Research prospects for technology transfer in Japanese multinational manufacturing companies

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1 Introduction

Technology transfer has been a means of solving the economic disparity between developed countries in the Northern Hemisphere and developing countries in the Southern Hemisphere, the so-called North-South problem, until the 1970s (Audretsch et al., 2014; Noh and Lee, 2019). The drivers of technology transfer in that North-South problem have been open economic policies, trade liberalization, technological advances in transportation and communication, and direct investment. Technology flowed from developed to developing countries using these channels, and studies of technology transfer in the 1970s attempted to explain technology transfer in the context of international trade flows, relying particularly on theories of international economics and international trade (Noh and Lee, 2019; Vernon, 1966; Wahab et al., 2012).

In the 1980s, however, direct investment, especially by multinational corporations, became the main channel of technology transfer. The study of technology transfer in the 1980s relied on theories of international production, international R&D, and transaction costs to explain the transfer of technology within MNCs (Buckley and Casson, 1991; Dunning, 1980, Noh and Lee, 2019; Reddy and Zhao, 1990; Teece, 1977; Wahab et al., 2012).

As the interest of technology transfer research has shifted to the transfer of technology within MNCs, research on the international transfer of Japanese

production systems has become more active, especially in Japan. In the 1980s, with the rapid appreciation of the yen and the rise of protectionism in the West, Japanese multinational manufacturing firms increased their foreign direct investment (FDI) to defend the overseas markets they had cultivated through product exports. The number of overseas factories of Japanese MNCs in Western countries increased, and the development of these factories became an important management issue for Japanese MNCs. The system of transferring the production technology system[1] from the parent factory in the home country to foster overseas factories is generally called the "mother factory system" (Nakagawa, 2012; Nakayama, 2003; Oki, 2014; Suh, 2014; Yamaguchi, 2006; Yoshimoto, 2011).

Furthermore, as China began to focus more on economic reform and opening-up policies in the 1990s, Japanese companies began to increase their direct investment in China. As a result, the number of Chinese subsidiaries of Japanese multinational manufacturing companies increased rapidly after 2000, and the overseas production ratio of Japanese multinational manufacturing companies increased accordingly. With the rapid increase in the number of overseas subsidiaries of Japanese multinational companies, the conventional mother factory system will not be able to sufficiently respond to the requests for technical support from overseas factories. Japanese MNCs are improving the conventional mother factory system and constructing a new mother factory system in order to respond to the rapid increase in requests for technical assistance to their overseas subsidiaries.

This study looks at the results of technology transfer research on Japanese MNCs, especially after the 1980s, and clarifies the issues of technology transfer research in Japanese MNCs.

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1 This study takes the concept of production technology system to mean "a system that refers to the combination or totality of various production technology elements" (Kambayashi, 2001, p.30; Kambayashi, 2003, p.5).

2 International transfer of Japnaese production systems

Since the 1980s, mainly Japanese researchers have accumulated a lot of research results on technology transfer. The reason why Japanese researchers have accumulated a lot of research results since that time is thought to be due to the fact that Japanese companies have been actively expanding their business overseas since the Plaza Accord in 1985. At the same time, as the products of Japanese firms dominated overseas markets, the Japanese production system that made possible their superior quality attracted attention. In order for Japanese firms to be competitive in overseas markets, it is necessary to transfer Japan's excellent production systems, and the fact that Japanese firms have actively transferred their production systems to overseas factories has attracted the interest of Japanese researchers, and research on technology transfer by Japanese researchers has flourished. In this section, we will review the previous studies on the international transfer of production systems in Japanese firms and confirm their findings[2].

2.1 Cultural specificity of Japanese style management

Until the products of Japanese companies swept overseas markets in the 1980s, the management of Japanese companies, so-called "Japanese management," did not attract much attention. It can be said that domestic and foreign researchers who discussed Japanese management up to that time rather

2 Munakata (1996) cites the existence of border regulations and linguistic and cultural unity as social characteristics of Japan as a country, especially in the formation of social order (p.82). Based on this understanding, he cites "mass production" and "parallel structure" (the parallel structure between the maintenance of order in the production system and the unrestricted quantitative and qualitative mobilization of human resources in companies) as the basic external and internal characteristics of the Japanese system. The correlation between these social characteristics and the technical aspects of production is described as "aesthetics of process" (p.69, 73). This research will also understand the "Japanese production system" based on the view of the same paper.

regarded Japanese management as a special kind of management rooted in the special culture of Japan.

For example, Abegglen (1958; 2006), who was the first in the world to publish research results on Japanese management, argued that the emergence and survival of Japanese management is rooted in Japanese culture. He identified three main characteristics of Japanese management: (1) lifetime commitment, (2) seniority system, and (3) existence of enterprise unions through his detailed research on five companies: NEC, Sumitomo Electric Industries, Sumitomo Chemical, Toyo Rayon (Toray), and Fuji Steel (Abegglen, 1958; Abegglen, 2006, pp.73-74).

The first, "lifelong relationship," is a social contract between the enterprise and its employees, a promise that all employees will cooperate to ensure the economic security of all those who work for the enterprise[3]. The second, "seniority system," states that seniority will be the primary determinant of wages and promotions. The third, "enterprise union," is a system in which all employees of a company, except for a few managers, belong to a single labor union, which is the sole negotiator with management. He concluded that this system of hiring, training, and rewarding employees is based on the unique Japanese values and culture of full and fair participation of all members of the community, just as in a family, village, or neighborhood, and that the Japanese employment system has not fundamentally changed in the 21st century (Abegglen, 2006, p.89).

Dore (1973) similarly acknowledged the significant role of Japanese culture in the emergence and survival of the Japanese employment system. He closely

3 The term "lifetime relationship" proposed by Abegglen has since come to be commonly referred to as "lifetime employment" and is used in a different way from its original meaning. According to translator Yoichi Yamaoka for Japanese translation, the term "lifelong relationship" pointed out by Abegglen does not refer to a "system" determined by the government or a company, but to a concept corresponding to a model or ideal type. Thus, the term has not been abolished or ended, but remains valid as a major concept to explain employment relations in Japanese corporate society (Abegglen, 2006, Japanese translation, p.288).

examined two British plants of English Electric (EE) (Bradford and Liverpool) and two Japanese plants of Hitachi (Dore, 1973, pp.11-12). Then, contrary to the convergence theory of industrial society, he explained that the employment system in Britain was changing from market-oriented to organization-oriented using the concept of "late development effect" as follows.

The organization-oriented employment system in Japan was born in the process of rational response to the very special conditions of Japan, and was adapted to late capitalism. Therefore, if there is a convergence, it is highly likely that the European market-oriented employment system will converge with the Japanese organization-oriented employment system, and in fact, there are signs of this in the British employment system. However, through subsequent research on the employment systems of large corporations in Mexico, Sri Lanka, and Senegal, he also reaffirmed the importance of Japanese values, ethics, and cultural traditions in Japan's organization-oriented employment system, and recognized the link between the Japanese employment system and Japanese society and culture. It also acknowledged the link between the Japanese employment system and Japanese society and culture.

Yoshihara (1997; 2015) identified the following characteristics as organizational traditions of Japanese companies (Yoshihara, 1997; Yoshihara, 2015, pp.285-286). They are (1) emphasis on harmony rather than competition, (2) collectivism rather than individualism, (3) dispersion and dissimilarity (distribution and allocation of wealth, power, and honor; let everyone have a flower), (4) equality (equality of opportunity as well as equality of outcome), (5) Japanese spirit and Western culture (accept foreign products and technology, but not foreign companies or people), (6) communication with heart and mind (culture of sensing), (7) craftsmanship, integral, incompatibility, and tacit knowledge, (8) emphasis on details, (9) gradualism, (10) high barriers to entry (internalism), and (11) emphasis on fieldwork and action rather than theory and analysis. He says that some of these characteristics are cultural traditions that

date back more than 1,000 years.

In this way, Abegglen (1958; 2006), Dore (1973), and Yoshihara (1997; 2015) argued for a link between Japanese management and Japanese culture. However, if, as they argue, the main characteristics and elements of Japanese management are strongly associated with Japanese culture, it will be difficult for Japanese firms to transfer and practice Japanese management to foreign countries with different cultures. This is because Japanese management is effective under the Japanese social and cultural environment, not under the foreign social and cultural environment.

In fact, the Plaza Accord of 1985 was the turning point for Japanese companies to move abroad in large numbers to defend the foreign markets they had built up through exports. However, many firms struggled in no small part due to the differences in social and cultural environments between Japan and other countries (Ichimura ed., 1988).

Yoshihara (1997; 2015) cites "offices" as a situation where Japanese firms particularly struggle in foreign countries. These offices include offices of overseas manufacturing subsidiaries, research institutes, development centers, overseas subsidiaries of non-manufacturing companies, general trading companies, securities companies, travel agencies, and retail companies. The foreign white-collar workers in these offices, i.e., managers, administrators, specialists, technicians, and clerical workers, avoided working for Japanese firms because of their negative evaluation of Japanese management, which is characterized by low starting salaries, gradual salary increases and promotions, lack of promotion opportunities, and decision-making in Japanese. Yoshihara (2015) describes such a situation as a "dark office" (Yoshihara, 1997; Yoshihara, 2015, p.115, 156-157).

2.2 Technological universality of the Japanese production system

However, the situation changed slightly in the 1980s when Japanese firms

began to expand overseas in large numbers. For example, Yoshihara (1983a) found that electric and automobile firms in Australia, New Zealand, and Singapore were successful in bringing Japanese production systems into their overseas factories.

For example, Yoshihara (1983a) studied 16 Japanese subsidiaries and 4 non-Japanese subsidiaries of electric and automobile companies in Australia, New Zealand, and Singapore, and found the following facts.

First, subsidiaries with strong management participation by Japanese firms transfer their production technology systems thickly and densely, while subsidiaries with weak management participation by Japanese firms transfer their production technology systems only thinly and sparsely. Second, not a single overseas subsidiary has a full-fledged production engineering department, and the most they can do is local adaptation (jig development) of production equipment introduced from Japan. Third, instead of automating the entire production line, overseas subsidiaries automate only important or easily mechanizable processes, leaving the rest to be done manually. Fourth, they bring in the same type of machinery and equipment that is used in Japan, but adapt it to local conditions by devising jigs for the machinery and equipment. Fifth, they enthusiastically transfer their production management know-how, such as soft production technology systems, i.e., information sharing systems, data-based management, tidiness, workplace discipline, proposal activities, and QC circle activities.

Yoshihara (1983a) points out three characteristics of the international transfer of production technology systems in Japanese companies based on these actual conditions: (1) frequent and continuous implementation of small innovations and improvements, (2) emphasis on the soft aspects of production technology systems, i.e., production management know-how, and (3) persistent daily efforts by Japanese dispatched workers to stay close to the workplace[4]. At the same

4 Yoshihara (1983b) evaluates management with these characteristics as "accumulation-

time, he argues that the production engineering systems of Japanese companies are performing quite well, though only impressively.

Shimada (1988) argues that technology has a "hardware aspect" represented by machines and factory equipment, a "software aspect" such as computer programs and invisible knowledge stock. Moreover, he argues that there are "humanware aspects" such as how humans interact with hardware and how humans interact with software. Through his extensive research on Japanese companies in the U.S., he points out the importance and effectiveness of the transfer of Japanese-style humanware technology in particular.

Ogawa (1990) investigated the actual status of technology transfer in nine Asian subsidiaries of Japanese companies (two subsidiaries in Singapore, four subsidiaries in Thailand, one subsidiary in Hong Kong, and two subsidiaries in Taiwan), and found that one of the subsidiaries in Taiwan was particularly successful in technology transfer. A retired engineer from a Japanese company was stationed at the Taiwanese subsidiary to provide guidance, and as the chief executive officer of the Taiwanese company, he worked day and night on technology transfer with the determination to live in Taiwan permanently. As a result, the Taiwanese subsidiary came to boast the highest level of technology in Taiwan (Ogawa, 1990, pp.47-49).

Cho (1994) proposed the following step-by-step process model of intra-firm technology transfer in Japanese firms. The first is the "learning" stage. In this stage, the foreign subsidiary directly introduces and learns the competitive advantage established by the Japanese parent company. A large number of employees travel back and forth between the home parent company and the overseas subsidiary to learn how to operate machines, change jigs and tools, prepare for work, and learn basic work methods. The second stage is the "establishment" stage. In this stage, the ability to respond to changes and abnormalities, which is indispensable for establishing the technology, is built

style management" and argues for its effectiveness in overseas factories (p.137).

up. The focus is on the management skills necessary to establish the technology introduced in the first stage. Overseas subsidiaries will develop local employees with management skills and reduce the number of employees dispatched from Japan. The third stage is the "improvement" stage. In this stage, the company tries to improve and upgrade its products and production facilities, and to form local inter-firm relationships. As the technology takes root within the organization, the company begins to find and cultivate subcontractors such as local mold makers, machining companies, and subcontractors. Foreign subsidiaries at this stage come to be positioned as highly independent entities within the MNC. The fourth stage is to establish "innovation" capability. Rather than being the final stage of technology transfer, this stage signifies the beginning of technology creation. Cho (1994) showed such a stage of technology transfer and argued that no foreign subsidiary will improve its technological capability by omitting the previous stage.

Nakagawa (1995) investigated the transfer of Japanese-style production management to Japanese companies in Thailand and found the following facts (pp.13-15, 92-95). First, with regard to "business technology" directly related to the production and development sites, such as machine operation skills and design technology, "daily work" is mostly transferred, while "inspection," "maintenance and repair of machinery and equipment," "work improvement and production process improvement," "purchasing of parts and raw materials," "improvement and development of jigs and tools," and "improvement and development of machinery and equipment" are transferred to some extent but not completely, and "product design and development" has not been transferred much. Second, with regard to "management skills" related to the work of managers who are not directly involved in production and development sites, Thai managers are confident in "safety management" and "quality management" but not so confident in "inventory management" and "cost management. Third, with regard to "Japanese-style production management," which refers to the

overall methods of production and development developed in Japan, only "5S" has become very widespread, but development-related methods have hardly penetrated, and methods related to the Toyota Production System are somewhere in between.

Based on the results of the survey, the book points out the existence of a hierarchical structure in the transfer of Japanese-style production control. In other words, in the transfer of Japanese-style production control, 5S is the easiest, QC circle and suggestion system are the next easiest, TQC and TPM are the next easiest, and finally JIT is the most difficult (Nakagawa, 1995, p.181).

Industrial Information Center of Hosei University and Okamoto eds. (1998) extensively discusses the technology transfer of Japanese firms to the United States, Malaysia, China, Korea, and Vietnam, and concludes the followings. (1) Overall, the transfer of assembly technology and production technology of the Japanese production system has progressed in East Asia, but the transfer of peripheral technology has not; (2) In terms of technology transfer, East Asia is at the level of operating technology, maintenance and repair, quality control, production control, and design technology for local rework of products; (3) Human resource development of both Japanese and foreign engineers is essential for the transfer of the entire Japanese production system; (4) Labor-management cooperation and equality of treatment of workers are essential for the functioning of the Japanese production system; (5) In order to transfer the Japanese production system, it is necessary to raise the level of education, develop human resources, and promote the absorptive capability of human resources in the host country (pp.286-287).

Pan (2001) conducted participant observation of three Japanese subsidiaries in China and two state-owned enterprises in China, and found the following facts about the transfer of the Japanese production system (pp.181-188). First, the hardware aspect of the transferred Japanese production system differs greatly depending on the purpose of Japanese firms' entry into the country, whether it is

local sales-oriented or third-country or home country export-oriented. Second, if the willingness and long-term commitment to transfer the Japanese production system to the local factory is small, the possibility of transferring the Japanese production system to the local factory will be small. Third, if the Chinese managers lack a change mindset and the frontline workers are not supportive of the Japanese production system, the possibility of the Japanese production system taking root in the local factory will be small. Fourth, Chinese social and cultural factors, political and business factors, economic and business factors, and educational and skill factors may become obstacles to the transfer of the Japanese production system.

These studies argue that it is not possible to transfer the Japanese production system in a total and radical way, but with effort, it is possible to transfer parts of the Japanese production system in a gradual way. This kind of introduction and function of the Japanese production system in overseas factories also serves as an evidence that the Japanese production system is not a special one rooted in Japanese culture, but a rational and universal technological system rooted in logic.

For example, Yasumuro (1992) cites two pieces of evidence that Japanese production systems such as 5S are universal technical knowledge rather than being a product of Japanese culture: (1) overseas factories are practicing what is collectively called "Japanese factory culture," such as the 5S movement, and (2) foreigners are studying, understanding, and incorporating it into their production systems by arranging it in their own way (pp.66-67).

Yoshihara (2015) points out the universality of the Japanese production system based on the fact that (1) Japanese plants in the U.K. implemented Japanese work practices, (2) NUMMI, a joint venture between Toyota and GM, dramatically improved its production performance, and (3) Japanese plants in Asia implemented Japanese production systems and achieved high production performance (production cost, productivity, defect rate, etc.), and describes

such situations as "bright" plants (p.115, 155-156).

In addition, following the rapid progress of the Japanese automobile industry in the 1980s, foreign researchers who scientifically analyzed the production system of the Japanese automobile industry began to similarly report the technological universality of the Japanese production system. Womack et al. (1990) referred to the production system of the Japanese automobile industry "lean production" and asserted the universality of its basic idea (p.9).

Lean production is a production system with the following characteristics (ibid., p.13). First, it combines the advantages of both handmade and mass production, and overcomes the disadvantages of both, such as the high cost of handmade and the lack of flexibility in mass production. Second, it aims to assemble teams of workers with diverse abilities at all levels of the organization, and to use applicable automated machinery to produce the right amount of diverse products. From the perspective of the differences in management standards from "mass production" and the differences in organizational characteristics that support these standards, the book went on to present new system characteristics as standard characteristics that future industries should follow (Munakata, 1993; Munakata, 1996, p.64).

Thus, while domestic and foreign researchers reported on the applicability of the Japanese production system to overseas factories, a series of studies that investigated the actual situation on the largest scale and in the most systematic manner appeared. This is a group of studies using the "application and adaptation" model developed by Tetsuo Abo and his group (Abo ed., 1988; 1994; Abo et al., 1991; Itagaki ed., 1997; Kumon and Abo eds., 2005). In the next section, I will take up a representative study (Abo et al., 1991) and confirm the results of study.

2.3 An "application and adaptation" model for the international transfer of Japanese production systems

Abo et al. (1991) proposed a "dilemma model of application and adaptation" to understand the trade-off between the two aspects of the production system in Japanese American factories (p.17). They called the aspect that maximizes the advantages of the management and production system, which Japanese companies are best at, "application" on the one hand, and the aspect that forces the system to be modified to adapt to various local environmental conditions "adaptation" or "corrective application" on the other.

They classified the components of the Japanese production system into seven groups: I work organization and its management and operation, II production management, III parts procurement, IV sense of participation, V labor-management relations, VI parent-subsidiary relations, and VII relationship with the local community. In addition, the following 24 items were identified: (1) job classification, (2) wage system, (3) job rotation, (4) education and training, (5) promotion, (6) operation cheif in I work organization and its management and operation, (7) production facilities, (8) quality control, (9) maintenance, (10) operation management in II production management, (11) local content, (12) parts suppliers, (13) parts procurement method in III parts procurement, (14) small group activities, (15) information sharing, (16) all-in-one feeling in in Ⅳ sense of participation, (17) employment policy, (18) employment guarantee, (19) labor union, (20) grievance handling in Ⅴ labor-management relations, (21) ratio of Japanese employees, (22) authority of the local company, (23) status of local managers in Ⅵ parent-subsidiary relations, and (24) donations and volunteer activities in Ⅶ relationship with the local community.

For each of these 24 items, the authors proposed an analytical model that considers the production system in Japanese American factories as a "hybrid" of "application" and "adaptation" by rating each item as "5" when it is closest to the Japanese system and "1" when it is closest to the American system. Table 1 shows

Table 1 List of evaluation of the degree of application and adaptation of Japanese production systems in 34 Japanese American factories

	Automobile assembly	Automobile parts	Home Appliances	Semiconductor	All industries
Ⅰ Work organization and its management and operation (average)	3.1	3.1	2.4	2.9	2.9
① Job classification	4.8	4.2	2.8	2.7	3.7
② Wage system	2.1	2.6	2.0	3.1	2.4
③ Job rotation	3.2	2.7	2.1	2.6	2.6
④ Education and training	3.4	2.9	2.2	3.0	2.9
⑤ Promotion	3.2	3.3	2.7	3.1	3.1
⑥ Operation chief	3.1	3.0	2.6	2.7	2.9
Ⅱ Production management (average)	3.4	3.6	3.1	3.1	3.3
⑦ Production facilities	3.9	4.8	4.0	4.6	4.3
⑧ Quality control	4.0	3.9	3.0	2.4	3.4
⑨ Maintenance	2.9	2.8	2.1	2.6	2.6
⑩ Operation management	2.9	3.0	3.3	2.9	3.0
Ⅲ Parts procurement (average)	3.0	3.0	2.6	3.7	2.7
⑪ Local content	2.3	2.7	2.0	3.7	2.7
⑫ Parts suppliers	3.8	3.7	3.6	4.4	3.9
⑬ Parts procurement method	3.0	2.6	2.1	2.3	2.5
Ⅳ Sense of participation (average)	3.9	3.8	2.3	2.9	3.2
⑭ Small group activities	2.7	2.9	2.2	2.4	2.5
⑮ Information sharing	4.4	4.1	2.4	3.3	3.6
⑯ All-in-one feeling	4.6	4.4	2.1	2.9	3.5
Ⅴ Labor-management relations (average)	4.2	4.1	2.7	3.5	3.6
⑰ Employment policy	4.3	3.8	2.4	3.1	3.4
⑱ Employment guarantee	4.9	3.8	2.2	2.3	3.4
⑲ Labor union	4.2	5.0	3.4	5.0	4.4
⑳ Grievance handling	3.2	3.9	2.8	3.6	3.3
Ⅵ Parent-subsidiary relations (average)	3.5	4.2	3.0	3.9	3.6
㉑ Ratio of Japanese employees	3.8	4.6	2.6	3.9	3.7
㉒ Authority of the local company	3.3	4.0	3.2	4.0	3.6
㉓ Status of local managers	3.3	4.0	3.2	3.9	3.6
Average	3.5	3.6	2.7	3.2	3.3
Ⅶ Relationship with the local community (average)	1.8	2.0	2.7	2.8	2.3
㉔ Donations and volunteer activities	1.8	2.0	2.7	2.8	2.3

Source: Abo et al. (1991, p.67, Table 3-A-3).

Table 2 Items of the four aspects evaluation

	Direct	System
People	People-Direct	People-System
	㉑ Ratio of Japanese employees	① Job classification
	㉓ Status of local managers	② Wage system
		③ Job rotation
		④ Education and training
		⑤ Promotion
		⑥ Operation chief
		⑭ Small group activities
		⑮ Information sharing
		⑯ All-in-one feeling
		⑱ Employment guarantee
		⑳ Grievance handling
Things	Things-Direct	Things-System
	⑦ Production facilities	⑧ Quality control
	⑪ Local content	⑨ Maintenance
	⑫ Parts suppliers	⑬ Parts procurement method

Source: Abo et al. (1991, p.55, Table 2-3).

the results of this analysis. Table 1 shows the results of the survey on the degree of application and adaptation in 34 Japanese American factories.

Furthermore, Abo et al. (1991) conducted a "four aspects evaluation" to distinguish and analyze the differences in the two aspects of (1) "bringing in" of "ready-made" products from Japan and (2) transplantation as a "system". The four aspects are "people-direct," "things-direct," "people-system," and "things-system" (pp. 55-57).

The first, "people-direct," refers to the dispatch of human resources trained in Japan to a local site to complement various local management functions, and the second, "things- direct," refers to the dispatch of parts and materials from Japan to a local site based on the premise of the "ready-made" production equipment system and operational know-how established in Japan and the parts procurement system established in Japan. The third "people-sysytem" is to transplant the human management "method" of Japanese management and Japanese production system to the local market, and the fourth "things-system " is to transplant the physical management "method" of Japanese management and Japanese production system to the local market.

Among the above 23 items of the Japanese production system except for the (24) donation and volunteer activities, they identified "people-direct" as (21) the ratio of Japanese employees and (23) the status of local managers, and "things-direct" as (7) the production facilities, (11) local content, and (12) parts suppliers. As for "people-system," all the items of "I Work organization and its management and operation" and "IV sense of participation," and two items of "V Labor-management relations," (18) employment guarantee and (20) Grievance handling were considered. Table 2 shows the relationship between them.

Based on the above analysis, Abo et al. (1991) obtained the following empirical results (pp.235-236): First, Japanese American factories as a whole operate with about a 50-50 ratio of elements of the Japanese and American production systems; second, by industry, the degree of application is highest in auto parts

and auto assembly, almost average in semiconductors, and lowest in consumer electronics; and third, the degree of application of "people-direct" and "things-direct" is high, and the degree of application of "people-sysytem" and "things-system" is low. In other words, while Japanese firms tend to bring in "ready-made" elements of production systems from Japan, they tend not to bring in "system" elements.

In short, Abo et al. (1991) found the following important facts: (1) Japanese parent factories are only partially able to transfer Japanese systems to their U.S. subsidiaries, (2) the transfer of Japanese production systems varies from industry to industry even among Japanese firms, and (3) "ready-made things" such as production equipment are easy to transfer, while "systems" such as institutions are difficult to transfer.

However, as with all research, their research naturally has its limitations. Ihara (2009) points out that one of the limitations of Abo et al. (1991) is that their research method relies on a one-day survey (Ihara, 2009, pp.17-18). Abo (1991) conducted a large scale and systematic study, and revealed some unique facts about the international transfer of Japanese production system, which is unrivaled by other studies. However, as Cho (1994) argues, if technology transfer is a phenomenon that is carried out step by step, it might have produced different research results if it had been possible to follow a single phenomenon over time and use case studies to confirm the causal relationship among them.

However, in a sense, this request is asking for the best. As the researcher's research resources are limited, it is not possible to carry out the research using all the methodologies. In any case, this study would like to confirm here that Abo et al. (1991) made a significant contribution to the study of the vertical transfer of production technology systems from parent factory to overseas factories in Japanese firms.

3 Mather factory system

Research on the international transfer of the Japanese production system reached its peak in the 1990s, and since the 2000s, a new trend has emerged to replace the conventional research: research on the mother factory system. Until the 1990s, the focus of research on the international transfer of the Japanese production system was mainly on overseas factories. In other words, it was to clarify the question of how to introduce production technology systems. The research focus was on the problems on the introduction side of the production technology system.

However, in the 2000s, the focus of research on the international transfer of production technology systems of Japanese firms rapidly shifted to the supply side, i.e., the parent factory in the home country. There are several reasons for this shift in the focus of research.

The first is the further growth of Japan's overseas production ratio. The overseas production ratio of Japanese manufacturing firms has been growing steadily from 26% in FY2002 to 36.8% in FY2018 (Japan Bank for International Cooperation, 2019). In short, the number of overseas factories has increased dramatically since the 2000s compared to the 1990s and before.

The second is the reorganization of Japan's domestic production. Japanese companies have reorganized and restructured their domestic production bases in response to the shrinking domestic market. In some cases, the parent factory in Japan stopped production altogether and transferred the entire production process to the overseas factory (Oki, 2014).

Third is the institutional fatigue of the mother factory system. Japanese companies have been effectively transferring their production technology system, which is a competitive advantage in their home country, to overseas by utilizing the mother factory system. However, with the rapid increase in the number of overseas production bases, the generous technology transfer through

the mother factory system has become a heavy burden.

As a result, the problem of how to transfer the production technology system to the rapidly increasing number of overseas factories has come to be the focus of attention. In this section, this study will review the previous studies on the mother factory system and confirm their findings.

The views of the research on the mother factory system can be divided into two categories. The first is the research that considers the mother factory system statically and focuses on the functions of the mother factory system. The second is the research that takes a dynamic view of the mother factory system and focuses on the changes in the mother factory system.

3.1 Staticism for mother factory system

First, this study will review the research on the mother factory system from a static perspective. Nakayama (2003) paid attention to the mother plant system, which is used as a measure of technical support by Japanese companies to their overseas subsidiaries, and investigated how Japanese automobile companies such as Toyota, Mazda, Nissan, and Honda provide technical support to their transplants (overseas factories).

Nakayama (2003) defines the "mother factory system" as "a method of support centered on dispatching personnel, which serves as the model plant and contact point when the home manufacturer provides technical support to its overseas production factories, dispatches engineers and managers who are suitable for the local market, and provides on-site guidance." (p.35), and further divides it into three categories: "mother factory system in a narrow sense," "mother factory system in a broad sense," and "non-mother factory system".

The mother factory system in a narrow sense is a support method in which "the supporting factory is specified in advance and provides exclusive support to the target transplant when the need for support arises from a decision made by the head office in addition to requests for support from the local site" (ibid., p.37). In

a broader sense, the mother factory system refers to a support method in which "a factory is not usually positioned as a support factory, and even if a support factory is not decided at the stage of support generation, it receives the intention of the head office, and (the overseas factory) acts as a contact point or a support factory at the stage of implementation" (p.37). The non-mother factory system refers to "the case where the support system is not taken as a factory unit".

The results of the study were as follows: Honda was the only company that adopted the mother factory system in a narrow sense, Toyota and Mazda adopted the mother factory system in a partial or limited sense, and Nissan adopted the non-mother factory system (ibid, pp.51-52). Nakayama (2003) found that the determinants of these types of companies were the accumulation of strategic decisions made by each company.

Yamaguchi (2006) conducted research on the "organizational capabilities that enable the transfer of advantage from the home parent company to overseas subsidiaries" (p.1) of multinational companies, particularly focusing on the organizational capabilities related to the international transfer of production systems of Japanese multinational manufacturing companies. He focused on the "mother factory system". According to the his work, a mother factory is "a large-scale organizational unit that plays a central role in the technology transfer strategy of a parent company by acting as a technology transfer center, receiving human resources from overseas, training them, and developing manufacturing technologies that can be easily operated overseas" (p.127). The mother factory system refers to "the organizational capability that enables the transfer of various organizational routines accumulated in the mother factory" (p.137).

Yamaguchi (2006), based on data obtained from 199 companies that may be engaged in manufacturing activities overseas, argues that the mother factory system (1) functions as a place where organizational routines stored in the form of tacit knowledge are communicated, (2) as an entitiy that transforms tacit knowledge into formal knowledge for the overseas factory, and (3) as a

function that creates a place to share tacit knowledge in the overseas factory by dispatching employees to the overseas factory (p.137, 240).

In addition, he found that (1) the role of the mother factory side in the mother factory system of Japanese companies is much larger than that of foreign companies; (2) as overseas factories accumulate organizational routines, the transfer of organizational routines based on the "transfer capability" of the mother factory decreases, and the transfer of organizational routines based on the "absorption capability" of the overseas factory functions increases; and (3) the transfer of high-level organizational routines that explain why the production system is constructed increases, the evaluation of the headquarters management for the overseas factory raises, and provides an opportunity for the overseas factory to become the mother factory for another factory (ibid., pp.240-241).

These reseraches take a static view of the mother factory system and do not assume that the mother factory system will change. This is probably because they were studying the mother factory system at a time when the burden of technical guidance and technology transfer on mother factories was not yet so great, and MNCs did not need to modify the mother factory system so much. It should be noted that the main concern of the research on the mother factory system at this stage was the vertical transfer of the production technology system from the home parent factory to the overseas factories.

3.2 Dynamicism for mother factory system

However, in the 2000s, as the ratio of overseas production by Japanese companies increased and the burden of technology transfer and technical guidance on the mother factory system became unbearably large, more and more studies began to discuss the mother factory system from a dynamic perspective.

For example, Yoshimoto (2011) argued against the fact that Nakayama (2003) and Yamaguchi (2006) focused solely on the "mass production function" as the

function of the mother factory, and developed a discussion of the mother factory system with the operation control function as the main axis. The operation control function is a function that controls, evaluates, and supports the direction of each mass production base of the same product business (Yoshimoto, 2011, p.7).

Yoshimoto (2011) divided mother factories into three types as follows. There are three types of mother factories: "pure mother factories" that have both operation control functions and mass production functions, "so-called mother factories" that have only operation control functions but no mass production functions, and "key factories" that have only mass production functions but no operation control functions (Yoshimoto, 2011, p.8).

The paper argues that, in the Czech factories of Japanese electronics companies, (1) for room air conditioner production bases, the Japanese mother factory serves as a model for management and evaluation from start-up to operation, and (2) For the compressor plant, the compressor plant in Thailand will serve as a model for operations and provide technology transfer and support. In particular, the latter Thai plant played the role of a "so-called mother base," and the paper revealed that the Thai subsidiary transferred its production technology system horizontally to the Czech plant.

Oki (2014) studied the mechanism by which the withdrawal of the home country's mass production activities hindered the capacity building of the overseas subsidiaries, and the mechanism by which the maintenance of the home country's mass production activities promoted the capacity building of the overseas subsidiaries. The results of the study are as follows (ibid., pp.177-181).

First, the absence of mass production activities from the home base affects the home base's knowledge of mass production and prevents the home base from supporting the improvement and formation of routines in foreign subsidiaries. Second, if the dynamic mass production knowledge to form new routines exists at the home base, a new advantage can be created by leaving mass production

activities at the home base and encouraging the formation of new routines through competitive pressure. Then, by transferring this new advantage to the foreign subsidiary, the Japanese firm can support the capacity building of the foreign subsidiary. Third, the home base of Japanese firms has an advantage over overseas subsidiaries in mass production activities, especially in improvement activities that require dynamic mass production knowledge. In addition, the home base maintains a system to share knowledge with overseas subsidiaries. Fourth, the home base does not engage in mass production activities by itself, but instead collects information and know-how from overseas subsidiaries that are engaged in mass production activities, thereby creating a system that can be called a "knowledge-intensive mother " that concentrates mass production knowledge at the home base. By adopting this system, the home base can continue to promote improvements and problem solving at overseas subsidiaries even after the home base withdraws from mass production activities.

Nakagawa (2012) argued that the generous support and transfer of technology through the mother factory system of Japanese companies places an excessive burden on the parent factory in the home country, which in turn hinders the smooth transfer of the production technology system. The paper analyzes the case of Daikin's air conditioner business, which has achieved a certain degree of success in solving this problem, and seeks a new production organization to replace the mother factory system.

Daikin Industries, which has been experiencing a turnaround in its business since the late 1980s, began to suffer from the introduction of too many new lines and new models in the 2000s. In 2003, Daikin Industries introduced a mother factory system to provide continuous technical support to its overseas manufacturing bases, but this technical support resulted in a shortage of human resources in the home country, putting pressure on the parent factories in the home country. In response, Daikin Industries encouraged its overseas factories to become independent, while the parent factory in the home country took on

the role of nurturing the overseas factories until they became independent and developing core technologies and base model products based on the needs gathered from overseas business bases. The parent factory in the home country no longer provides hand-holding and guidance to the overseas factories.

Suh (2014) studied the structure, function, and formation mechanism of global knowledge networks in multinational companies through the case studies of Toyota Motor Corporation and Hyundai Motor Company. The results of the study are as follows (p.209). (1) Toyota's knowledge is difficult to transfer and Hyundai's knowledge is easy to transfer. (2) Toyota's knowledge was generated at each plant in its home country and used in a decentralized network, while Hyundai's knowledge was concentrated in its production technology research center in its home country and used in a decentralized network. Toyota transferred knowledge overseas through its mother factory system, and Hyundai transferred knowledge overseas through its model factory system. Toyota's Global Production Center (GPC) and Production Research Office provided technical support to the mother factories during the period of rapid growth of overseas factories.

Thus, in the 2010s, several studies have pointed out that the mother factory system changes in response to the rapid increase in overseas factories. For example, "mother bases" that dropped mass production functions from pure mother factories (Yoshimoto, 2011), "knowledge-intensive mothers" that abandon mass production activities (Oki, 2014), mother factories that specialize in the development of core technologies and products (Nakagawa, 2012), and GPCs and Production Research Offices that support mother factories (Suh, 2014) are found. It can be said that these are measures to increase the production technology capacity of overseas subsidiaries while reducing the workload of the parent factory in the home country. However, they are still part of the system of transferring the production technology system from the parent factory in the home country.

On the other hand, it is also an important discovery that some overseas factories have begun to transfer their production technology systems horizontally to other countries in a way that is coexistent with the mother factory system. International horizontal transfer refers to the transfer of technology from one overseas factory of a multinational corporation to another overseas factory in another country. For example, the Thai plant of a Japanese electronics company in the compressor business transferred its production technology system to the Czech plant (Yoshimoto, 2011), and the Kentucky plant of Toyota Motor Corporation in the United States became the mother plant of the Mexican plant and transferred its production technology system (Suh, 2014, p.208). These facts mean that the transfer of production technology systems from the parent factory in the home country to the overseas factories, i.e., vertical transfer, is not enough to provide technical support to the rapidly increasing number of overseas factories, and some multinational companies have responded by using international horizontal transfer of production technology systems as well. This means that some multinational companies are now responding to the rapid increase in the number of overseas subsidiaries by using international horizontal transfer of production technology systems.

4 Conclusion

In this paper, we have reviewed the studies on technology transfer in Japanese multinational manufacturing companies since the 1980s. The overview did not cover the entire technology transfer in Japanese MNCs, but focused on the changes in the relationship between the parent factory in home country and its overseas factories. As a result, this study has obtained the following perspectives on the study of technology transfer in Japanese MNCs.

First, it is expected that the interest of technology transfer research in Japanese MNCs is shifting from vertical transfer to international horizontal

transfer. This study first focuses on the international transfer of the Japanese production system, which was mainly conducted by Japanese researchers, and confirms their research results. Since the Japanese production system was understood as a part of the Japanese management and the Japanese management was thought to be rooted in the unique culture of Japan, it was thought to be difficult to transfer the Japanese production system to foreign countries with different cultures. However, in the 1980s, the number of cases in which Japanese production systems were successfully transferred internationally increased, and the technical rationality and universality of Japanese production systems came to be emphasized. The international transfer of the Japanese production system is characterized by the partial transfer of the Japanese production system and the shading of the international transfer by industry, and it has become clear that component-by-component analysis and industry-by-industry analysis are necessary.

This study then outlines the research on the mother factory system as a new trend in the research on the international transfer of the Japanese production system. The research on the mother factory system in the 2000s did not assume changes in the mother factory system, but the research on the mother factory system in the 2010s and after will assume changes in the mother factory system. This is because the number of overseas factories of Japanese multinational manufacturing companies has increased rapidly since the 2000s, and the pressure on overseas factories to provide technical support from their home country parent factories has become higher than ever before.

In response to the increasing pressure of technological support to overseas subsidiaries, Japanese MNCs have developed two methods: one is to reduce the transfer of production technology systems by narrowing the area of responsibility of the home parent or encouraging the independence of overseas subsidiaries, and the other is to transfer production technology systems from other overseas subsidiaries horizontally without reducing the transfer

of production technology systems. It became clear that two methods were being developed to cope with the situation. At this stage, it is confirmed that the significance of conducting research on international horizontal transfer of production technology systems has increased.

Second, the interest of technology transfer research in Japanese MNCs remains in "learning on the part of the technology recipient (taught) ". Most of the studies have focused on the vertical transfer of production technology systems (i.e., the transfer of production technology systems from the parent factory to its overseas factories), and have focused on "learning to accept (or be taught) technology," i.e., how effectively and efficiently the overseas subsidiaries learn the production technology systems of their parent factories. This is natural, since the main purpose of technology transfer is to develop the entity who receive (or are taught) the technology.

However, technology transfer is a management phenomenon that can be realized through the interaction between the two parties, and it can only be realized when there is a party that teaches the technology and a party that receives the technology. It is not only those who accept (are taught) technology that learn technology, but also those who supply (teach) technology should learn technology. However, previous studies have paid little attention to the "learning on the part of those who supply (teach) technology". In the study of technology transfer, paying attention to the learning on the part of those who supply (teach) the technology and elucidating the mechanism may be a promising research topic.

In the study of technology transfer in Japanese MNCs, one of the promising research topics is to analyze the international horizontal transfer of production technology systems from the perspective of "learning on the part of technology suppliers". In the future, the author will conduct research based on this idea[5].

5 Some of the research results are reported in Fujioka (2020; 2021).

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