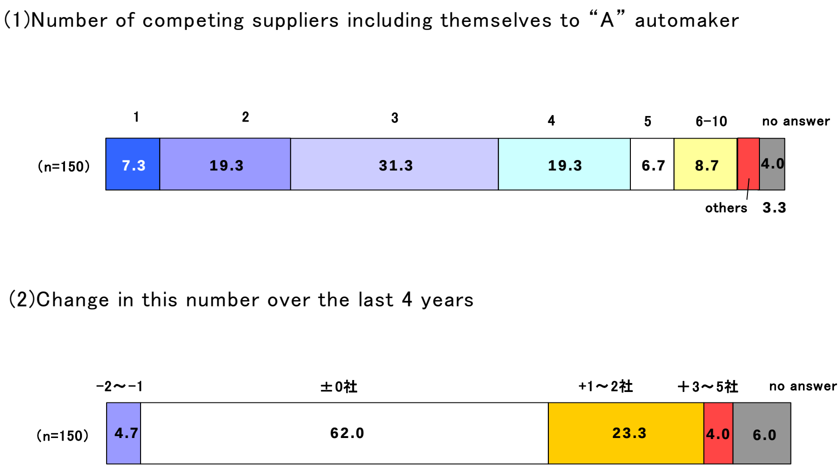
[6] Under 'the detailed-controlled drawing components' practice, an automaker undertakes detailed engineering for a component. And the automaker owns the final drawing and provides a supplier with it for production. See Asanuma(1989) and Fujimoto(1999).

development of components in more than 86% (combining the approved drawing components and assigned drawing components) of the total transactions.

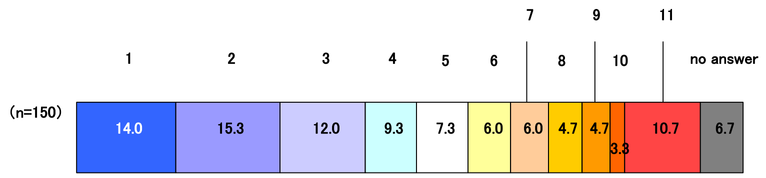
As for competition, 67% of the responding suppliers said that they were selected by ‘development competitions’. Some 23% said they received exclusive orders from automakers. The remaining 11% cited biddings.

Respondents were also asked to choose the most important capability from five alternatives for winning competition. The most important capability, selected by 53%, was proposing and developing new components technologies or new-concept components beyond improvement of existing technologies. The second most important capability, chosen by 23%, was lowering costs through manufacturing process improvements. The third, chosen by 17%, was reducing costs through design improvements. The fourth, selected by 4%, was developing components in accordance with specifications given by automakers, and the fifth, chosen by 3%, was guaranteeing quality and just-in-time delivery.

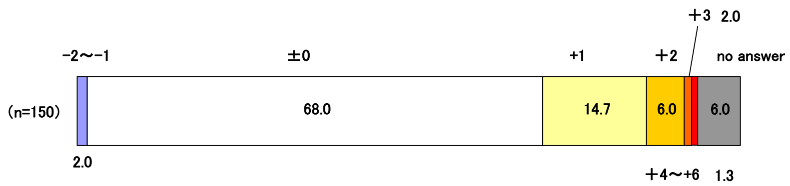
Figure 6: Outline of Components Transactions (2)



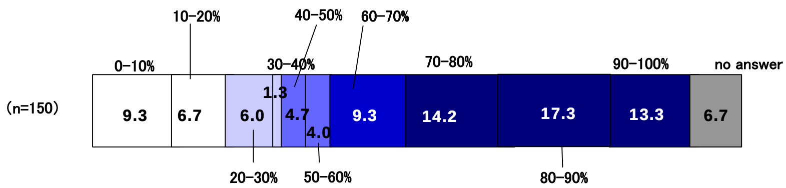
(3)Number of Japanese automakers the respondents are dealing with



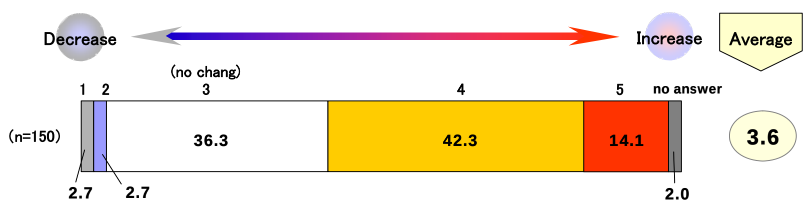
(4)Change in this number over the last 4 years



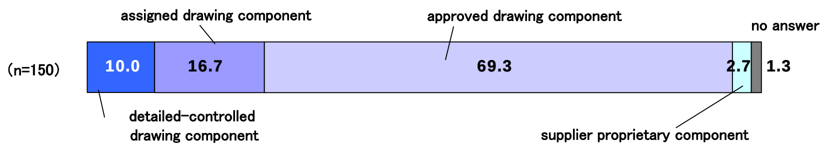
(5)Amount of development workload that the respondents undertook



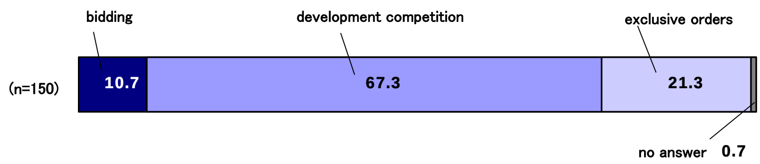
(6)Change in this ratio over the last 4 years



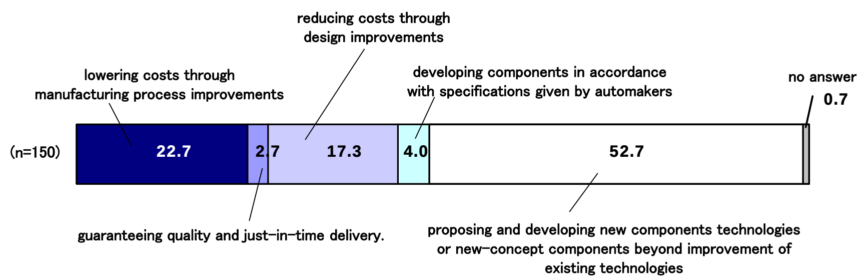
(7)Type of component transaction



(8)Type of component transaction



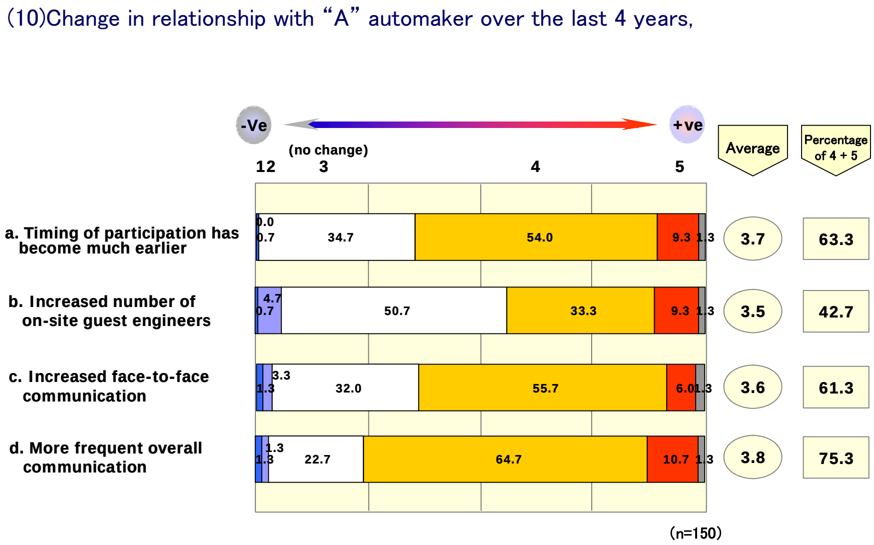
(9)Most important capability



Regarding the relationship with a main customer automaker, 63% of the responding suppliers chose "started to participate in development activities from a much earlier stage than before," 43% chose "we have increased the number of on-site guest engineers who work at the main customer automaker", 62% chose "face-to-face communication during the development process increased", and 75% chose "there was more frequent overall communication (includes all forms of communication, emails, phone calls, and face-to-face)", respectively. These results suggest that the relationship between suppliers and their main customer automakers is becoming tighter and closer with regards to R&D activities.

In the recent Japanese auto industry, as indicated above, major suppliers have not only increased number of their customer automakers but also deepened relations with their main customer automakers. Meanwhile, in order to survive fierce competition, suppliers are required to have a capability to develop cutting-edge new components or technologies beyond improvements of existing technologies.

Figure 7: Outline of Components Transactions (3)



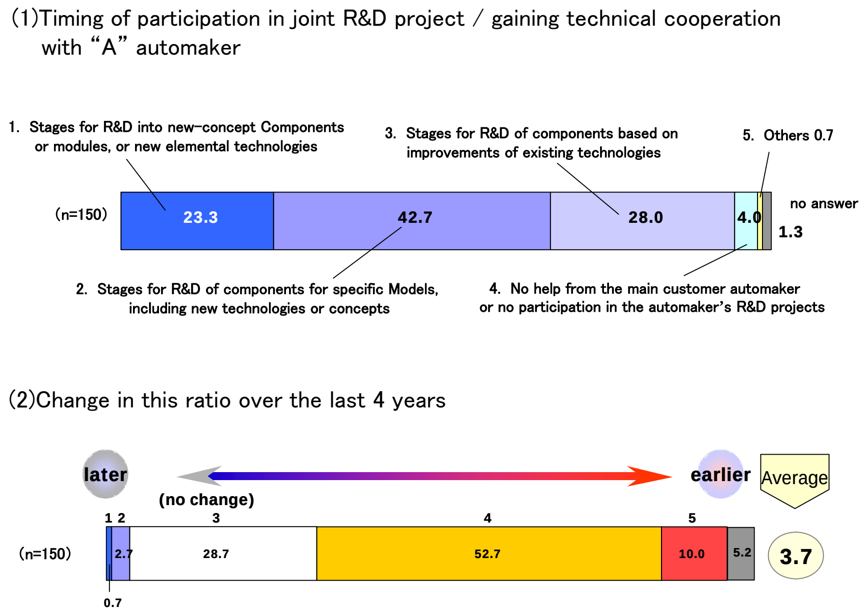
3.2. Stages for R&D Cooperation

Next, we would like to look into the realities of cooperation in the development of advanced technologies.

Responses to "Question 1" on stages for R&D cooperation with a major customer automaker or gaining help from it are compiled in Figure 7. Of the total responding suppliers, 23% were for "1. Stages for R&D into new-concept components or modules, or new elemental technologies (such as new materials), including pilot studies on technologies that are not planned for specific models;" 43% for "2. Stages for R&D of components for specific models, including new technologies or concepts beyond improvements of existing technologies or products;" 28% for "3. Stages for R&D of components based on improvements of existing products;" 3% for "4. No help from the main customer automaker or no participation in the automaker's R&D projects;" and 1% for "5. Others." Based on discussions in Section 1, the advanced technology development cooperation is identified for the first and second cases. Asked on any change in the stages for cooperation over the past four years, 63% said that they began to cooperate with the main customer automakers in earlier R&D stages than in the past.

Consequently, a majority of suppliers are now cooperating with their respective customer automakers even in the development of advanced technologies, and the timing that they began to cooperate have become earlier than before.

Figure 8: Stages for R&D Cooperation

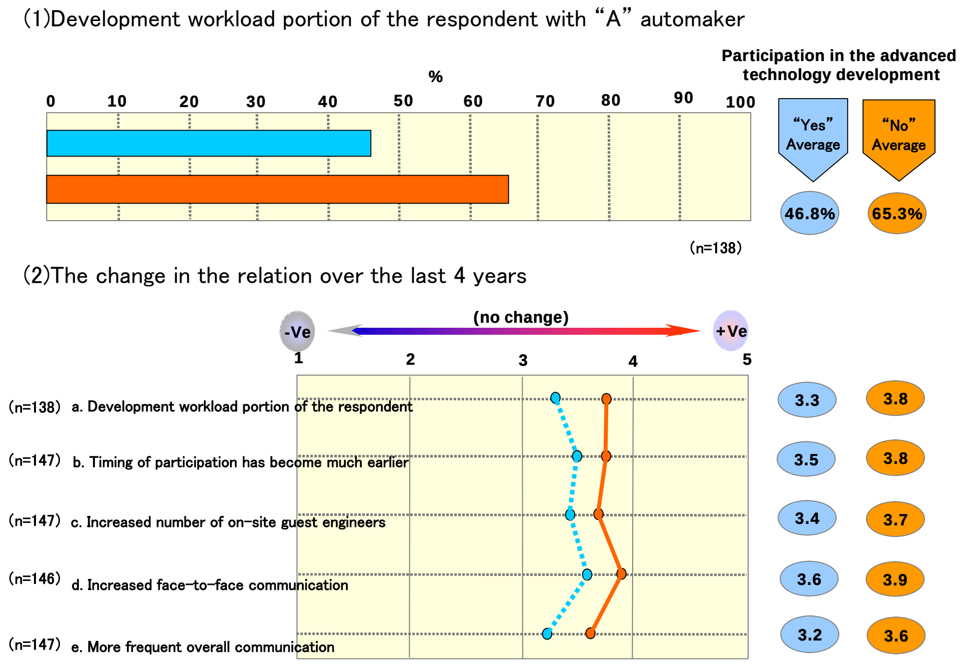


3.3. R&D Cooperation and Inter-company Relations

Next, we used the questionnaire survey data to consider any difference between suppliers that cooperate and do not cooperate with the main customer automakers in the development of advanced technologies.

As discussed earlier, relations between automakers and their respective suppliers are dominantly based on ‘the approved drawing components’ practice. Therefore, no significant difference was seen between various components’ drawing type. Classification by the components’ drawing practice may be too rough to be useful.

Figure 9: Advanced technology R&D Cooperation and Business Relations



Suppliers’ average workload portion of their joint R&D operations with their main customer automakers was significantly higher (the significance level at 1% in t-test) for suppliers cooperating with automakers in advanced technology development than for those keeping away from such cooperation. On any change in such workload portion over the past four years, the former (suppliers cooperating with automakers in advanced technology R&D operations) pointed to a more significant expansion (1%) than the latter (those keeping away from such cooperation). As for relations with main customer automakers, the former feature cooperation in earlier R&D stages (1%) than the latter, a faster increase (5%) in face-to-face communications, a faster increase (5%) in overall communications, and a greater expansion (1%) in on-site guest engineers stationed at automakers, respectively. These data suggest that suppliers cooperating with automakers in advanced technology R&D operations have closer relations with automakers than those keeping away from such cooperation.

3.4. Suppliers' Capabilities and Cooperation with Automakers in Advanced technology Development

Next, we would like to examine the relationship between suppliers' capabilities and their cooperation with automakers in advanced technology development activities.

Based on the resources-based view of the firm, the core elements of resources and capabilities that define corporate competitive advantage are knowledge and know-how accumulated in the companies (e.g., Teece et al., 1997; Barney, 1997). This may mean that the higher the knowledge and know-how accumulated in a supplier are, the more probable that supplier is to be allowed to take part in advanced technology development. Therefore, the following working hypothesis is led:

(Working Hypothesis) The higher the knowledge and know-how accumulated in a supplier are, the more probable that supplier is to be allowed to take part in advanced technology development.

We have utilized the above-mentioned supplier questionnaire survey data for the verification. As incomplete responses were excluded from the data, the number of samples or responding suppliers for this analysis came to 145.

As an indicator of advanced technology development cooperation as an explained variable of the working hypothesis, we have made up a dichotomous variable – "1" for the first and second responses to "Question 1" in Section 3.2 and "0" for the third and fourth responses[7]. One respondent chose the fifth alternative ("Others") and has been excluded from the samples because no details have been explained.

[7] My hypothesis is that the difference between the first and second responses, or whether an automaker cooperates with its suppliers in advanced development of a component or a technology separately from development of a specific product model or in the development of a specific product model including a component or a technology does not necessarily reflect capability gaps between suppliers, because the difference may depend primarily on characteristics of components or projects, or on whether the component or the technology is the core system of the specific product model, whether the development is accompanied by changes in materials and whether an assembly of components changes dramatically (whether a major shift to a module or a system is planned).

As for suppliers' knowledge levels as the explaining variable, component-specific knowledge is separated from architectural knowledge, based on Takeishi (2003)[8]. As control variables, we have used "the technology change" for controlling changes in relevant component technologies, "the external interdependency" for controlling the external architecture characteristics of relevant components and "the internal interdependency" for controlling the internal architecture characteristics of the components, based on earlier studies such as Takeishi (2003), Nobeoka (1999) and Han (2002). For details including original questions that constitute variables, see Table 1.

The logit analysis has been used for the verification of the hypothesis since the explained variable is a dichotomous variable. Table 2 indicates averages of major variables, standard deviations and the correlation matrix. Table 3 shows the results of the logit analysis.

First, Model 1 of Table 3 indicates that suppliers' component-specific knowledge has a positive effect on their cooperation with automakers in advanced technology development. The effect is at a 10% significant level. This means that the working hypothesis has been supported in regard to component-specific knowledge. Second, the model indicates that component-specific knowledge is more important than architectural knowledge for suppliers to be permitted to cooperate with automakers in advanced technology development. Architectural knowledge is thus insignificant. Third, the model also indicates that the technology change as a control variable has a positive effect at a 1% significant level and the external interdependency a positive effect at a 5% significant level. These indications mean that the faster the technology change is and the more interdependent the components are to others, the higher the probability is for suppliers to be permitted to cooperate with automakers from the advanced technology development stage. This finding is an interesting theme for future study.

These results thus suggests that suppliers that are identified as having relatively higher-level component-specific knowledge and the capability to develop advanced technologies or new components beyond improvements of existing technologies are more probable than other suppliers to have cooperated with automakers from the advanced technology development stage and have eventually developed closer business relations with automakers.

[8] Component-specific knowledge is the knowledge about performances, costs and production processes for specific components. Architectural knowledge is the knowledge about coordination of components that are structurally and functionally related to each other (Takeisihi, 2003).

Table 1: Explanations on Variables

Variable	Specification	Note
Participation in the advanced technology development	The dichotomous variable is set at "1" for Alternative 1 or 2 of the five listed on the right side and at "0" for Alternative 3 or 4.	**Question:** In what stage of components R&D operations at the major customer automaker do you participate or gain help from the customer? (Choose one alternative) 1. Stages for R&D into new-concept components or modules, or new elemental technologies (such as new materials), including pilot studies on technologies that are not planned for specific models 2. Stages for R&D of components for specific models, including new technologies or concepts beyond improvements of existing products. 3. Stages for R&D of components based on improvements of existing products. 4. No help from the main customer automaker or no participation in the automaker's R&D projects 5. Others (Specifically:)
Component-specific knowledge	Average score of responses to 10 right questions	**Question**: What is your estimated level of knowledge about the following points compared with levels for automakers? (A five-point Likert scale for each question) a. Functional design b. Structural design c. Material design d. Durability design e. Core technology f. Manufacturing process g. Quality control h. Manufacturing cost i. Material cost j. Components cost
Architectural knowledge	Average score of responses to 8 right questions	**Question**: What is your estimated level of knowledge about the following points compared with levels for automakers? a. Final customers' needs and preferences regarding Component X (main component) b. Automakers' manufacturing processes (particularly, availability for assembling) c. Functional coordination with other components d. Structural coordination with other components **Question**: What is your estimated level of knowledge compared with levels for automakers about the following points regarding "other components" linked closely to Component X? a. Knowledge about engineering b. Knowledge about production c. Knowledge about evaluation d. Knowledge about costs
Technology change	Score of response to right question	**Question**: How do you evaluate the following item in comparison with other components in general? a. Technological changes are fast
External interdependency	Total of the following scores of responses to right questions: External interdependency = −a−b−c+d−e+f	**Question**: How do you evaluate the following items in comparison with other components in general? a. External interfaces are standardized within the company. b. External interfaces are standardized within the industry (adopted at two or more companies). c. Component X functions independently (can be designed without considerations to functions of other components) d. Component X functions multi-dimensionally. e. Component X is structurally independent (can be designed without considerations to structures of other components). f. Component X is structurally complex.
Internal interdependency	Total of the following scores of responses to right questions: Internal interdependency = g+h	**Question**: How do you evaluate the following items in comparison with other components in general? g. If a subcomponent design is modified, most other subcomponent designs must be modified. h. If a mix of materials is modified even slightly for Component X, the production method and production process conditions (pressure, temperature, timing, time, procedures, etc.) must be modified considerably.
Toyota dummy	A dummy variable set at 1 for Response 1 of responses to right questions and 0 for any other response	**Question**: What is you main customer automaker? (Choose one) 1. Toyota 2. Nissan 3. Honda 4. Mitsubishi 5. Mazda 6. Suzuki 7. Daihatsu 8. Fuji 9. Isuzu 10. Hino 11. Nissan Diesel 12. Others

Table 2: Descriptive Statistics and Correlation Matrix of Major Variables

	Variable	AV	SD	1	2	3	4	5	6	7
1	Participation in the advanced technology development	0.67	0.47	1.00						
2	Component-specific knowledge	3.80	0.61	0.23	1.00					
3	Architectural knowledge	2.97	0.67	0.06	0.22	1.00				
4	Technology change	3.43	0.79	0.28	0.14	0.07	1.00			
5	External interdependency	−4.57	3.21	0.24	0.01	−0.11	0.18	1.00		
6	Internal interdependency	6.77	1.52	0.02	0.10	0.12	0.06	0.04	1.00	
7	Toyota dummy	0.39	0.49	0.15	0.01	−0.11	−0.19	0.03	−0.06	1.00

If the absolute value of a correlation coefficient≧0.22 then 1% significant, ≧0.18 then 5% significant

Table 3: Logit Analysis Results

Model	1			2		
explained variable	Participation in the advanced technology development					
	β	S.E.	p	β	S.E.	p
Component-specific knowledge	0.52	0.30	0.08	0.49	0.30	0.10
Architectural knowledge	0.13	0.27	0.63	0.19	0.28	0.49
Technology change	0.65	0.26	0.01	0.80	0.27	0.00
External interdependency	0.16	0.07	0.02	0.16	0.07	0.02
Internal interdependency	−0.05	0.13	0.71	−0.03	0.13	0.81
Toyota dummy				1.02	0.43	0.02
定数項	−2.76	1.55	0.08	−3.81	1.65	0.02
−2logL	162.9			156.9		
Negelkerke R2	0.19			0.24		
sample size	145			145		

A yellow cell means p<0.10

3.5. Progressive practice of Toyota’s Suppliers

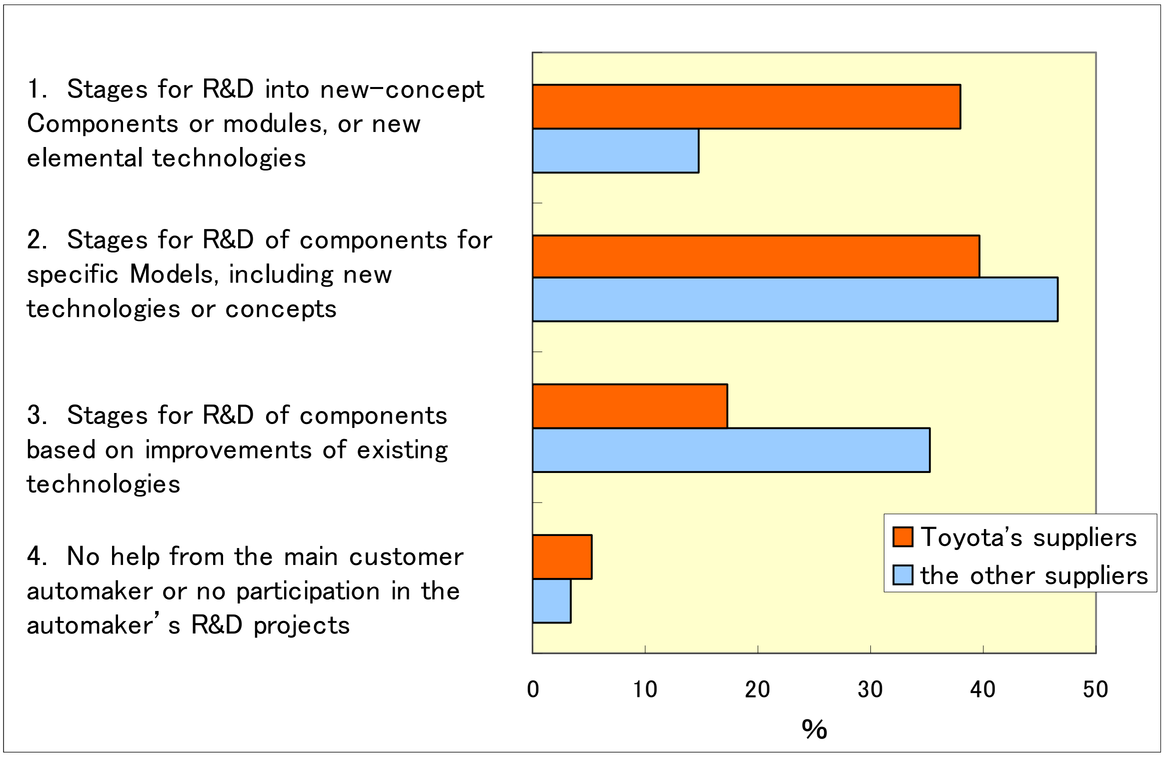
The Section 2 analysis found that Toyota has gone ahead of other Japanese automakers in cooperation with suppliers in the development of advanced technologies. Therefore, this subsection looks into differences between suppliers whose main customer automaker is Toyota (Toyota’s suppliers) and the other suppliers.

Figure 9 shows a comparison between responses by Toyota’s suppliers and the others to “Question 1” in Section 3.2. Of Toyota’s suppliers, those in the first category accounted for more than 35%. This percentage more than doubled the level for the other suppliers. Of Toyota’s suppliers, those in the second category also accounted for more than 35%. This percentage is slightly lower than for the other suppliers, however, a combination of the first and second categories for Toyota’s suppliers was 16.2 percentage points larger than for the other suppliers. The difference between Toyota’s suppliers and the others was at a 1% significant level.

Model 2, in which a Toyota dummy is added to Model 1 of Table 3, indicated Toyota dummy’s positive effect at a 5% significant level even after all the other variables were controlled. Model 2 also indicated that the addition of Toyota dummy improved the regression’s explanation power. In short, Toyota’s suppliers are more probable than the others to participate in the main customer’s advanced technology development projects. The probability gap was calculated about 36 percentage points.

In this way, Toyota has joint R&D operations with major suppliers from the advanced technology development stage more positively than other automakers.

Figure 10: Differences between Toyota's Suppliers and the Others



4. Conclusion and Discussions

4.1. Cooperation in Advanced technology Development and Inter-company Relations

The above analyses indicated that Japanese automakers and their respective suppliers have expanded their cooperation into the development of advanced technologies over the past decade.

In the Japanese automotive market, the automakers need to realize enough functionality and product quality at low price. Furthermore, for example, the automakers need to realize not only the basic 'drive', 'turn', 'stop', and 'gasoline mileage' functions, but also 'user-friendliness', 'huge baggage area', 'airbags', 'active safety' and 'CO2/NOX reduction' features. Thus today, automotive technology development races have grown fiercer.

For most of automotive components, technological innovations are rapid, including development and utilization of new materials (particularly, a shift from metals to plastics) and advanced IT technologies, miniaturization and lightening. In addition, a shift has made fast progress to modules over the recent years. New design concepts for automotive components have been proposed one after another and some have been put into practice.

Under these circumstances, automakers have been prompted to cooperate with their suppliers in the development of advanced technologies excluding cores (e.g., Konno and Okuda, 2005). Such conditions have apparently exerted a great impact on business relations between automakers and their suppliers.

The advanced technology development projects are more difficult to manage than projects that only involve making improvements to existing technologies. The former projects are not free from a high level of uncertainty, so the parties find it difficult to precisely judge in advance what each of them should do to what extent, what level of resources (human, materials, financial or knowledge) should be provided and the probability of success.

Additionally, with the advanced technology development projects, new and innovative technology is only actualized when both parties provide their latest technology and know-how to each other, engage in extended information exchange and repeat trial and error processes. This kind of knowledge transfer, fusion and creation process is bilateral, highly sophisticated and invisible, it is therefore difficult to manage. In addition, even if an automaker and a supplier succeeded in generating new innovative technologies, it is difficult to measure how much contribution has been made by which party, or how much of the resulting profits should be attributed to which party.

Furthermore, in case either of them disclose proprietary information to third parties, the repercussions are tremendous. Even if parties closed NDA (Non-Disclosure Agreement), it is difficult to prove illegal activity / or wrong doing on an objective basis.

According to the above discussion, we can conclude that; because the joint-style advanced technology development activities are difficult to manage only by way of contracts, automakers tend to collaborate with the truly core suppliers. Core suppliers in this sense refer to suppliers with whom the automaker has had a long-term, cooperative and trustful relationship, and moreover suppliers who have high R&D capabilities. Consequently, though the number of core suppliers that can take part in automakers' advanced technology development are limited, the relationships between automakers and the core suppliers should become closer (Konno 2002).

4.2. The Future of the Supplier System

In the past mass media, a lot of experts eagerly reported the “collapse of the keiretsu system in the Japanese automotive industry.” However, our findings indicate that such view is somewhat superficial.

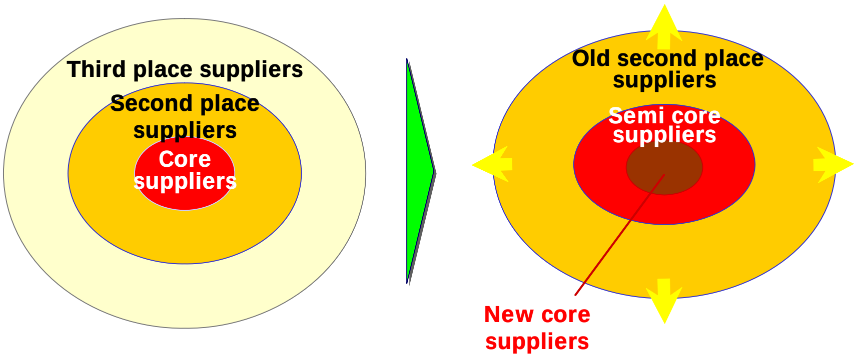
Business relations between Japanese automakers and their respective suppliers are expected to grow more open (the transaction base in the supplier system is expected to be more and more diversified) in the future. As far as we know from interviews and surveys, Japanese automakers started to proactively encourage their respective suppliers to expand the transaction base after 2000. The first reason for this is that auto production can no longer be expected to continue with fast growth. The second reason is that Nissan has reformed its keiretsu-based purchasing strategy to successfully reduce purchasing costs under its ‘Revival Plan’. Also, technological divisions of automakers once tended to be a rather passive opinion that “if keiretsu suppliers are permitted to diversify their customer base, it will lead to leakage of our technology.” However recently, the prevailing opinion is changing; “Even new technology may be easily imitated once it is launched in the market. If this is the case, proactively selling our co-developed technologies from an early stage and making that technology the de facto standard, will lead to cost reduction through mass production effects. This may be desirable for both automakers and their suppliers[9].” Such opinion also seems to be assisting the movement toward open business relations.

However, such movement does not necessarily lessen the importance of long- term, cooperative and close relationships between automakers and their respective suppliers. As noted by Konno (2004), the movement toward opening business relations may be limited to relations for improvements of existing technologies. Relations for the development of advanced technologies (i.e. new-concept automotive components and new elemental technologies) may grow more closed, as indicated in this paper.

For this reason, now core suppliers in the Japanese automotive industry will be divided into two groups – a limited number of real core suppliers that can produce new innovative technologies along with automakers, and the rest. Suppliers’ responses to such changes may be important to win competition.

[9] Source: my interview with a purchasing manager at a Japanese automaker (on May 30, 2002), etc.

Figure 11: Division of Core Automotive Suppliers



4.3. Progressive practice of Toyota's Suppliers and Future Problems

Even amid such general trend, our findings indicate that Toyota has gone ahead of other automakers. Toyota has cooperated with major suppliers from the advanced technology development stage more positively than other automakers. Its quantitative achievements in this regard are far more than those at other automakers. Toyota has also proactively coordinated the joint-style advanced technology development projects which include two or more suppliers (which include horizontal cooperation between suppliers).

As automotive technologies have been advancing rapidly, Toyota's excellent production and product development operations cannot guarantee its future competitiveness. If failing to develop advanced technologies, even Toyota could be outperformed by others. Given Toyota's recent success, it seems that the network that Toyota has built for cooperation with suppliers in the development of advanced technologies might have contributed to the firm's international competitive edge.

The progressiveness of the network that Toyota has built for cooperation with suppliers in the development of advanced technologies indicates the firm's excellent management of cooperation. This paper doesn't address details of automakers' management of cooperation with suppliers in the development of advanced technologies. However, this is a very interesting theme.

In this respect, an engineer who had served as general manager for quality control at Toyota said: "Toyota has a strong philosophy that quality and cost problems should be solved from the true source. And, suppliers are partners. If quality and cost problems cannot be solved without going back to the stage for development of advanced components technologies, we may never resist cooperation with leading suppliers[10]." Probably, such philosophy, organizational cultures or the relationship of trust between companies might have supported cooperation in the development of advanced technologies.

Anyway, studies have not been accumulated in this area. In the future, multi-faceted surveys should be accumulated to look into the management of cooperation in advanced technology development.

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[10] Source: my interview on July 10, 2001.

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