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Recent Corporate Restructuring in the Japanese Semiconductor Industry: The case of M Corporation

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Abstract: Restructuring is an essential process for the better competitiveness of the corporation in terms of production cost or/and product quality. The spatial importance of corporate restructuring relates to the locational changes of production processes at the global scale. In order to explain corporate restructuring processes, reference is usually made to two basic concepts: the new international division of labor, or NIDL, and the product cycle. However, both of these models, based on the behavior of multinational corporations, emphasize the reduction of production cost. They give little attention to another means of competition in industrialized economies, i.e. restructuring processes connected with product quality. It is this form of restructuring that is emphasized in this paper, which analyzes the underlying factors behind the recent restructuring trends of M Corporation, a leading semiconductor manufacturer. The research demonstrates that there were two strong characteristics of this recent restructuring. First, M Corporation withdrew from making less profitable products at intra-firm level. Second, it concentrated on more profitable technology-oriented products. The reasons that M Corporation has chosen the above restructuring methods stem from three factors: the weaknesses of competitors' production systems, the existing information infrastructure, and the corporate culture of M Corporation. The research reported in this paper will alter existing industrial location concepts.

Keywords: Corporate restructuring, Japan, semiconductor industry, new international division of labour, product cycle, industrial location.

Introduction

Restructuring is an essential process for better competitiveness of the corporation in terms of production cost or/and product quality. It is associated with organizational and industrial changes. The spatial importance of corporate restructuring lies in the locational changes of production processes at the global scale. Since the late 1960s, industrial agglomerations of production in core areas have been increasingly dispersed towards the periphery in the process of restructuring. This is a transition from geographical specializations based on sectors (for example, steel regions) to more functional specialization associated with the increasing refinement of the division of labour within the firm (such as corporate control regions, concentrations of R&D, branch plant economies, etc.) (Hymer, 1972; Massey, 1984).

Corporate restructuring processes can be explained in relation to two basic concepts: the new international division of labour (NIDL、新國際分業) and the product cycle. The concept of NIDL focuses on the growing contradictions of the capital/labour relationship in traditional industrial agglomerations, and on the changing nature of production itself. The pressure of international competition has forced capital to search for cheaper, more docile sources of labour in less developed countries of the world in order to restore profitability. This transfer of capital has been made possible by advanced in transportation and communication technologies which have reduced the fraction of distance and, crucially, by the progressive deskilling of the production process which has allowed firms to take advantage of cheap, unskilled labour in the periphery (Bluestone and Harrison, 1982; Fröbel et al., 1980; Lipietz, 1986). As a result, NIDL is strongly marked by the circulation of semi-finished manufactures from one nationally-based work station to the next. In this process, skilled and technologically contrived labour tasks are commonly assigned to the core countries of the international capitalist system, whereas unskilled, routine tasks (especially those that consume large quantities of labour) tend to be shifted out to selected regions of the global periphery (Scott, 1987). Capitalist multinational corporations (MNCs、多國籍企業) are the major agents of the NIDL, which is a strategic response to the continuous imperative of capital accumulation in

MNCs. NIDL involves a reorganization of the geography of the productive structure of MNCs, which stimulates the growth of industrial production in the newly industrialized economies (NIEs) and elsewhere. NIDL is, in this view, the result of the multinational restructuring of production. The central importance of international capital in shaping the NIDL is clearly indicated by the fact that only a very small number of developing countries have developed a significant level of industrialization (Dicken, 1992). Thus, investment may switch back to the old industrial regions as computer-aided production increases the global locational strategies of multinational corporations (Schoenberger, 1988).

The general spatial evolution described in NIDL has much in common with the product cycle (Storper, 1985). According to product cycle theory, price elasticity is postulated as being low in the early stages of the manufacture of a new product, and, therefore, of little locational consequence. At the same time, however, the creation and introduction of these new products is seen to require several factors: freedom and flexibility in the sourcing of inputs; strong and swift communications with suppliers, customers, and even competitors; and affluent markets that can afford these new and expensive products. The maturing of these products brings the first steps towards product standardization, in that the need for flexibility in input sourcing declines, economies of scale derived from mass production become available. Although concern for costs of production begins to emerge, price competition may not have begun. Eventually, production may be relocated and decentralized within a country. Exporting to other countries may precede overseas production in those countries which may, in turn, expand to service the market in third countries. Beyond this stage of maturity is the standardized product stage, when there is strong price competition, so that the potential for low-cost supply draws manufacturers to less developed countries. The home country, where the innovation originated, then begins to re-import rather than export (Vernon, 1966). Many aspects of this theory have been criticized, such as its overemphasis on technology change and exclusion of almost all other considerations, and its neglect of technology transfer and parallel production adopted by some MNCs in order to overcome the trade barriers of some countries, etc (Taylor, 1986).

However, the NIDL concept seems to reach its limitation with the increasing competition from the NIEs in mass production. According to the product cycle concept, a corporation producing customer-oriented or highly sophisticated products for a dynamic market needs close co-location both of R&D and production sites, and of customer and supplier. In addition, the life cycles of new products become gradually shorter, and manufacturers have to swiftly transform newly developed ideas into products. This means that large multinational corporations have to choose between the strategies of customized production, and mass production, since the nature and spatial context of these two strategies are different. In mass production, firms have to search out low production costs by the internationalization of their production functions. When the mass production stage is reached, technology is standardized to a certain level and the spatial division of the production process becomes an effective strategy. On the other hand, customized production requires the close scrutiny, and even forecasting, of market changes, and the continuous upgrading of processing and design technologies. Vertical integration by means of information technology or co-location of production functions is essential in this latter restructuring strategy.

This paper examines the recent restructuring trend of a Japanese semiconductor firm with reference to M Corporation, and analyzes the underlying factors that force the firm to adopt new restructuring strategies. Data used in this study were collected by the following methods:

1. Questionnaire surveys conducted in the production facilities during April and May 2000,

2. Personal interviews and e-mail questionnaires at the headquarters of MC and Electron Devices, which is one of the MC’s in-house companies, during 2000 and 2001, and

3. Official press releases of MC during 1994 and 2001.

Studies on semiconductor production and its location pattern

Semiconductor development and production processes can be broadly divided into: design, front-end (diffusion) and back-end (assembly). In the 1980s, the spatial distribution of the semiconductor production sites was explained by means of the specific production environments required for each production process (Scott, 1987; Scott and Angel, 1987, 1988; Yamaguchi, 1982; Tomozawa, 1989; Yanai, 1991). In the case of the United States, Scott and Angel (1988) pointed out that the semiconductor industry showed both dispersal and agglomeration patterns. Customer-oriented production was concentrated in Silicon Valley, and mass production was distributed among Southeast Asian countries. The spatial division of labour was developed even among the Southeast Asian countries and China. The spatial distribution of the Japanese semiconductor industry was also explained in terms of the nature of the production process and the technological level. Design, production development, and trial production, which need close customer contact and R&D, were located around the Tokyo (東京) and Osaka (大阪) areas. Assembly processes, which are by nature labour-intensive, were dispersed to remoter areas of Japan because of the availability of the labour force (Yamaguchi, 1982; Takeuchi, 1993; Tomozawa, 1989; Matsubara, 1987). Firm strategy and its competition system at this time were based on keeping production costs low by means of the spatial division of production functions. Both NIDL and product cycle concepts can be effectively explained by the corporate restructuring process of this period.

Since the late 1980s, the focus of the corporate strategy has shifted from the cost-oriented spatial division of labour, to quality and lead-time (i.e. time from product development to market). Some studies pointed out the corporate restructuring of American semiconductor manufacturers in product and production process development by multinational technology development teams (Angel, 1994). On the Japanese side, the labour location factor in the semiconductor industry shifted from cost-orientation to quality-orientation as a result of the development of technology and the automation of production processes in the 1980s (Tomozawa, 1989; Takeuchi, 1993). Another change has been the construction of integrated plants and regional subsidiaries instead of subcontracting, in order to reduce the lead-time of production (Itoh, 2000). These restructuring processes can be seen as an integration of certain production functions for better technology efficiency. In this aspect, the restructuring strategies of the US and Japanese firms are different. The US firms use the mobility of labour (by mean of multinational technology development teams), whereas Japanese firms use plant (capital) integration.

International competition patterns developed by MNCs in the later 1980s were severely influenced by the development of NIEs. In the 1980s, semiconductor producers, namely fabless[1] producers, emerged in the United States (Dicken, 1998). Fabless firms develop a core skill in product design and development, quality assurance, sales, and customer support. However, the production processes that need a huge amount of investment for building, equipping and operating a fab, are outsourced to foundries. These fabless firms generally use Taiwanese, Korean, and Singaporean foundries for the actual production process. Through this new production process the US semiconductor firms gained flexibility of production to respond the market dynamism. In an age of supply deficiencies in the semiconductor industry, however, fabless firms face difficulties in actualizing their designs into semiconductors since there are many coordination problems between fabless firms and foundries (ÓhUallacháin, 1997).

Very recently, some studies such as Mazurek (1999), and Nishimura (1998) point out that, due to the maturation of technology and the development of information sharing, separation of semiconductor production from other functions has become available, and new types of business models are emerging. In addition, a new production system called the ‘Chipless Model’ has appeared in recent years. In this system, a new venture develops only the IP (Intellectual Property) to be used in the semiconductor and sells it to the manufacturers (Sangyo Taimuzu, 2000). This US-style restructuring process has generated new version of NIDL in the global economy. In the 1980s, the US firms systematically separated their technology linkage between the US and Southeast Asia and even between countries in Southeast Asia. In new strategy, however, the US firms subcontract out their capital-intensive production processes (a process of diffusion) to NIEs and concentrate on higher value added and customer interface processes. This process involves separation of production not only in terms of functions but also in terms of capital.

With regard to the Japanese semiconductor industry, however, many studies have concluded that the traditional vertically integrated system is no longer capable of providing the necessary time reduction in production processes and should be changed to the horizontal network production system (Nishimura, 1998, Sangyo Taimuzu, 1999; JDB Research Report, 1999). Intensification of circuit accumulation and diversification of semiconductor usage have led to a crisis for existing vertically integrated firms (JDB Research Report, 1999). The Japanese vertically integrated production system came in for criticism for giving priority to the national production system rather than the international one (Chusho Kigyo Kinyukosha, 2000). Use of the supply chain management system, adoption of the fabless model, intensification of technology support and service in sale functions are given as examples of the Japanese adaptation to the changing semiconductor market (Sangyo Taimuzu, 1999). However, there is little known about the actual restructuring strategy of Japanese semiconductor firm and its underlying forces.

Restructuring of Japanese firms: the case of M Corporation

After recovering from war damage in the mid 1950s, the Japanese economy started growing rapidly. This rapid growth continued until the early 1970s. During this period of rapid growth, Japanese manufacturing industries experienced a major shift from light to heavy industries, a change made possible by imported technologies and inexpensive oil and raw materials from abroad. This high growth period of the Japanese economy ended with the first oil shock in 1973. Furthermore, the transition of the foreign currency exchange system from fixed rates to a floating rate in 1970 induced a swift appreciation of Japanese yen (in terms of US dollar). The high oil price and high Japanese yen appreciation during the 1970s not only made the growth rate slower but also forced Japanese industry to become more energy efficient and more internationally competitive. The combination of high oil prices and the higher value yen with intensified competition with NIEs in East Asia brought about a major restructuring of the Japanese economy (Fujita and Tabuchi, 1997). These restructuring processes were followed by relocation of the production functions to Southeast Asia.

Although the semiconductor industry was developed in Japan more recently than in the US, it is one of the major industries contributing to the development of other electronic industries and Japanese economy. Recently, Japanese semiconductor corporations have faced a crisis generated by severe competition from the combined production system of US fabless firms and Taiwanese and Korean foundries in the area of mass-production. To analyze the strategy of restructuring used by Japanese firms to escape from the crisis, M Corporation, a leading semiconductor manufacturer, has been selected as a case study. First, the locational changes of production facilities related to changing corporate strategy with the application of information and communications technology are outlined. Then, recent organization changes and subsequent location changes are analyzed.

Change in allocation of intra-firm functions

Production

MC started mass production of transistors and ICs in the mid-1950s and 1960s respectively. Until the first-half of the 1960s, all electronic communication equipment was produced at the headquarters plant located in Tokyo. In the later half of the 1960s, the type and volume of semiconductor products quickly increased as a result of opening to foreign markets. Accordingly, A1 plant was constructed in 1962 on the periphery of Tokyo as a new production facility. In 1964, D1 subsidiary was established to expand semiconductor production. This subsidiary was strategically located to avoid the rising labour costs of the Tokyo area and to exploit the availability of cheap labour and the attractions of local government in Northern Honshu (Kitagawa, 1994). The decentralization of semiconductor production facilities was followed by the establishment of D2 subsidiary in Southern Kyushu in 1970 (Table 1 and Fig.1).

Expansion of production facilities continued in the 1970s with the construction of back-end (assembly) subsidiaries in foreign countries and remote areas of Japan, all designed to exploit cheap labour costs. This phase of production expansion up to the 1970s can be explained with the concept of NIDL, which emphasizes the searching throughout the globe for low production cost locations. In the 1980s, the corporation changed its strategy, with the internationalization of front-end plant in each world semiconductor block. The construction of these front-end plants had two main meanings: to void the semiconductor trade fraction, and to enter the US and European markets. In the 1990s, two integrated semiconductor subsidiaries (O6 and O8) were established in China in the form of joint ventures to exploit the abundance of cheap engineers and the proximity to the Asian market. In addition, a joint venture assembly subsidiary was established in Indonesia in 1996.

In terms of management strategy, D1 and D2 became mother plants. Although D1 was established as an assembly plant, one front-end plant and one back-end plant were constructed from scratch in the same prefecture. On the other hand, D2 established its own subsidiaries, D3, D5, and D8. D6, producing compound semiconductors, was established as an assembly subsidiary, but it became a consolidated production facility with the construction of one front-end plant in the same prefecture (see Fig. 2).

At present, A1 plant is a production base concentrating on R&D and trial production of silicon semiconductor work. Successfully conducted trial productions are passed on to D1, D2, D6, D7 and D9 subsidiaries for mass production. On the other hand, compound semiconductor R&D activities are mainly carried out at R2 research centre and production is carried out in D6 subsidiary.

Since the 1980s, the spatial distribution of semiconductor production facilities in MC has been reorganized in two different groups: technologically sophisticated facilities mainly located in Japan, and mass production facilities located both in regional area of Japan and foreign countries.

Research and Development

There are seven domestic and five overseas research laboratories in MC (Table 2). The central research laboratory (CR) is located near Tokyo. R1 and A1 plant are located on the periphery of the Tokyo area, while R2 and R3 research centres are located near the Osaka area. Among the overseas research centres, R4 to R7 are located in the USA while R8 is located in Germany. The R1 research centre is devoted to the development of new materials and devices. A1 is for the development of silicon VLSI, R3 for human interface, and R2 for compound semiconductor development. The CR combines all the research results. Semiconductor trial production lines (clean room) are present at A1 and R2. These two facilities (A1 and R2) function as a bridge between intra-firm research and production functions.

Internationalization of MC's R&D began with the establishment of R4 (USA) in 1988. Subsequently, R5 (USA) was established in 1991. The establishment of R8 is intended to develop relations with various European research centres and institutions, and to contribute to the advance of scientific computing in Europe. In recent years, MC laboratories have been actively collaborating with European research institutes in the areas of parallel computing, supercomputing, artificial intelligence, and next generation communication. There are two main reasons for establishing Japanese R&D in the US: to increase sales and service delivery to the US markets, and to take advantage of the science and technology infrastructure of the US through linkages to universities and employment of US scientists (Florida and Kenney, 1994; Angel and Savage, 1996). In the case of the electronics industry, the second purpose is the more important, and, as a result, contact between the US and Japanese central R&D sections can be stronger than that of firms whose production facilities are located only in the United States (Angel and Savage, 1996).

Technological differences and transactions among MC's semiconductor production facilities

In semiconductor production it is said that front-end production is more capital- and technology-intensive than back-end production. Moreover, the innovation level of semiconductor production technology can be evaluated by two criteria: wafer diameter and processing technology (design rule). Although larger wafer size leads to greater profitability, it demands highly skilled and advanced technology. In addition, miniaturization technology makes the IC size smaller and more powerful. This processing technology also demands a huge amount of R&D expense and the most advanced technology (Kikuchi, 1999).

Table 1 shows the production process, wafer size, and processing technology of MC's semiconductor production facilities around the world. There are four wafer fabrication facilities outside Japan. These facilities are located in the three non-Japanese semiconductor market blocks of the world (America, Europe, and Asia). In terms of wafer size, there is no particular difference in MC semiconductor production subsidiaries. Processing technology, however, shows differences, not only among the production facilities of Japan, but also between Asian and USA subsidiaries. Of the wafer production facilities of Japan, D1 and D2 subsidiaries use the most advanced processing technology. In the case of D6 plant, however, it is impossible to make an evaluation from the point of view of processing technology since this plant produces a compound semiconductor that needs more sophisticated technology than a pure silicon semiconductor.

MC announced the construction of a 12-inch wafer production plant in the USA in 1999. It was a unique decision in MC's history, since nearly all the initial largest wafer production facilities had started from plants located in Japan and then diffused to foreign countries (Sangyo Taimuzu, 1999). This was because the newly developed wafer needed a close tie-in with the A1 plant conducting trial production. This construction plan, however, was delayed for many reasons. In November 2000, MC announced that its joint venture company, E Company, would construct a new plant within the campus of D9 to produce a 12-inch wafer using 0.13μm processing technology. This shows that MC still adheres to the concept that 'technology development will occur in Japan and will later be diffused to foreign countries'. The nature of technology development evidently constrained the spatial distribution of production at the global scale.

Furthermore, the technological level is different among the Asian assembly subsidiaries. The present assembly line in Malaysia (Linear IC), for example, was moved from Singapore. The former Singapore subsidiary now assembles more sophisticated and higher value-added DRAM (Dynamic Random Access Memory). The former lower value-added assembly line (Linear IC) of the Malaysian subsidiary was moved to a newly constructed Indonesian subsidiary (Sangyo Taimuzu, 1999). This shows that MC systematically moves its value-added production centres around Asian countries to maintain low production costs. This restructuring pattern, however, is somewhat different from the existing NIDL concept since MC upgraded the existing plants rather than closing down the plants that had rising production costs in the developing countries.

Another index to determine the technological innovation level of the subsidiary is the percentage of engineers among production workers (Feldman, 1994). The percentages of production engineers and locally employed engineers are shown in Table 1. Subsidiaries conducting front-end work have a higher engineer percentage than those of assembly subsidiaries of Japan and foreign countries. Among the wafer fabrication subsidiaries of Japan, D1 and D2 have a higher percentage of engineers than the other subsidiaries. Of the foreign wafer fabrication subsidiaries, O5 (USA), O8 (Shanghai, China、中國上海), and O4 (England) have higher percentages of engineers. In addition, O5 has the highest percentage of engineers and employs the lowest percentage of local engineers. From personal interviews, it has been established that this is due to the fact that the control of technical workers in the USA is difficult and the rate of job transfer at inter-firm level is very high compared to Japan. Highly trained USA engineers can easily move to better jobs and this creates a very risky situation for Japanese firms. It is therefore impossible to place the most advanced technology bases in the USA. However, the situation is different in the case of O8 subsidiary where an abundant supply of cheap engineers is available.

The placements of production described above indicate that having leading technology production bases in foreign countries is difficult for MC. This distribution pattern of production functions in technological terms reveals the trend that was explained in the product cycle theory. Newly developed product and production technology was firstly diffused to production plants located in the periphery of Japan, and with the maturity and standardization of this technology it is subsequently diffused to the other countries of the world to take advantage of the economies of scale.

The intra-firm transaction pattern (June, 2001) of MC is shown in Fig. 2. Basically, the transaction process occurs between front-end and back-end production processes. In domestic subsidiaries, D2 subsidiary conducts front-end and partial back-end processing. The rest of the wafers manufactured in D2 are assembled at its owned subsidiaries of D3, D5, and D8. In D7 subsidiary, both front-end and back-end processes are conducted in the same plant. In addition, D7 assembles wafers shipped from D9 subsidiary. Although D9 subsidiary was established as an integrated plant, it mainly conducts the front-end process, and back-end process is transferred to D7 and O3 (Singapore) subsidiaries. Some wafers produced at one plant of D6 subsidiary are assembled at another plant of the same subsidiary and the rest are sent to its subsidiary D4 for assembly. Some wafers produced at one plant of D1 subsidiary are partly assembled at two other plants and the rest are sent to O2 (Malaysia) and O7 (Indonesia) plants for assembly. The D2, D6, and D8 subsidiaries partly maintain a high value-added assembly functions while shipping the rest of the standard semiconductor assembly to Malaysia and Singapore. On the other hand, D7 subsidiary has started to emphasize assembly while maintaining an integrated production system.

Wafers produced at O4 (UK) plant are sent to O3 (Singapore) and O1 (Ireland) for assembly. The O5 (USA) subsidiary, which formerly produced semiconductors as an integrated plant, is now conducting only front-end production, and wafers are shipped to O3 (Singapore) subsidiary for assembly. O8 (Shanghai, China) subsidiary, which formerly produced semiconductors in an integrated system, is now conducting wafer fabrication only, and products are shipped to O2 (Malaysia) subsidiary for assembly. The O6 (Beijing、北京, China) plant is the only plant conducting semiconductor production in an integrated system among MC's overseas subsidiaries. There are three main reasons for this. First, O6 is using old processing technology and the interface is difficult between O6 and other assembly subsidiaries. Second, China itself is a large market for semiconductors and most of the products of O6 are shipped to the China market. Third, labour costs are still cheap enough to maintain assembly together with the front-end production.

In sum, the production process of the MC subsidiary has changed from the past, and the present production system reveals both a disintegrated and an integrated pattern of production process among the production subsidiaries. Overseas integrated subsidiaries, apart from O6, have shifted to front-end production, and assembly is conducted in Singapore and Malaysia. The transaction pattern also reveals that wafer fabrication of low value-added and standardized products is conducted both in domestic and foreign subsidiaries, and these wafers are assembled into semiconductors in the Malaysian and Indonesian subsidiaries. On the other hand, high value-added and customer productions are carried out by the domestic integrated subsidiaries, or between an integrated or front-end subsidiary and the Singapore subsidiary.

Information technology and business processes in M Corporation

Information technology enables companies to operate through their individual units and remain fully autonomous while the organization still enjoys the economies of scale which centralization creates (Hammer and Champy, 1993). In managerial terms, computer networks operating in cyber-space through telecommunication channels have obviously increased the ability to multi-site organization in order to control and disperse their activities (Gillespie and Williams, 1988). In sum, many multinational corporations see their exclusive information networks as a central element of their competitive advantage (Langdale, 1989; Kitchin, 1998).

Since 1983, MC has used information technology at intra-firm level. The consolidated information system of MC's semiconductor business can be explained through CIMS, Consolidated Information Management System for Semiconductor. The semiconductor business of MC as a whole is responsible for the management of various types of information: market, customer, sales, production, technology etc. Through CIMS, it is possible to access real-time information of intra-firm function from anywhere in the world. To get the necessary speed in production and sales, a unified database named (GAINS) was introduced in 1990. Information from separate systems of production and sales are sent to the central database of GAINS and adjusted to eliminate duplication and defects, and are then made available anytime, anywhere in the world. In production, 'Innovation for Semiconductor Hyper Integrated Production' has been established to get a speedy response to the market. Production sites and product strategic business unit are in matrix relation. The production lines are also established in matrix relation. Therefore, it is possible to produce memory and microcomputers on the same line. With such a system, market changes can be quickly reflected on the product line[2].

A general framework of new product development is analyzed to understand the application of information and communication technology in the production process (Fig. 3). In fact, the firm acts as a coordinator to facilitate customers' technology procurement by utilizing its existing infrastructure and the technology that it is continuously accumulating. In particular, basic and applied technology is acquired from its internal

R&D, universities, and other private and government R&D departments. With the development of intra-firm networks, these technology acquisition facilities are decentralized from headquarters and located near the technology sources, regardless of national boundaries. These decentralized facilities, however, have a real-time connection with the firm's central research facility through the Intranet. The network helps to avoid costly research duplication, allows improved co-ordination of projects with an international potential, and speeds up the information and data flow between the research centres. In addition it has increased the opportunity for contact between research departments and other corporate functions within the firm (Howell, 1990).

In the age of customer-oriented production, a close relationship with the customer is essential to maintain existing markets and to find new ones. Product design development, new application ideas, and weaknesses of currently produced products are the main knowledge inputs from the customer. Since semiconductor customers are distributed all around the world, MC uses its existing sales network, design subsidiaries and newly established design centres and development centres as customer cooperation facilities. There are ten overseas sales subsidiaries and four overseas manufacturing and sales subsidiaries in the MC semiconductor business. Thirty domestic and eighteen overseas design centres have been established since the 1980s. In addition, more than ten development centres have been established around the world to promote the system LSI business since 1992. Two design subsidiaries were also established in 1980 and 1986 respectively. As in the case of basic R&D, these sales and design development functions are decentralized to be close to customers and are connected to other intra-firm functions through the Intra-firm network. Acquired processing and design technologies are accumulated at the production engineering section. From the combination of these inter- and intra-firm functions, MC is able to produce leading age customer products and can support its customers with the best semiconductor solutions.

In general, although the production functions from product design to marketing of a new product are located in different part of the world, those functions are well connected by the intra-firm network.

Recent restructuring of M Corporation's semiconductor business

Since the late 1960s, MC has split up its production function by establishing regional and overseas subsidiaries. However, R&D and trial production plants are under the direct control of corporate headquarters. In 2000, MC reorganized into three in-house companies. Each in-house company was formed through the combination of closely related product groups. Electron Devices, for example, includes semiconductor, electronic components, and plasma display product groups. In addition, applied R&D and sales functions formerly controlled by corporate headquarters were transferred to each in-house company (see Fig. 5).

There have been three major organizational changes in the MC semiconductor industry (Fig. 4). The first change was the establishment of E Company, a joint venture between MC and H Corporation. This new company bases its R&D and trial production in A1 plant while its mass production is conducted in O9 subsidiary (owned by MC) and another plant in Singapore (owned by H Corporation) in a contract production system[3].

The second organizational change was the separation of the company's optical and compound semiconductor production with the establishment of a new company (C Company), 100 percent owned by MC. This company has its headquarters in Tokyo and uses R1 and R2 research centres to conduct R&D. The establishment of this new company is to develop a highly integrated research, development and production organization closely attuned to the market trend[4].

The third organizational change was related to the merging and reintegration of existing production subsidiaries and production plants. In particular, the assembly subsidiaries of D3, D5, and D8 (which are under D2 in managerial terms) were integrated as a new subsidiary[5]. In addition, all domestic semiconductor production subsidiaries were consolidated into three groups, namely, D1, D2, and D6 groups. D1 and D2 concentrate on system LSI production while D6 focuses on general purpose IC and discrete devices. Two design subsidiaries of MC, responsible for hardware and software design of LSI respectively, merged in 2002 to strengthen capacities for providing customer solutions and product development[6].

Restructuring the production process was also conducted in the late 1990s and 2001 in response to the severe competition in the semiconductor industry. First, production and marketing functions were reorganized in terms of the customer base in 1999[7]. In particular, former product-based organizations like system microcomputers and system LSI were reorganized as the LSI division 1 (responsible for the consumer market), LSI division 2 (responsible for the networking market), and LSI division 3 (responsible for the PC and PC peripheral equipment). Each reorganized division specialized in a strategic field to provide innovative solutions and customer focus. The intention is also to promote the level of cooperation and understanding with customers through the ability to provide true systems solutions in a variety of product categories.

The second process change is the closedown of semiconductor assembly and test operations in the United States, and has resulted in the loss of approximately 100 employees at O5 subsidiary. With this action, O5 subsidiary was restructured in order to be more cost-effective and to better focus on USA-based customer requirements. In addition, manufacturing shifted focus away from DRAM to higher-value-added system LSI and logic devices to meet demand from the growing communications market[8]. All other MC semiconductor production plants also shifted their product from DRAM to more profitable semiconductor products. The detailed content of these product changes is shown in Table 3. As a consequence of this action, O4 (UK) subsidiary reduced its DRAM production capacity and more than 600 employees lost their jobs.

The third process change is the merging of domestic assembly plants and the closedown of old wafer fabrication lines of production and testing. In particular, two assembly plants of D1 subsidiary were merged into one location to facilitate more effective management. Six-inch wafer trial production lines at A1 plant and mass production line of other domestic production subsidiaries were closed. As a result of these structural reforms, MC reduced its workforce by more than 4000.

In sum, MC *chooses* profitable businesses from its existing semiconductor industry and *concentrates* on implementing its integration strategy with them. With the establishment of the new company, MC withdrew from less profitable and severely competitive business areas such as DRAM. In addition, technologically sophisticated plants in Japan were upgraded and integrated while some overseas mass-production plants were closed down.

Discussion and Conclusions

The various elements of the recent restructuring of the MC semiconductor business show two strong characteristics. First, MC withdrew from making less profitable products at the intra-firm level. For example, MC withdrew from DRAM production because it faced severe competition from the new, up and coming semiconductor firms, especially USA fabless firms and Korean and Taiwanese firms. MC, however, used the strategy of reintegration of DRAM business with the establishment of new ventures rather than close down the whole business. Through this strategy, it can still use existing production facilities and human resources. In addition, as MC holds a 50 percent share of E Company, half of the technicians and engineers have been transferred from MC. This has the strong advantage that technicians from E Company well understand the intra-firm communication language and technology of MC. In terms of technological communication and product development, both M and H corporations can establish more rapid mutual understanding with E Company compared to other firms.

Second, MC concentrates on more profitable technology-oriented products. The newly established C Company has the same level of authority with MC in terms of management. However, in terms of MC as a whole, C Company is still contributing to the existing information network and product development. The only difference from the previous vertically integrated production system is that C Company was established as a consolidated subsidiary including its own marketing, R&D, and production functions rather than being a simple production subsidiary. Through this integration C Company can focus on the compound semiconductor industry.

In addition, the merging of production subsidiaries like D3, D5, and D8 to form a new semiconductor assembly subsidiary represents a strategy of re-integrating production by reducing the number of employees. The closedown of old trial production and mass production lines also shows that the company is adopting the new strategy in which sophisticated products are emphasized by dropping less profitable products and less efficient production processes.

From these organizational restructurings, it can be said that MC is adopting its own intra-firm restructuring strategy against severe market competition (Fig. 5). This strategy, however, is difficult to evaluate as a vertical disintegration of production where every process of each product is carried out by financially non-related firms. Instead of vertical disintegration, MC separated its individual product type into each fully authorized division. The new concept of restructuring is able quickly to detect the dynamism of market and swiftly respond within specific niches by using existing technology and the intra-firm network. In fact, MC announced that as an integrated device manufacturer armed with a technological base ranging from circuit design to process and device design and packaging, it aims to provide devices that can only be developed through vertically integrated technology[9]. This point will contribute to the economic development of declining old industrial regions by means of the advanced technology continuously accumulated there.

The reasons that MC has chosen the above restructuring methods stem from three factors: the weaknesses of competitors' production systems, the existing information infrastructure, and the corporate culture of MC. The semiconductor market in recent years has brought vertically integrated firms into a very difficult situation. In particular, competition for the lower priced market has intensified with the development of fabless firms. However, there are some weaknesses in this fabless production system. Nearly all the weakness can be explained by product cycle concept of the technology development path. The main weakness is that it is difficult to produce leading age semiconductor products due to technological and inter-firm communication and coordination problems. Since technology is always moving forwards, newly developed technology generated from historically accumulated technologies still remains within the closed system of vertically integrated firms while standardized technology diffuses to the small start-up firms. In other words, it is difficult for newcomers to handle the most advanced semiconductor products in technological terms.

Fabless companies face difficulties in coordinating into a cohesive customer offering their many outsourced facilities, services and technologies. Although many of the elements of a fabless company offering are rapidly maturing, the fabless company relies on all of these elements working well together to succeed[10]. There are two major problems in this coordination issue: technology transfer and equipment coordination. Technology transfer of new technology at inter-firm level is very difficult. It is difficult even at intra-firm level, as shown in the case of MC where initial stages of product development are conducted within Japan and diffused to the domestic mother plants and then eventually to foreign countries. As Feldman (1994) has urged, when technology is complex and evolving rapidly, long distance standardized transmission is not possible.

Problems related to adjustment between processing equipment (facilities) can arise in the new model for producing leading age semiconductors. ÓhUallacháin (1997) for example, pointed out that since semiconductor production technology is advancing very rapidly, very expensive production equipment has to adapt to innovations. Therefore, even though design companies develop a design with the most advanced technology, it is impossible to convert this into a product unless the foundry has enough investment in its own production facilities and has nearly the same level of technological knowledge.

The second factor that forced MC to adopt new strategy is the development and application of information and communication technology. With the development of IT, firms have been able to improve their intra- and inter-firm communication linkages. Vertically integrated firms have effectively introduced IT in their existing leased line intra-firm networks (LAN, WAN) and extended it to the inter-firm network. On the other hand, start-up firms are able to access historically expensive inter-firm networks at a comparatively cheaper price through the Internet. Since small start-up firms have no effective intra-firm network, they have to rely on inter-firm networks. However, in the case of coordination between a corporate headquarters and subsidiaries, the information and telecommunication systems are *internal* to the firm, and are thus under budgetary and technical control. In contrast, the telecommunication networks which link multinational customers, suppliers, or business partners are *external* in nature, and as a result, it is more difficult to exercise precise technical and managerial control (Roche, 1993). In addition, as mentioned earlier, the nature of technology diffusion and technology accumulation makes it difficult to produce a leading-age product. In these situations, business styles have gradually separated between vertically integrated leading-age product producers on the one hand, and vertically disintegrated standardized product producers on the other. MC, with its existing information infrastructure, had no choice except to move to high value-added products by using the existing infrastructure constructed over a long period.

The final reason for the recent restructuring centred on the corporate culture and on even the industrial culture of Japan. Matsuhashi and Togashi (1988: 185) state, '…the Japanese counterparts in the electronic industry, particularly the high tech industry, have selected another way of raising labour productivity of the domestic factories. … Such location-based strategies of Japanese producers have been aimed at getting over the disadvantage of labour costs by further increasing labour productivity'. This is the general pattern of the Japanese electronic industry. It can be interpreted from this that Japanese firms use a strategy in which rising production costs of existing plants are covered by upgrading the plant in technological terms and producing high-value added products there. Many studies prove this assumption with the example of decentralization of production plants from Tokyo and formation of mother plants in remote areas (Kitagawa, 1994; Itoh, 2000). MC itself improved this point by changing its former production plants, such as A1, into R&D plants. In addition, the earliest production subsidiaries of D1 and D2 have been improved as mother plants with the development of the semiconductor industry.

In today's restructuring, however, Japanese firms use a new version of the traditional strategy by improving the semiconductor work through making it more technology-oriented by means of *choice* and *concentration*. Other large Japanese semiconductor firms have also withdrawn from less profitable and severely competitive DRAM production in 1998 and concentrated on high value-added system LSI products[11]. Through this strategy, vertically integrated firms can effectively utilize their historically accumulated technology, information infrastructure and management skills.

The new restructuring strategy and the resultant allocation of production functions, described in this study, will alter the existing industrial location concepts. The NIDL concept is related to the movement of mass production to the developing countries to exploit the cheap and docile labour, while product cycle theory is concerned with the technological aspect of production differentiation between core and periphery. Recent corporate restructuring is related to both of NIDL and product cycle concepts. However, the means of restructuring is quite different. MC decided to cut-off its mass production which facing severe competition from NIEs and consolidated its technologically highest production facilities, in order to emphasize customer-oriented products. In addition, MC still uses the modified vertically integrated production system (product-based) instead of the popular multi-layer horizontal production organization. The resultant changes in spatial order are related to plant closure in developing countries and to the upgrading of high-class plants in the developed countries.

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[1] In the world of semiconductors, the term fab refers to a foundry. A fabless company designs a product (usually, a semiconductor) but does not make the product itself.
[2] This paragraph is based on the M Corporation’s semiconductor business guidebook published in 1998.
[3] *Press Release of MC*, 28 November, 2000.
[4] *Press Release of MC*, 10 January, 2001.
[5] *Press Release of MC*, 31 July, 2001.
[6] *Press Release of MC*, 28 September, 2001.
[7] *Press Release of MC*, 25 March, 1999.
[8] *Press Release of MC*, 6 April, 2001.
[9] *Press Release of MC*, 31 July, 2001.
[10] *Press Release of Gartner Dataquest*, 9 April, 2000.
[11] *Nihon Keizai Shinbun*, 14 January, 1998 and 4 December, 1998.