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Production Networks of Japanese and American Automobile Industry: Contrasting Evolution and Convergence

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1. Introduction

(1) Background of the Study

In the rapid development and diffusion of digital information systems, there has been a phenomenal change in global production network (GPN), where much wider opportunities have been opened for global business collaborations, so that the international geography of production and innovation, and thus, the dominant modes of international knowledge diffusion have been transformed in a remarkable manner [Ernst and Kim (2001)]. In this process, one of the most salient features in industrial organization is the transition from "MNCs" (multinational corporations, which are characterized by their emphasis on stand-alone overseas investment projects) to "GNFs" (global network flagships, which are characterized by their coordinating role in integrating their geographically dispersed supply, knowledge and customer bases into global networks) as the major driving force of international business activities [Ernst and Kim (2001), Ernst (2001)].

Especially, in IT-related electronics industries such as PCs and semi-conductors, the phenomenal transformation in their global production network has been observed in Mowery and Macher (2001), Luethje (2001), Ernst (2001) etc. In particular, there has been a general trend towards vertical specialization, whereas highly diversified patterns of collaboration can be observed across inter-firm and intra-firm transactions coordinated by GNFs [Mowery and Macher (2001), Luethje (2001), Ernst (2001, Figure 1 and Figure 2)]. Accordingly, possible patterns of international technology spillovers are also diversified, and greater opportunities can be expected for technological catching up by lower tier suppliers in developing countries.

(2) Research Agenda

Then, what about in case of automobile industry? In this study, mainly focusing on Japanese and US final automobile assemblers, the dynamic evolution of production network in automobile industry is illustrated, and its underlining factors are analyzed.

In the production network of automobile industries, final assemblers are at the top of the hierarchy to play coordinating roles as network flagships, while components suppliers are at the lower tiers to be network members. However, as discussed below, there has been a significant difference in the structure of hierarchy between Japanese firms and US firms (i.e., tall hierarchy, flat hierarchy), while the structure of both countries has been changed in the last three decades along with the recent development of IT-based information systems. Furthermore, their structure is closely related to the product architecture (i.e., integral architecture, modularized architecture), type of skills (i.e., context specific skills, general skills), and style of production systems (i.e., shorter assembling line, longer assembling line), all of which can be crucial factors for the relative competitive strength of automobile firms in each country. In this study, a historically evolutionary process of Japanese automobile assemblers as well as that of US automobile assemblers will be discussed in the following context.

As Japanese assemblers had gained significant competitive strength in 1970s and 1980s, a lot of researches analyzed their competitive performance, and a so-called

“J-system”, or a unique and complementary system of production, skill formation, employment, and assembler-suppliers relationship was discussed, where highly efficient development and utilization in so called “context specific skills” was pointed out [Aoki (1988), Aoki et al. (1994), Koike (1994), Clark and Fujimoto (1991), Asanuma (1989, 1997), Ito and MacMillan (1998)]. However, since the middle of 1980s, US assemblers have carried out their drastic business restructuring processes towards “modularization strategy”, so that they have recovered their competitive performance to a significant degree in 1990s. On the other hand, Japanese assemblers have carried out only a limited shift towards the modularization strategy while remaining their conventional business styles to a considerable degree [Fujimoto (2001), Takeishi et al (2001), Ikehara (2001)].

Given this historical development in automobile industry in the last three decades, the following four questions might attract our attentions; i.e., (1) What are the sources for relative inefficiencies in US assemblers in 1970s and early 1980s? (2) How can we illustrate the “modularization strategy”, and how has this strategy improved the previous inefficiencies of US assemblers since the middle of 1980s? (3) Why has Japanese assemblers carried out only a limited shift towards the “modularization strategy”? (4) Considering product specific characteristics of automobiles as well as recent development in IT-based infrastructure, what are the future perspectives of production network in automobile industry?

(3) Research Outline

Noting these questions in mind, this study examines the recent evolution of production network in automobile industry with focusing on the dynamic shift in the product architecture strategy, the type of skills, and the style of production systems, while contrasting the difference between Japanese assemblers and US assemblers.

In section 2, regarding to the first question, the conventional patterns of production network in 1970s and 1980s are compared between Japanese assemblers and US assemblers. US assemblers are stylized as “MNCs” model, while Japanese assemblers are stylized as “quasi-integrated” model. Then, contrasting with a high efficiency of Japanese assemblers, the sources for inefficiencies of US assemblers are examined in their higher cost of communication and coordination, where the context specific skills are not efficiently developed and utilized. In section 3, regarding to the second question, the key elements of “modularization strategy” of US (and European) assemblers are pointed out. Then, the sources for efficiency improvement in communication and coordination are analyzed, where the context specific skills are no longer so much required. In section 4, regarding to the third question, two major factors for a “limited shift towards modularization” by Japanese assemblers are pointed out. Then, considering these two factors, “integration strategy” is pointed out as an alternative strategy, which is more compatible with the historical development of Japanese assemblers. In section 5, regarding to the fourth question, it is expected that (a) due to the development of IT-based infrastructure, the existing divergence between US assemblers and Japanese assemblers in terms of “context specific skills” and “degree of modularization” is likely to be narrowing down, whereas (b) due to product specific characteristics of automobiles, the divergence is likely to remain in the near future.

Finally, further research questions are pointed out regarding to the co-existing evolution of "modularization strategy" and "integration strategy".

2. Two Stylized Patterns: US vs. Japanese Automobile Assemblers

In this section, based on the existing literature, the two contrasting stylized patterns of production network in automobile industry are illustrated, i.e., "MNCs model" for US assemblers and "quasi-integrated model" for Japanese assemblers. Then, the sources for relative efficiency between these two models are discussed to explain the competitive advantage of Japanese automobile industry in 1970s and 1980s.

(1) "MNCs Model" for US Assemblers

The observation by Aoki (1988), Asanuma (1989, 1997), Clark and Fujimoto (1991) etc. on the supplier system of US automobile assemblers can be summarized as Figure A, which is originally from Figure 6.4.2. (Clark and Fujimoto, 1991, p139). Although they did not explicitly pointed out, this figure implies that US assemblers can be stylized as MNCs (multi-national corporations) model following the discussion by Hymer (1960), Caves (1971, 1982), and Dunning (1981), etc. In their discussion, MNCs are characterized by their tendency to "internalize" their businesses, i.e., due to some idiosyncratic characteristics of firm specific intangible assets (e.g., useful know-how on business, technological knowledge, brand name of firms or products etc.), their benefit cannot be fully internalized in case of out-sourcing or open market transactions. Accordingly, it is more likely that MNCs would internalize, or integrate their businesses within themselves, so that they can maximize the benefit from their firm specific assets.[1]

Consistent with this discussion of MNCs, Figure A illustrated that US assemblers were characterized by larger in-house component operations, and thus, higher degree of vertical integration. In other words, the majority of "value adding activities" are carried out within assemblers. For instance, in terms of product designing and development, final assemblers are likely to carry out most of the activities, and they are less likely to be out-sourced to the suppliers in open market. In terms of components assembling as well, final assemblers are likely to carry out most of its activities, and they would purchase "piece by piece" individual components with less value added from larger number of smaller suppliers.

As a result, the assembling line of US assemblers is likely to be longer, and the assembler-supplier relationship is characterized by "flat hierarchical structure". In this style of division of labor, the suppliers are not so much required to have higher level of designing and engineering capability, but they are more required to supply individual "piece

[1] As one of the idiosyncratic characteristics of intangible assets, public goods characteristic (non-exclusiveness) of know-how or information can be pointed out. For instance, buyers in the open market cannot evaluate the true value for a set of particular know-how before obtaining its full information. However, once obtaining its full information, due to its non-exclusive characteristic, the buyer has a strong incentive to bargain its price to be much lower than its true value.

by piece" components at lower production cost, whose product design was already well defined and specified by the assembler. Then, in selecting suppliers, the assembler generally offers an open bidding competition, where the main performance criteria is the cost competitiveness, and the contracting term for winners of competition is likely to be shorter.

(2) "Quasi-integrated Model" for Japanese Assemblers

In contrast, as illustrated in Figure B, which is originally from Figure 6.4.1. (Clark and Fujimoto, 1991, p139), Japanese assemblers were characterized by smaller in-house component operations and lower degree of vertical integration. In other words, unlike MNCs model of US assemblers, Japanese assemblers were outsourcing higher portion of "value adding activities" to suppliers.

Then, given the idiosyncratic characteristics of firm specific intangible assets, how can Japanese assemblers internalize or retain their returns? Based on the findings by Aoki (1988), Asanuma (1989, 1997), Clark and Fujimoto (1991), Ikeda (1997) etc, it is implied that Japanese assemblers would "quasi-internalize" the returns from their specific intangible assets in a "quasi-integrated" relationship between assemblers and suppliers in the following sense. Japanese assemblers and suppliers typically have a long-term and recurrent relationship in their contracts. In this relationship, they have close and intensive communication and coordination with each other to develop their "context specific skills", i.e., some particular technological know-how and/or information have been developed and shared among them which can be efficiently utilized in transactions among themselves, while they cannot be efficiently utilized in transactions with other suppliers. Thus, this context specific characteristic can induce both assemblers and suppliers to cooperate with each other to internalize their returns in their "quasi-integrated" relationship.

Here, the next question would be "can this quasi-integrated relationship be one of the sources for the competitive performance in Japanese automobile industries in 1970s and 1980s?" The above-mentioned studies seem to have illustrated some elements to support for this argument, i.e., based on intensive communication and coordination in this quasi-integrated relationship, context specific skills have been efficiently developed and utilized to achieve relatively high productivity performance of Japanese assemblers and suppliers in following manners.

Firstly, high performance in product designing and development is expected in collaboration of assemblers and suppliers. Unlike US supplier system of a "flat hierarchical structure", Japanese supplier system is characterized with a "tall hierarchy" in Figure B, where assemblers make direct transactions only with limited number of 1st-tier suppliers. 1st tier suppliers are producing relatively sophisticated and integrated components out of sub-components and/or materials supplied from 2nd tier suppliers, which are further supplied from 3rd and 4th tier suppliers. Then, 1st-tier suppliers generally have high engineering capabilities, and they frequently collaborate product designing and development activities with assemblers, typically in a manner so called "DA (Drawings Approved) parts" [Asanuma(1989), Clark and Fujimoto (1991)]. During this process of collaboration, context specific skills of 1st-tier suppliers are fully utilized in intensive communication and coordination with assemblers, so that the designing and development of a new product can be achieved in a shorter period with taking less development cost.

Secondly, higher productivity is expected in the continual improvement activities of suppliers, which are called VA (value analysis) and VE (value engineering). Throughout the stages of product life cycle (i.e., product development stages, trial production stages, and mass production stages), assemblers offer some value incentives to suppliers to continually improve their productivity in both cost and quality performance. Then, with intensive communication and coordination with assemblers, suppliers may take various opportunities to improve their product design and production processes; e.g., by responding better to final customers' needs, by upgrading the quality of material ingredients, and by revising the arrangement in production processes etc.

Thirdly, higher productivity is expected through an efficient system of logistics and inventory management so called "JIT (just in time)" system. This system can achieve a very high information efficiency without utilizing sophisticated IT technologies, while heavily dependent on the context specific skills in a following manner. Using the indicator called "Kanban (message board)", the real time information on the exact amount and variety of final assembled product is transmitted to the suppliers towards the downstream along the hierarchy (i.e., from assembler to 1st tier suppliers, from 1st tier suppliers to 2nd tier suppliers, and then, from 2nd tier suppliers to 3rd tier suppliers, and so on). Then, responding to this information at each tier level, suppliers are supposed to deliver immediately the exact amount and the variety of components towards the upstream along the hierarchy. As a result, with an intensive communication and coordination, flexible and immediate response to changes in customers' demand as well as minimized inefficiencies in inventory management can be achieved.

(3) Sources for Comparative Efficiency between Japanese Assemblers and US Assemblers

Summarizing the discussion, as one of the major sources for the relative competitive advantage of Japanese assemblers, high efficiency in communication and coordination based on their context specific skills can be pointed out. In contrast, in case of MNCs model of US assemblers, context specific skills have not been fully developed and utilized, and communication and coordination among assemblers and suppliers are not carried out in an efficient manner. In particular, suppliers are not given sufficient opportunities to engage in product designing and development activities as well as in continual improvement activities without much communication and coordination with assemblers. Hence, the potential opportunities for improving overall productivity from more collaborative efforts between assemblers and suppliers could not been achieved than otherwise.

Furthermore, as another crucial source for the relative competitive advantage of Japanese system, the structure of hierarchy in the assembler-suppliers relationship can be pointed out. In particular, comparing with a "flat hierarchy" of US system, a "tall hierarchy" of Japanese system seems to be much more efficient in communication and coordination, which is especially so in the era before IT-based technologies have become available, and thus, cost of communication and coordination was still relatively high. This point can be discussed both in terms of (1) logistics and inventory management, as well as of (2) assembling cost.

Firstly, in terms of logistics and inventory management, the relative efficiency can be discussed as follows. In case of "tall hierarchy" of Japanese firms as observed in JIT system, assemblers make direct transactions only with limited number of 1st tier suppliers. Then, in this structure, the cost and efforts in logistics and inventory management can be minimized through an efficient linkage of network members across multiple tiers in a tall hierarchy. In contrast, in case of "flat hierarchy" of US system, assemblers make direct transactions with larger number of smaller suppliers, and the assemblers are responsible for a greater coverage for the logistics and inventory management. Thus, their required administrative cost is likely to be huge, and its efficiency is likely to be lower.

Secondly, in terms of assembling cost, the relative efficiency can be discussed as follows. In case of Japanese system with "tall hierarchy", relatively integrated unit components are likely to be assembled in final assembly, and the production line is likely to be shorter. On the other hand, in case of US system with "flat hierarchy", greater number of "piece by piece" components is likely to be assembled, and the production line is likely to be much longer in final assembly. Then, as discussed in Ikehara (2001) and Takeishi et al. (2001), this can lead to a crucial cost disadvantage for US system, as the wage level of workers in assembling firms is generally much higher than that in components firms in US labor market.

3. Recent Development in US Assemblers: Towards Modularization Strategy

As discussed in previous sections, the conventional production network of US automobile assemblers in 1970s and early 1980s was stylized as MNCs model, and they were behind in their relative efficiency and productive performance against quasi-integrated model of Japanese assemblers. However, since the middle of 1980s, US assemblers have carried out a drastic restructuring in their business styles, and since 1990s, they have recovered their competitive performance to a significant degree.

Then, how have US assemblers carried out their restructuring in business styles and why can their newly developed system be successfully efficient? In this section, following the discussion by Aoshima et al (2001), Takeishi et al (2001), Fujimoto (2001) and Ikehara (2001) etc., the core elements of their business restructuring are summarized as a drastic shift towards the "modularization strategy", which was implemented by European assemblers as well. In particular, the idea of the modularization strategy is briefly described, and then, possible factors are illustrated which explain a significant recovery of productivity performance along this strategy.

(1) Modularization Strategy in US and European Assemblers

In explaining the modularization strategy, it might be useful to illustrate the case of "desktop PC" as a typical example of "modularized product" in following manners. In case of desktop PCs, peripheral external devices such as HD drive and DVD ROM drive can be connected by a standardized interface (e.g., SCSI cable). In addition, inside of the machine, there are several independent sub-systems such as CPU, main memories, FDD etc., each of which has its own functional performance with its standardized product design. Then, users can upgrade the system by replacing a certain sub-system (e.g., CPU, main memories) depending on their needs and preference.

Here, a desktop PC is considered to have a relatively "modularized product architecture", and the "modularization strategy" can be explained as follows, i.e., (1) the sections are identified where the functional interdependence is relatively weak with each other (e.g., CPU unit and FDD unit), (2) for these sections, their interdependence is ignored for the time being, and each of these sections are considered to be an independent module, (3) then, these sections are connected with an interface, which has a relatively simple and standardized structure, (4) as a result, the overall system can be seen as a composite of modules (sub-systems) which are independent with each other [Aoshima et al. (2001)].

Given this idea of the modularization strategy, it has been widely observed that US and European automobile assemblers have implemented this strategy in their business restructuring process since 1980s. In particular, instead of using "piece by piece" individual components, they have drastically introduced modularized unit components such as (a) cockpit module, which includes inside panel, meters, steering and steering shaft, air-conditioner unit etc., and (b) the driving module, which includes clutch, propeller shaft, flywheel, and drive shaft etc.

The shift towards modularization strategy seems to have been started in US assemblers since the middle of 1980s (Asanuma, 1997). On the other hand, this shift has been observed even more drastically in European assemblers since the middle of 1990s (Tekeishi et al. 2001, and Ikehara 2001). For instance, Volks Wagen and Daimler Benz started several plants in 1996 and 1997, which introduced this strategy in an intensive manner [i.e., Volks Wagen: Resende factory in Brazil, Boleslav factory in Czecho, Mosel factory in former East Germany; and Daimler Benz: Vance factory in US and Hambach factory in France]. In these plants, core suppliers of modularized components are jointly located with the assembler, and they typically form an industrial park of suppliers.

(2) Efficiency Improvement in Modularization Strategy

Along with this shift towards modularization strategy, it should be noted that the two major sources for inefficiency in MNCs model of US firms were considerably mitigated to improve their competitive performance in following manners.

Firstly, in the previous MNCs model, despite the importance in intensive communication and coordination among assemblers and suppliers, their efficiency is relatively low for US firms due to the lack in their context specific skills. In contrast, in the recent modularization strategy, the relative importance in communication and coordination was significantly reduced, i.e., each module can be independently designed, developed and produced, and thus, substantial cost of communication and coordination can be saved, while each module can improve its functional performance for each category. Accordingly, the underdevelopment in context specific skills of US firms is no longer a crucial source for their competitive disadvantage.

Secondly, in the conventional MNCs model, due to the flat structure of US supplier system, assemblers have greater number of 1st tier suppliers and the production line in final assembly is relatively long, and thus, the efficiency in logistics and inventory management is relatively low, while the labor cost in final assembly is relatively high for US firms. In contrast, with the implementation of modularization strategy and the intensive use of highly modularized unit components, the conventional flat structure has been shifted to a tall structure; i.e., the number of 1st tier suppliers is reduced and the production line is shortened to a significant degree. As a result, the efficiency in logistics and inventory management can be significantly improved for assemblers. In addition, the labor cost of final assembling can be significantly reduced, especially considering the labor market condition in US where the wage level of final assemblers is much higher than that of components suppliers.

4. Recent Development in Japanese Assemblers: Limited Shift towards Modularization

In this section, contrasting with a drastic shift towards modularization strategy by US and European firms, a recent development in the production network of Japanese assemblers is stylized as a limited shift towards modularization strategy, and its underlying factors are discussed.

(1) Limited Shift towards Modularization

As discussed in section 2, looking back the conventional systems of US firms and Japanese firms in 1970s and early 1980s, it is interesting to observe that "quasi-integrated model" of Japanese firms was more likely to share the elements of "modularization strategy"; i.e., higher degree of out-sourcing, more sophisticated and integrated components, shorter production line in final assembly, and tall hierarchy in assembler-suppliers relationship.

However, according to Takeishi et al. (2001) and Ikehara (2001), the degree of modularization seems to have been reversed since 1990s. In other words, although Japanese firms have made some moderate shift towards modularization strategy, as a result of a drastic shift by US and European firms, the degree of modularization has been higher for US and European assemblers than that for Japanese assemblers. For instance, in terms of components of assembling, more highly integrated and comprehensive modules are sub-assembled by US and European first tier suppliers. Accordingly, in factories of final assemblers, the assembling line is shorter for European and US firms than that for Japanese firms. In addition, the number of first tier core suppliers is likely to be fewer for European and US assemblers than that for Japanese assemblers. Furthermore, in terms of the degree of out-sourcing for US and European assemblers, higher portion of activities such as product designing and development is likely to be out-sourced to first tier core suppliers.

Then, despite possible benefits from modularization strategy, why has the shift been rather limited for Japanese assemblers as compared with US and European assemblers? The following discussion points out two major factors to explain this "limited shift towards modularization"; i.e., (a) relating to context specific skills of Japanese firms, various kinds of adjustment costs can arise, and (b) in case of automobiles, due to their product specific characteristics, the size of adjustment costs are likely to be large.

(2) Adjustment Costs Relating to Context Specific Skills

The first factor is the adjustment costs relating to context specific skills. As discussed in section 2, in quasi-integrated model of Japanese firms, context specific skills have been developed and utilized in a long-term and recurrent relationship, which achieves high efficiency in communication and coordination in the collaboration among assemblers and suppliers. Similarly, within each firm, context specific skills have been developed and utilized for individual production workers, which have been based on long-term employment system [Koike and Inoki (1987), Koike (1994), Asanuma (1997), etc.].

Thus, suppose a drastic shift towards modularization takes place, and the context specific skills become much less crucial, and then, a long-term and recurrent relationship as well as a long-term employment system might be less efficient and could be abolished. As a result, adjustment costs can arise in various manners. For instance, the existing skills embodied in individual workers as well as in firm specific intangible assets would be wasted. In addition, huge amount of retirement cost would be required in the existing system of labor management, which is compatible with longer-term employment of workers. Furthermore, the incentives for workers as well as for suppliers to commit themselves for longer-term cooperative efforts would be damaged seriously [Ikehara (2001), Takeishi et al. (2001)].

(3) Product Specific Characteristics of Automobiles and Integration Strategy

The second factor is the product specific characteristics of automobiles to imply that, in case of automobiles, the relative importance in context specific skills as well as the size of adjustment costs is likely to be large; i.e., when automobiles have a relatively "integral architecture" (as contrasted with "modularized architecture"), the benefit from context specific skills is relatively large, and "integration strategy" can be more efficient in following manners [Fujimoto (2001), Aoshima et al. (2001) etc.] .

Here, in explaining "integral product architecture", it is useful to illustrate the case of "notebook PC", which has a relatively "integral product architecture", which is contrasted with "desktop PC" as discussed earlier. In case of notebook PCs, although peripheral external devices such as DVD ROM drive can be connected with an interface, these devices are preferably installed inside of the machine to take advantage of the portability. In addition, each internal sub-system (e.g., CPU unit, FDD unit etc.) is integrated to be a "unified system", which has its own "model specific" product design in order to improve "model specific" performance (e.g., to economize limited space, to achieve a stylish product design etc.) of the product as an overall system. Thus, notebook PCs have a relatively "integral" product architecture, and the "integration strategy" can be explained as follows, i.e., various interrelated complications in a system are allowed and accepted, and all of them are to be integrated through continual adjustments in order to achieve the optimally balanced performance as an overall system.

Given this classification, "automobiles" are more likely to have "integral product architecture", which is similar to "notebook PCs" rather than "desktop PCs". Consumers usually purchase the final products (automobiles) as an "integral system", i.e., although they can theoretically purchase batteries, tires, and other components separately from automobiles themselves, they would not do so in most cases. Accordingly, in their product market, the most crucial factor would not necessarily be the functional performance for individual modules per se, but would be the total performance as a system that is characterized by the model specific "product concept" (e.g., sporty and durable RUV, comfortable and balanced sedan, etc.), which can differentiate themselves from others to create their model-specific unique values as a total system [Yasumoto (1999)].

Then, in case of products with integral product architecture, the relative importance in context specific skills is expected to be high. It is because, in pursuing the optimal balance among individual sub-systems towards the common goal of "product concept", close and intensive communication and coordination among sub-systems are required. Then, throughout this optimizing process, context specific skills (e.g., sharing context specific information, technological knowledge, business know-how etc.) among members in collaboration can play crucial roles in improving their efficiency.

5. Future Perspectives and Further Research Questions

As discussed in section 3 and 4, comparing a recent development of production network between US and Japanese firms, there has been a significant divergence in terms of (1) utilization in context specific skills, and (2) degree of modularization; i.e., Japanese firms are still characterized by intensive utilization of context specific skills to achieve intensive communication and coordination. On the other hand, US firms are characterized by drastic shift towards modularization, where the context specific skills are not so much required.

Then, considering the recent development of IT-based globalization in combination with the product specific characteristics of automobiles, what can be the future perspectives for the existing divergence between Japanese firms and US firms? In following discussion, it will be pointed out that (a) due to development of IT-based globalization, the existing divergence is likely to be narrowing down, while (b) due to product specific characteristics of automobiles, the existing divergence is likely to remain at least in the near future. Finally, based on these discussions, further research questions are pointed out regarding to the co-existing evolution of "modularization strategy" (compatible with "general skills") and "integration strategy" (compatible with "context specific skills").

(1) General Trend of Convergence

In the recent development of IT-based globalization, the relative importance of "context specific skills" can be significantly reduced. On the worldwide common information platform of "internet", the knowledge can be converted into a standardized format with minimal costs, and it can be much more readily transferred across firms and country borders. Here, the modularization strategy can comfortably take advantages of this technological innovation, as the business collaboration can take place among "modules" which are connected with each other with standardized interfaces of a simple structure.

Thus, even without utilizing context specific skills, the efficient communication and coordination becomes more available among business partners who have not shared context specific knowledge and information based on a long-term and recurrent relationship. Accordingly, following the recent trend of US and European firms, Japanese firms are more likely to take a further shift towards modularization strategy, where they would build new business relationship with "global suppliers", who might be distantly located but have highest-class capabilities in their complementary technological categories.

(2) Persistent Divergence and Underlying Factors

On the other hand, the existing divergence between Japanese firms and US firms is likely to remain at least in the near future in following manners. Firstly, due to the existing difference in firm specific intangible assets embodied in human resources and technological and knowledge systems etc. as well as that in social and institutional factors such as labor market conditions, Japanese firms are still likely to have comparative advantage in utilizing context specific skills, while US firms are likely to have that in utilizing general skills.

Secondly, due to the varieties in product architecture, there can be a significant variation in the relative importance in context specific skills across products as well as across unit components (modules) in following manners [Fujimoto (2001), Aoshima (2001), Kusunoki et al. (2001), Han and Konnou (2001) etc.]. In section 4, it was discussed that "automobiles" are more likely to have the elements of integral architecture, and thus, the relative importance in context specific skills is high as compared with that for products of modularized architecture such as "desktop PCs". However, among automobiles, there can be a considerable difference across products and component units (modules); i.e., At the level of final products, "sedan style cars" have a relatively integral architecture of "monocoque body" and the importance in context specific skills is relatively high, whereas, trucks have a relatively modularized architecture of "body on frame" and the importance in context specific skills is relatively low. At the level of component units, "air conditioner units" have relatively integral architecture, whereas, "combination meters" have relatively modularized architecture. Further, even within the same category of products and/or modules, there can be a variation in relative importance of context specific skills depending on the "openness" of architecture strategy; i.e., the relative importance is higher in case of "closed architecture strategy", whereas the relative importance is lower in case of "open architecture strategy".[2]

Then, considering these two set of factors [i.e., (1) comparative advantage in utilizing skills, (2) relative importance in context specific skills], it is generally expected that Japanese firms are likely to make a strategic decision to take advantage of utilizing

[2] As discussed in Kokuryo (1999) and Aoshima et al. (2001), the architecture of a particular module (e.g., air condition unit, driving unit, etc.) is called "closed", when the module can be applied only to a particular model of final assembled car. On the other hand, it is called "more opened", when the module can be applied across several models of cars by the same assembler. It is even "further opened", when the module can be applied to various models by various assemblers.

context specific skills, so that they would focus more on product categories with a relatively integral products, while producing modules with a relatively closed architecture. In contrast, US firms are likely to make a strategic decision to take advantage of utilizing general and skills, so that they would focus more on a relatively modularized and opened architecture.

In sum, due to several factors considered above, the divergence between Japanese and US firms in their strategic focus on product architecture as well as their utilization on context specific skills is likely to remain in the near future, although the size in divergence is likely to be gradually narrowing down due to the recent development of IT-based globalization.

(3) Further Research Questions

Finally, regarding to this co-existing evolution of "modularization strategy" and "integration strategy", we can further explore following research questions; i.e., (1) "In which manner, these two contrasting strategies have been co-existing and dynamically changing?", and (2) "How can these dynamic patterns be explained?"

It is naturally expected that the relative size of both merits and demerits for each strategy can be a crucial explanatory factor. For instance, in case of integration strategy, the main merit would be the "quasi-internalization" of greater value added by optimizing products for their targeted market, which is achieved through intensive communication and coordination among assembler and suppliers. On the other hand, the main demerit of integration strategy would be its higher cost of communication and coordination, as the potential benefit from specialization and economies of scale cannot be fully exploited in the open global market.

Hence, it can be a very interesting question to ask how various firm specific intangible assets (e.g., firm specific historical experiences, human resources, technological and knowledge systems etc.) as well as social and institutional factors (e.g., labor market conditions, regulatory systems in each location etc.) would have effects on these merits and demerits, and accordingly, how these factors would explain the difference as well as the similarity in the strategic decision among individual cases.

Furthermore, it is another attractive question to ask that, after making a general decision on the product architecture strategy (i.e., modularized architecture vs. integral architecture), "how would each strategy be further modified so that its demerits can be mitigated and/or its merits can be promoted?" For instance, in case of integration strategy, its major demerit would be higher costs, as this strategy is not likely to be fully compatible with IT-based information infrastructure. However, modifying the conventional integration strategy might mitigate this demerit in a following sense. As discussed in Nonaka and Takeuchi (1995) and Dieter and Kim (2001), the knowledge can be created in going through both phases of tacit knowledge and explicit knowledge. Accordingly, when focusing on the explicit knowledge phase of "context specific skills", IT-based information infrastructure can be still utilized efficiently in order to develop and restore context specific skills among quasi-integrated network members; i.e., building the knowledge database and utilizing three-dimensional CAD and CAMs can be a good set of examples.

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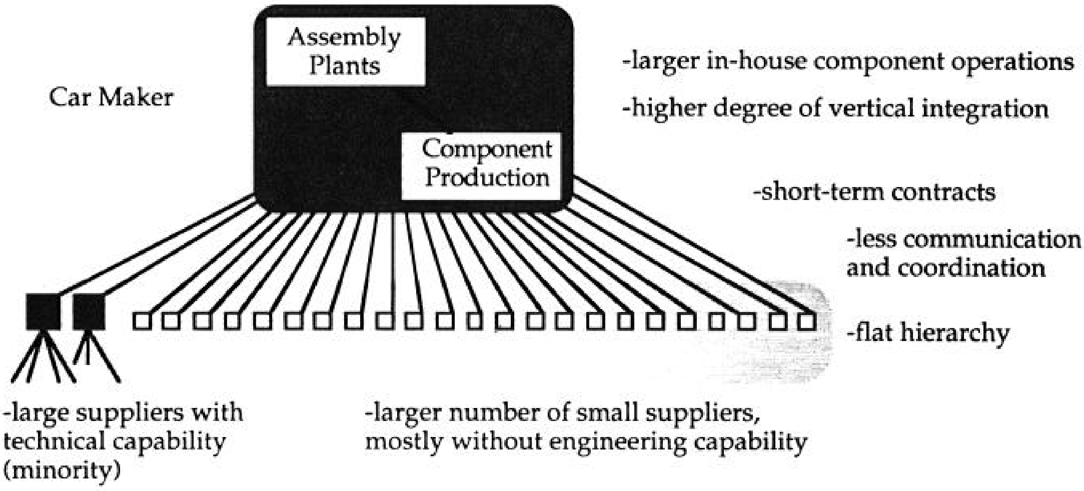
Figure A. Traditional U.S. Supplier System



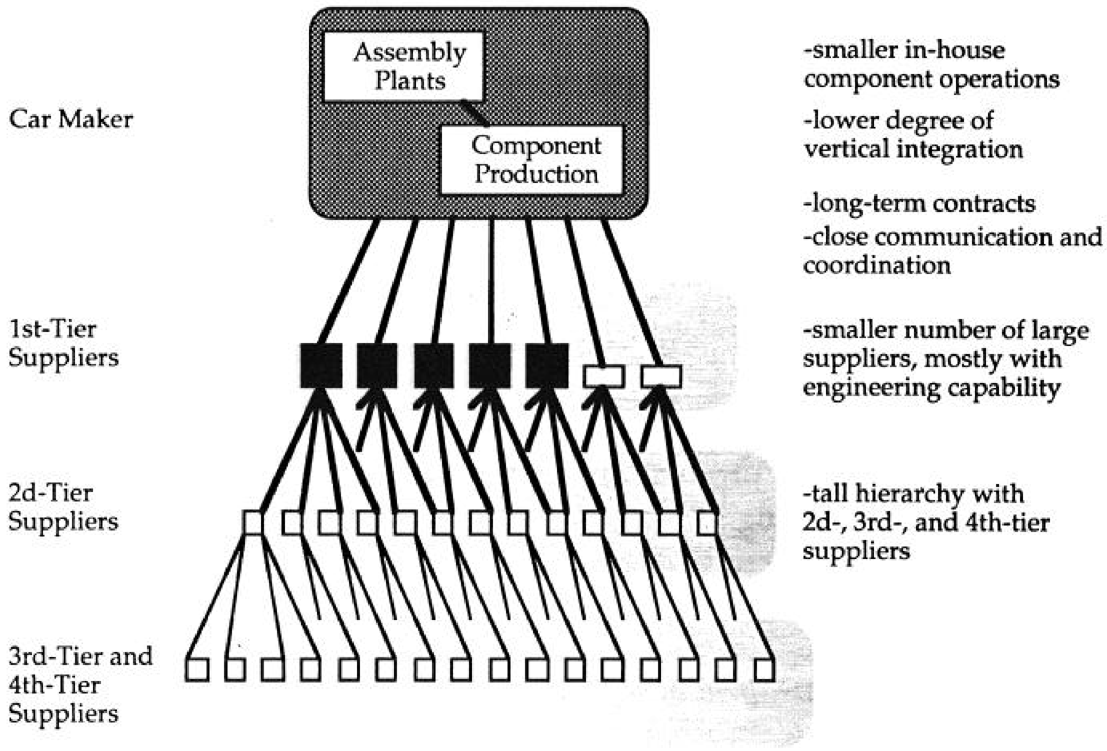
Note: This diagram illustrates ideal types of supplier systems rather than reality. The size and number of suppliers in the diagram do not reflect actual data. Only one assembler is assumed in each case.

■ Car Maker ■ Supplier with Engineering Capability

□ Supplier without Engineering Capability

Source: Clark and Fujimoto (1991, p139), Figure 6.4.2.

Figure B. Japanese Supplier System in the 1980s



Source: Clark and Fujimoto (1991, p139), Figure 6.4..1.