Chapter 2
The Mother Plant in Japan and Its Transplant in the United States

2.1 Research Questions

Utilizing similar automatic transfer machine systems and similar parts, the J mother plant in Japan and the JA transplant in the United States have manufactured the same standard type of car component. This chapter analyzes how productivity and work practices (i.e., production workers' skills, assistant first-line supervisors' control, and manufacturing engineers' roles) at the J mother plant and the JA transplant changed from the mid-1990s to the early 2010s. How different were productivity and work practices at the JA transplant from those at the J mother plant?

My previous research (Shibata 2001) clarified the productivity gaps that existed between the J mother plant and the JA transplant in the mid-1990s. The operating rate at the JA transplant, on average, was lower by more than 10 % than the operating rate at the J mother plant from 1992 to 1997. Specifically, operating rates were 71 % at the JA transplant and 83 % at the J mother plant in 1997. Did productivity at the JA transplant approach productivity at the J mother plant in the early 2010s?

These operating rate gaps in the mid-1990s resulted mainly from differences in the troubleshooting and maintenance skills possessed by production workers, maintenance workers, and assistant first-line supervisors (team leaders) at the J mother plant and the JA transplant. Production workers at the J mother plant maintained production skills that were integrated with some mechanical troubleshooting skills. In contrast, production workers at the JA transplant resolved few production problems. Did production workers at the JA transplant improve their troubleshooting skills and participate in solving problems on the shop floor in the early 2010s?

Assistant first-line supervisors with strong troubleshooting skills at the J mother plant effectively controlled the skill formation of production workers based on the

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trusting relationships they had with production workers and they protected production workers from some unreasonable orders from upper management in the mid-1990s. Many of the team leaders were not promoted from within the JA transplant and had lower level troubleshooting skills than did the assistant first-line supervisors at the J mother plant. Because production workers at the JA transplant voluntarily transferred to other jobs by exercising rights they had in the seniority-based job-bid systems, the team leaders at the transplant were not able to control the skill formation of production workers. Did the team leaders at the JA transplant do a better job of promoting skill formation and limiting job transfers of production workers in the early 2010s? That is one of the questions answered in this chapter.

Other previous research of mine (Shibata 2009) examined the roles of manufacturing engineers at Japanese plants including the J mother plant. While effectively linking with product design engineers, production supervisors, and production workers, manufacturing engineers at the J mother plant and the headquarters of the J firm were extensively involved in the design of production lines, production method development, production preparation, and production improvement. Were the roles of American manufacturing engineers at the JA transplant similar to the roles of Japanese manufacturing engineers at the J mother plant in the early 2010?

This chapter compares the control assistant first-line supervisors exercised at the J mother plant with the role played by production workers' individual choices at the JA transplant. How did the resulting work practice differences affect plant productivity in the early 2010s?

2.2 Research Method

I conducted pre-research at the J mother plant in Japan for 2 days in March 2010 and intensive research for 1 week in July 2010; and pre-research at the JA transplant in the United States for 1 day in November 2009 and intensive research for 1 week in August 2010. Like my previous research in the mid-1990s, I used the following research methods at both plants in 2010: participant observation, qualitative interviews, and the gathering of hard unpublished data. Following advice concerning qualitative research methods provided by Glaser and Strauss (1967), Harlan and Robert (1998), and Zetka (1998), I interviewed various groups of employees.

At the J mother plant in Japan, I conducted in-depth and structured interviews with 33 managers/employees in total: a general manager who controlled the plant, a plant manager, five production division (section) managers, three manufacturing engineering managers, two machinery and tools managers, three maintenance managers, a personnel manager, three first-line supervisors, three assistant first-line supervisors, ten production workers, and a union executive who was in charge of the J mother plant. At the JA transplant in the United States, I had in-depth and structured interviews with 32 managers/employees in total: the Japanese president of the American subsidiary firm of the parent firm whose responsibilities included oversight of the JA transplant, a Japanese plant manager, two American assistant plant managers, two American and one Japanese production division (section) managers, two American and one Japanese manufacturing engineering managers, one American and two Japanese machinery and tools managers, one American and one Japanese maintenance manager, one American and one Japanese personnel manager, a Japanese business planning manager, two American first-line supervisors, two American team leaders, and ten American production workers (experts). The JA transplant was not organized by unions.

These managers and supervisors, half of the production workers interviewed at the J mother plant and the JA transplant, and the union executive at the J mother plant were selected by the plant managers at both plants. The rest of the production workers were chosen randomly from among various workers, such as those with high or low skills. Walking among the production division (section) managers, manufacturing engineering managers, machinery and tools managers, and assistant and first-line supervisors (team leaders) at the J mother plant and the JA transplant, I asked them questions about the changes occurring at the workplaces, specifically about productivity, production workers' skills, assistant first-line supervisors' control, and manufacturing engineers' roles from the mid-1990s to 2010. My previous research at the J mother plant and the JA transplant did not include analysis of manufacturing engineers' roles. Therefore, in this research I asked manufacturing engineering managers at both plants about manufacturing engineers' roles, skills, career development, and organizations. Visually inspecting many machines at both plants, I was granted many clarifications concerning the functioning of the production machines, jigs (fixtures), tools, and dies from the manufacturing engineering managers. In addition, in July 2010 and June 2011, I interviewed nine former Japanese managers and supervisors: a general manager, two production division (section) managers, three first-line supervisors, and two assistant first-line supervisors of the J mother plant, and the Japanese president of the American subsidiary firm of the parent firm, whose responsibilities included oversight of the JA transplant (Table 2.1).

After my research at the J mother plant and the JA transplant in 2010 and 2011, I conducted follow-up research by visiting the J mother plant in 2014, by meeting former managers (supervisors) of the JA transplant in 2014, and by calling and sending electronic mails to the incumbent/former managers (supervisors) of both plants from 2012 to 2014. Finally, I had discussions with the incumbent/former Japanese managers and supervisors of the J mother plant and the JA transplant concerning the changes of productivity and work practices at the J mother plant and the JA transplant from the mid-1990s to the early 2010s, the differences between both plants, and the causes for the differences.

Table 2.1 Numbers of managers and employees interviewed, 2009–2011

	J Mother Plant		JA Transplant		
	Number		Number		Nationality (Number)
	Incumbent	Former	Incumbent	Former	
General manager (president)	1	1	1	1	Japanese (2)
Plant manager	1		1		Japanese (1)
Assistant plant manager	[a]		2		American (2)
Production division/section manager	5	2	3		American (2)/ Japanese (1)
Manufacturing engineering manager	3		3		American (2)/ Japanese (1)
Machinery and tools manager	2		3		American (1)/ Japanese (2)
Maintenance manager	3		2		American (1)/ Japanese (1)
Personnel manager	1		2		American (1)/ Japanese (1)
Business planning manager	0		1		Japanese (1)
First-line supervisor	3	3	2		American (2)
Assistant first-line supervisor (team leader)	3	2	2		American (2)
Production worker (expert)	10		10		American (10)
Union executive	1		[a]		
Total	33	8	32	1	

Note The J mother plant is located in Japan; the JA transplant in the United States
[a]The J mother plant has no assistant plant managers, whereas the JA transplant has no unions

2.3 Overview of Plants Researched

The J firm began producing the car component at the Japanese headquarters' plant in 1962. The firm opened the J mother plant in 1967 and moved its production from the headquarters' plant to the J mother plant. The JA transplant in the United States commenced producing the car component in 1990.

The organizational structure at the J mother plant consisted of a plant manager, division/section manager, first-line supervisor, assistant first-line supervisor, and group leader. All of the first-line supervisors, assistant first-line supervisors, and group leaders were union members at the J mother plant, like at many other large Japanese manufacturing firms. The Japanese supervisors at the J mother plant played dual roles of management member and union representative, roles which are quite different from American supervisors' roles (Shibata 1999). Management and the enterprise union at the J mother plant have long maintained cooperative relations.

The management hierarchy at the JA transplant included a plant manager, assistant plant manager, division/section manager, first-line supervisor, and team leader. Contrary to the J mother plant, the JA transplant had assistant plant managers and no group leaders. All managers and supervisors at the transplant were exempt employees, whereas team leaders and workers were not exempt employees. The United Auto Workers union (UAW) tried unsuccessfully to organize workers at the JA transplant in 2006 and 2009.

Most interesting from the mid-1990s and the early 2010s were both the increase in middle-aged supervisors and workers at the J mother plant in Japan and the localization of the management at the JA transplant in the United States. The J mother plant and two other plants in the same area composed a car component complex (J complex). Table 2.2 shows the age distribution of assistant and first-line supervisors and workers at the J complex in 1994 and 2010.[1] Almost all assistant and first-line supervisors and regular workers at the J firm in Japan begin their careers as workers, right after graduating from high school. Assistant and first-line supervisors tend to leave supervisory positions at the age of 55. In the mid-1990s, all of the employees at the J firm in Japan were mandatorily retired at 60 years of

Table 2.2 Age distributions of supervisors and workers, J Complex,[a] 2010 versus 1994 (%)

Age	First-line supervisors	Assistant first-line supervisors	Workers[b]	Total
60+	0.0[c] (0.0)[d]	0.0 (0.0)	3.0 (0.0)	3.0 (0.0)
55–59	0.0 (0.0)	0.0 (0.0)	10.7 (4.8)	10.7 (4.8)
50–54	0.8 (1.8)	1.7 (1.8)	10.7 (2.3)	13.2 (5.8)
45–49	2.3 (1.3)	2.4 (3.2)	12.2 (2.6)	16.9 (7.1)
40–44	1.7 (0.6)	4.5 (4.4)	14.0 (6.9)	20.2 (11.9)
35–39	0.0 (0.0)	1.1 (0.5)	14.7 (10.2)	15.7 (10.6)
30–34	0.0 (0.0)	0.0 (0.0)	4.8 (18.4)	4.8 (18.4)
25–29	0.0 (0.0)	0.0 (0.0)	3.7 (22.3)	3.7 (22.3)
20–24	0.0 (0.0)	0.0 (0.0)	9.0 (10.3)	9.0 (10.3)
18–19	0.0 (0.0)	0.0 (0.0)	2.9 (8.7)	2.9 (8.7)
Total	4.7 (3.7)	9.7 (9.8)	85.6 (86.5)	100.0 (100.0)

Source Unpublished documents of the J complex
[a]The J complex includes the J mother plant
[b]Although the J complex had no contingent production workers in 1994, the indicated number of workers in 2010 includes regular and contingent production workers
[c]Number in 2010
[d]Number in 1994

[1]The manager who provided me with these data stated that the age distribution at the J mother plant was similar to the age distribution at the J complex.

age. However, in the mid-2000s, the mandatory retirement age was raised from 60 to 65 years, due to the change in the pension system. Employees who want to continue to work after the age of 60 enter into annual employment contracts with the J firm.

At the J complex, the ratio of assistant and first-line supervisors and workers who were over 45 years old, in total, increased from 17.7 % (in 1994) to 43.8 % (in 2010). By contrast, the ratios of young workers drastically declined: the percentage of workers between 25 and 29 years old declined from 22.3 % (1994) to 3.7 % (2010), and the percentage of workers between 18 and 19 years old declined from 8.7 % (1994) to 2.9 % (2010). The main causes for the decline in the percentage of young workers were both the transfer of manufacturing by the J complex to its foreign transplants and the introduction of automatic transfer machine systems at the complex. Nevertheless, as some of the managers stressed, the ratios of relatively young assistant and first-line supervisors slightly increased: from 0.5 % (in 1994) to 1.1 % (in 2010) among assistant first-line supervisors between the ages of 35 and 39 years, and from 0.6 % (1994) to 1.7 % (2010) among first-line supervisors between 40 and 44 years old. In contrast, the ratio of first-line supervisors who were between 50 and 54 years old declined from 1.8 % (1994) to 0.8 % (2010).

At the JA transplant in the United States, management led by Japanese expatriates in 1990 was replaced by management controlled by American managers in 2010. When the JA transplant began producing the car component in 1990, most of the management positions were occupied by the Japanese expatriates from the J mother plant in Japan. In addition, 60 Japanese employees, many of whom were production employees and manufacturing engineers, were sent from the J mother plant to the JA transplant for a few months.[2] Although the JA transplant retained three American division/section managers in 1996, the Japanese plant manager and 25 Japanese expatriates (including production, maintenance, manufacturing engineering, and machinery and tools managers) played main roles at the JA transplant. Many Japanese employees who were temporarily dispatched from the J mother plant to the JA transplant executed troubleshooting and setting up machines.

In 2010 as well as 1996, management positions of both the president of the American subsidiary firm of the parent J firm and the plant manager were occupied by Japanese expatriates. Yet, according to the Japanese plant managers' analyses and my participant observation, two American assistant plant managers and three American production division/section managers actually controlled the workplaces. One Japanese production division manager and 11 Japanese expatriates supported the American managers (Table 2.3). Only when severe production problems occurred, such as machine or die malfunctions which resulted in sustained low productivity, were some Japanese visiting employees sent to help out at the J transplant for a few weeks. After the 2008 economic crisis, the number of the

[2]Young production workers, who were in their late 20s and held high school diplomas, were included in the temporarily dispatched employees. Some of the young production workers with high troubleshooting skills remarkably improved their English language ability while temporarily working at the JA transplant.

Table 2.3 Numbers of managers and expatriates, JA Transplant, 2010 versus 1996

	2010	1996
	Number (Nationality)	Number (Nationality)
President (Subsidiary firm including the JA transplant)	1 (Japanese)	1 (Japanese)
Plant manager	1 (Japanese)	1 (Japanese)
Assistant plant manager	2 (American)	–
Production division (section) manager	3 (American) 1 (Japanese)	3 (American)
Expatriate	11 (Japanese)	25 (Japanese)

Source Unpublished documents of the JA transplant

Japanese expatriates and visiting employees was distinctively cut back. Yet some American team leaders whom I interviewed at the JA transplant did not like the fact that management at the JA transplant reduced the number of the Japanese expatriates and visiting employees. This was mainly because the Japanese expatriates and visiting employees possessed higher troubleshooting skills than did the American engineers and supervisors at the transplant. The American team leaders stressed that the Japanese expatriates and visiting employees were indispensable for improving productivity at the JA transplant.

2.4 Productivity Differences

Before the JA transplant in the United States began producing the car component in 1990, management at the J mother plant in Japan did not fully grasp the extent of the lower skill level of American production workers. Consequently, the automatic transfer machine systems utilized at the J mother plant, which require production workers with high skills, were transferred to the JA transplant. Hence, in the mid-1990s, despite utilizing exactly the same automatic transfer machine systems and similar parts to manufacture the same car components, the average operating rate of the production line at the JA transplant was lower by more than 10 % than the operating rate at the J mother plant (Shibata 2001). According to the Japanese production managers at the J mother plant, the operating rate was one of the important productivity indexes used at the J mother plant and the JA transplant. The actual number of car components manufactured per hour was divided by the planned hourly production quantity. This was defined as the operating rate at both plants. The planned hourly production quantities (assuming no stoppages of production lines) have been the same at the J mother plant and the JA transplant.

The standard type of car component produced in the mid-1990s was replaced by the new standard type of car component at the J mother plant in 2002 and at the JA transplant in 2003. The new standard type of car component was more compact, powerful, and relatively lower priced than the previous car component. The Japanese manufacturing engineers at the headquarters and at the J mother plant developed more efficient automatic transfer machine systems for the new car component than the previous automatic transfer machine systems. The new machine systems included more compact and lower-in-height (under 1.5 m high) production machines and robots. The J mother plant introduced the new automatic transfer machine systems in 2002. Although the lower-in-height production machines and robots enabled production supervisors and managers to control more easily the production workplaces and workers, it was more difficult for production workers to operate the compact production machines and robots.

The Japanese manufacturing engineers at the J mother plant modified the new automatic transfer machine systems in order to introduce them at the JA transplant in 2003. Some American manufacturing engineers at the JA transplant partially participated in the process of modifying the automatic transfer machine systems. Unlike in the mid-1990s, the automatic transfer machine systems introduced at the JA transplant in 2003 were similar—if not exactly the same—to those introduced at the J mother plant in 2002. The automatic transfer machine systems at the JA transplant were somewhat easier to operate than those at the J mother plant. This was mainly because management at the J mother plant and at the JA transplant (specifically Japanese manufacturing engineers) judged that the skill level of the American production workers at the JA transplant, on average, did not yet reach the skill level of Japanese production workers at the J mother plant. Due to the fact that the JA transplant did not deploy the same automatic transfer machine systems as at the J mother plant, operating rates after 2003 may not indicate productivity differences between the two plants as accurately as operating rates in the mid-1990s. The operating rates at the JA transplant improved in 2008, 2009, and 2010 and were only 2–4 % lower than the operating rates at the J mother plant (Table 2.4). Specifically, the operating rate at the J transplant increased from 71 % (in 1997) to 76 % (in 2003) and 80 % (in 2010). In contrast, the operating rate at the J mother plant slightly decreased from 83 % (1997) to 80 % (2002) and 82 % (2010).

For around 10 years after the JA transplant started its operation in 1990, the operating rate index was used to evaluate and compare productivity at the JA

Table 2.4 Annual average operating rates[a] of production lines, 1992–2010 (%)

	1992	1996	1997	2002/2003[b]	2008	2009	2010
JA transplant (in United States)	72	67	71	76	77	78	80
J mother plant (in Japan)	82	84	83	80	81	82	82

Source Unpublished documents of the JA transplant and the J mother plant
[a]Operating rate = Actual hourly production quantity/planned hourly production quantity (×100)
[b]Starting years of producing of new products utilizing new automatic transfer machine systems (J mother plant in 2002, JA transplant in 2003)

transplant to productivity at the J mother plant. Although operating rates at the JA transplant were lower by more than 10 % than those at the J mother plant in the 1990s, operating rates at the JA transplant were improved in the late 2000s. This led management at the J mother plant to not analyze the causes for operating rate gaps between the J mother plant and the JA transplant in the early 2010s as thoroughly as in the mid-1990s.

Rather, management at the J mother plant and the JA transplant shifted their interest in production performances from operating rates to total productivity, which includes an accounting for the production system's ability to cope with changes in production volumes and product variety. As explained in Chap. 1, management of the JA transplant has responded less to large changes in production volumes and product variety of the car component. The JA transplant has often relied on the J mother plant for these changes. Therefore, the J mother plant manufactured greater volumes of the car component instead of the JA transplant. Regarding product variety, as of August 2010, the JA transplant produced 25 different types of a standard car component per day, whereas 50 different types of the same standard car component were produced at the J mother plant. As a result, the Japanese managers whom I interviewed at the J mother plant and at the JA transplant stressed that the total productivity at the JA transplant was 10 % lower at the J transplant in the early 2010s than that at the J mother plant.

2.5 The Japanese Mother Plant

2.5.1 The Reinforcement of Production Workers' Skills, Supervisors' Control, and Manufacturing Engineers' Roles

The carmakers to which the car component has been supplied have strongly demanded that the J firm, including the J mother plant and its transplants, reduce the cost of the car component. In response to the requests, management at the J mother plant conducted extensive improvement in work practices (i.e., production workers' skills, assistant first-line supervisors' control, and manufacturing engineers' roles) from the mid-1990s to the early 2010s.

According to my participant observation, the primary task of most production workers at the J mother plant in the early 2010s was to set up car component parts, change some jigs (fixtures)/tools, and troubleshoot on automatic transfer machine systems, which was not so different from the task of the production workers in the mid-1990s. In the mid-1990s, the production workers remedied abnormal conditions by either restoring the conditions to their original state or by conducting some mechanical troubleshooting procedures. Right after introducing the new automatic transfer machine systems in 2002, some mechanical production machines/devices in the previous automatic transfer machine systems were replaced with electric/electronic production machines/devices such as microcomputers. The production workers increasingly needed the help of electrical maintenance workers to correct electrical problems. For example, the number of times when the electrical maintenance workers were requested to help in some production processes was three to four times as great as that in the mid-1990s. To cut down on these requests to electrical maintenance workers, assistant first-line supervisors at the J mother plant asked electrical maintenance workers to teach production workers some electrical troubleshooting methods. The production workers were willing to learn the electrical troubleshooting methods because of their trusting relationships with the supervisors. As a result, the number of requests to electrical maintenance workers for help dropped back to the mid-1990s levels.

Skill training programs at the J mother plant, which are composed of on-the-job training (OJT) and off-the-job training (OffJT) programs, were more improved from the mid-1990s to the early 2010s. The assistant first-line supervisors temporarily transferred some highly skilled production workers to the manufacturing engineering division (specifically the production-process engineering division) of the J mother plant. The dispatched workers studied structures of production lines, and methods of productivity improvement.[3] The J mother plant provided production workers with more OffJT programs within their working hours in the early 2010s than in the mid-1990s; in the early 2010s these consisted of a program of 132 h to be completed within 3 years of being hired, 144 h within the following 8 years, and 288 h within the following 10 years. To be promoted to assistant first-line supervisors, the production workers had to complete all of the OffJT programs. Some production workers whom I interviewed at the J plant, who had attended joint skill training programs with Toyota, stressed that skill training programs at the J mother plant were more elaborate and effective than the training programs at Toyota's plants.

The J firm, including the J mother plant, employs certified highly skilled production workers.[4] The certified highly skilled production worker system was transferred to the JA, JT, and JC transplants. The J firm in Japan introduced the certified highly skilled production worker system borrowed from a German car component firm in 1977. The main role of the certified highly skilled production workers at the German firm was to change jigs/tools/dies. In addition to their role of changes, the certified highly skilled production workers at the J mother plant mainly

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[3]Bechy (2003a, b) asserts that tangible objects increase communication among employees on the shop floor. Based on her research in an American firm, production machines that can be touched constitute tangible objects between workers and engineers. However engineering drawings do not function as tangible objects, because the workers may not fully understand the engineering drawings. At the J mother plant in Japan, highly skilled production workers can understand production machines and engineering drawings. Therefore more use of tangible objects has created common ground and increased communication among workers and engineers at the J mother plant.

[4]Although the J mother plant retained certified highly skilled production workers in the mid-1990s, the certified production workers were included among production workers in my previous article (2001).

execute difficult troubleshooting and machine maintenance. For example, when some production problems occurred in production processes, production workers first tried to resolve the difficulties. When the production problems could not be resolved by the production workers, the production workers reported the problematic conditions to assistant first-line supervisors and certified highly skilled production workers. If the certified highly skilled production workers and/or assistant first-line supervisors could not resolve the production problems within 30 min after attempting to resolve the difficulties, the assistant first-line supervisors then asked maintenance workers or manufacturing engineers to troubleshoot. In terms of skill training programs and promotions for certified highly skilled production workers at the J mother plant, assistant and first-line supervisors first recommend production workers to be candidates for becoming certified highly skilled production workers. After receiving many special troubleshooting and maintenance skill training programs, the candidate production workers are promoted to the position of certified highly skilled production workers. In the early 2010s, 20 % of the production workers, on average, were certified highly skilled production workers at the J mother plant.

Unionized assistant first-line supervisors at the J mother plant, all of whom had come from the shop floor, resolved some of the difficult problems in production workplaces by employing high troubleshooting skills, and facilitated continuous improvement (*kaizen*) activities performed by production workers. They also guided the skill formation of production workers, evaluated production workers' performances, and determined job transfers of production workers in the early 2010s as well as in the mid-1990s. The assistant first-line supervisors decided the job transfers of production workers based on the principle of "the right person should be in the right place." A job-bid system based on employees' individual choices was not utilized for production workers at the J mother plant.

The assistant first-line supervisors reinforced workplace control from the mid-1990s to the early 2010s. For example, as explained in this chapter, the supervisors required production workers to gain some electrical troubleshooting skills. While involving production workers, the supervisors led cost reduction activities at the workplaces. However, control measures performed by assistant first-line supervisors were supported by the trusting relationships those supervisors had with production workers at the J mother plant. The workplace control exercised by the Japanese assistant first-line supervisors was characterized by its "middle-up-down" decision-making processes.[5] As an example of the utilization of the middle-up-down decision-making processes, in order to reduce production costs in the early 2010s, upper management demanded that the assistant first-line supervisors decrease the number of production workers and overtime work hours. While acceding to the upper management's demanding orders, the assistant first-line supervisors sometimes requested that upper management modify their

[5]Nonaka and Takeuchi (1995) claim that the middle-up-down decision-making by middle managers characterizes product development management in Japanese manufacturing firms.

orders in an effort to protect the workers. These types of middle-up-down decision-making actions and trusting relationships with production workers were not in evidence at the JA transplant.

The continuous improvement (*kaizen*) activities promoted by assistant first-line supervisors at the J mother plant are very important. Many production workers at the J mother plant suggested new ideas for productivity improvement. Some of the suggestions concerning continuous improvement, such as moving a parts box to a spot from where a worker could access the parts, were relatively simple and could be easily implemented by him/her. Concerning the more difficult suggestions, which could employ more technology, such as the suggestion to introduce a clearly visible display which quickly indicates the appropriate production tools at the changeovers, could not be implemented solely by the workers. The assistant first-line supervisor who had received training in the production-process engineering division of the J mother plant drew up the specifications and sketch for the display. With the help of the manufacturing engineer at the J mother plant, the display was introduced on the shop floor. The assistant first-line supervisor noted in a continuous improvement summary sheet that this continuous improvement activity was realized mainly by a production worker, with some help from the assistant first-line supervisor and the manufacturing engineer. This continuous improvement process served to motivate the production worker even more and increased a sense of trust between the supervisor and the worker. It has been reported in Japan that the academic ability of blue-collar workers with a high school diploma has declined because of the increasing share of high school students who go on to universities and hence do not become production workers. However, the assistant first-line supervisors whom I interviewed at the J mother plant, all of whom had graduated from high school and had been promoted from production worker jobs, were very capable. The elaborate skill training programs provided at the J mother plant helped the assistant first-line supervisors and production workers to develop their full potential.

Manufacturing engineers, including machinery and tools engineers at the J mother plant and the headquarters of the J firm in Japan, played much fuller and more linking and innovative roles from the mid-1990s and the early 2010s than did the manufacturing engineers at the JA transplant. For example, as explained earlier, the manufacturing engineers at the J mother plant and the headquarters of the J firm developed more efficient automatic transfer machine systems, including compact and lower-in-height production machines and robots in 2002. The innovative roles of the manufacturing engineers contributed more to productivity improvement than did the activities of the production workers, such as continuous improvements (*kaizen*) and quality control (QC) circle activities.

Manufacturing engineers play four main roles (Shibata 2009): (1) designing production lines/processes (i.e., production line design), (2) developing production methods and/or designing production machinery (production method development), (3) preparing the production of new products (production preparation), and (4) resolving difficult production problems and improving existing production lines, processes, and machinery (production improvement). Management at the J firm, including the J mother plant, has regarded the roles of manufacturing engineers as very important. The J firm in Japan maintains multiple and overlapping divisions of manufacturing engineering. The J mother plant maintains a production-process engineering division and a machinery and tools division. The production-process engineering division plays full roles in production line design, production preparation, and production improvement; and a partial role in production method development. The machinery and tools division plays a full role in production preparation and a partial role in production method development. The headquarters of the J firm has a manufacturing-design engineering division, a manufacturing-method developing division, and a machinery and tools division. These three manufacturing engineering divisions play full roles in production line design, production method development, and production preparation.

One of the key roles executed by the manufacturing engineers at the J mother plant and the headquarters of the J firm in Japan concerns in-house machine production. Most of the Japanese plants/firms I previously researched purchased much production machinery and equipment from outside machine-production firms. By contrast, a machinery and tools division of the J mother plant designs and/or produces medium- and small-sized machinery, jigs, and dies. A machinery and tools division of the headquarters of the J firm designs and/or manufactures large-sized machinery and equipment. Fifty-one percent of the production machinery and equipment and 99 % of the production robots used at the J mother plant were designed and/or produced at the two machinery and tools divisions. More highly skilled workers who were provided with special skill training programs at the technical skill training center of the J firm produced the machinery, equipment, robots, and/or the important devices for their operation. The in-house sourcing production machinery, equipment, and robots more precisely fit the needs of the J mother plant than production machinery, equipment, and robots produced at outside machine-production firms, and thus differentiated the J mother plant from other competitors. Although it is an advantage for the J mother plant and the headquarters of the J firm to have machinery and tools divisions, orders for machinery and equipment from the J firm have fluctuated. When the orders decreased, it was difficult for the J firm to retain employees at the machinery and tools divisions. At that time, the J firm transferred some more highly skilled workers at the machinery and tools divisions to work at the production divisions as regular production workers. Such workers' job transfers were not executed at the JA transplant.

Another interesting aspect of the role played by the manufacturing engineers at the J mother plant and the headquarters of the J firm in Japan concerns how it was linked to the work of product design engineers, production supervisors, and production workers. The new/modified product design work for the car component was executed by the product design engineers at the J mother plant. A new car component has been put on the market around every 10 years, with the car component often being modified in response to the car makers' requests. Manufacturing engineers at the J mother plant and the headquarters of the J firm participated in the product design work in its early stages, and began designing/modifying production lines for the new/modified car component before finishing the product design. Manufacturing engineers at the headquarters were mainly in charge of new production lines, while manufacturing engineers at the J mother plant assisted the new production line work. Manufacturing engineers at the J mother plant were responsible for modifying existing production lines. The processes of participating in product design activities and developing production lines simultaneously by manufacturing engineers (i.e., concurrent engineering) began at the J firm in the 1970s, whereas many other Japanese firms introduced concurrent engineering work in the 1990s.

The collaboration of manufacturing engineers with assistant first-line supervisors and production workers at the J mother plant is noteworthy. Due to the elaborate skill training programs at the J mother plant, the production workers and supervisors could grasp exactly what occurred in production workplaces, and could communicate well with the manufacturing engineers. The workers and assistant first-line supervisors offered the manufacturing engineers numerous effective tips and requests concerning existing production lines. Many improvement proposals by the production workers and supervisors were accepted for implementation by the manufacturing engineers. The strict requirements of the supervisors helped guide the manufacturing engineers, especially the younger manufacturing engineers. Conversely, while often walking around production workplaces and improving production lines, manufacturing engineers at the J mother plant comprehended how production lines and machines designed by the manufacturing engineers were operated. These activities by the manufacturing engineers in production workplaces and the suggestions offered by the production workers and assistant first-line supervisors greatly helped to design new production lines and machines. These linking roles among the manufacturing engineers, the production workers, and the assistant first-line supervisors at the J mother plant were less in evidence at the JA transplant in the United States.

2.6 The U.S. Transplant

2.6.1 The Introduction of Production Expert Positions and the Expansion of Manufacturing Engineers' Roles

According to both the analysis made by Japanese managers at the JA transplant in the United States and my own analysis, there transpired two main changes in work practices at the JA transplant from the mid-1990s to the early 2010s: the introduction of a new production expert position, and more involvement by American manufacturing engineers in the modification of the new automatic transfer machine system.

Automatic transfer machine systems utilized at the JA transplant in the mid-1990s and the early 2010s introduced some difficult production processes which require on-the-spot troubleshooting. However, since the JA transplant began producing the car component in 1990, American production workers have only partially integrated production skills with troubleshooting skills and thus perform little troubleshooting, unlike their Japanese counterparts at the J mother plant. To facilitate troubleshooting in the difficult production processes, management at the JA transplant introduced a new production expert position in 1999. Production experts at the JA transplant are similar to the certified highly skilled production workers at the J mother plant. When the JA transplant introduced the production expert position, management at the JA transplant sets a rule that the maximum number of production experts could be no more than 10 % of the total number of production workers. There were two main reasons for setting a maximum number of production experts. The first reason was to minimize production workers' opposition to the introduction of production expert positions because of accompanying wage gaps between production workers ($11.50–$18.00/h, as of 2010) and production experts ($13.00–$19.00/h). Second, management at the JA transplant judged that the number of production expert candidates would not reach 10 % of production workers because of production workers' lower skills at the JA transplant. Production workers who had at least 3 years of work experience were eligible to apply for the production expert position. The selection of applicants was not based on seniority rules, but rather was based on skill levels, written examinations on their incumbent jobs, and interviews by production managers.

In 1999, nine production experts were enrolled and provided with off-the-job training (OffJT) programs for approximately 100 h, and one-on-one on-the-job training (OJT) programs. The OJT programs were conducted by Japanese highly skilled production workers both at the JA transplant in the United States and at the J mother plant in Japan. After receiving the training, the production experts were able to solve some of the problems which tended to occur in the difficult production processes. The nine production experts were highly satisfied with the elaborate training programs which they had received, especially the training programs conducted by the Japanese highly skilled production workers in Japan. Some of the production experts expressed that they had not benefitted from these fruitful skill training programs while they had worked at other American plants.

However, several years after being promoted to the expert position, six of the nine production experts voluntarily transferred to the maintenance section at the JA transplant, using the seniority-based job-bid system, to take advantage of the higher hourly wages that maintenance workers received ($19.00–$25.00/h, as of 2010) versus those of the production experts ($13.00–$19.00/h). That left only three production experts. Management at the JA transplant decided to promote two of the production experts to team leaders, and moved the other production expert to the technical skill training section. As a result, the JA transplant had to fill another nine production expert jobs. Retention of the production expert position system was not the only issue at the JA transplant. After 2003, the Japanese highly skilled trainers for the production expert candidates were replaced by the American incumbent production experts and trainers in the training section. Unfortunately, the American incumbent production experts did not impart their skills to the expert candidates thoroughly, as the incumbent production experts feared that the production expert candidates would eventually be used to replace them as production experts.

After the introduction of the production expert position, maintenance workers at the JA transplant were able to spend more of their working time on preventive maintenance. The preventive maintenance led to a decrease in troubleshooting and breakdown maintenance. The time spent by the maintenance workers on preventive maintenance as a percentage of total working time increased from 14.0 % (in 1996) to 30.0 % (in 2010). This was coupled with a decrease in the percentage of time spent on breakdown maintenance from 86.0 % (1996) to 70.0 % (2010).

The second main change in work practices at the JA transplant in the United States from the mid-1990s to the early 2010s was the involvement by American manufacturing engineers in modifying new automatic transfer machine systems. When the JA transplant began producing the car component in 1990, Japanese manufacturing engineers were dispatched from the J mother plant to the JA transplant to set up automatic transfer machine systems and to determine under what conditions (e.g., machine speed and pressure) the machines would operate. Because stable production was one of the most important issues at the JA transplant in its early stages, locally hired American manufacturing engineers in the production-process engineering division and the machinery and tools division of the JA transplant were not required to modify the production machines in order to improve the productivity of the production line. Additionally, many automatic transfer machine systems at the JA transplant were designed by Japanese manufacturing engineers, and some of the machine systems were produced at the J firm in Japan. Therefore, American manufacturing engineers at the JA transplant took little interest in the automatic transfer machine systems.

However, as new automatic transfer machine systems utilized at the J mother plant were modified to be introduced at the JA transplant in 2003, management at the JA transplant dispatched a few American manufacturing engineers to the J mother plant in Japan. The American manufacturing engineers partially modified the new automatic transfer machine systems together with Japanese manufacturing engineers at the J mother plant. As an example of this collaboration, the American manufacturing engineers developed an automatic parts-checking machine system employing a new optical sensor technology that had not been used even at the J mother plant in Japan. After the new automatic transfer machine systems were deployed at the JA transplant, the American manufacturing engineers in the two manufacturing engineering divisions partially modified the machine systems to improve productivity, all with the permission and help of a production-process engineering division of the J mother plant in Japan.

2.6.2 *The Difficulty in Enhancing Employees' Skills and Modifying Their Roles*

Three work practice situations remained unchanged at the JA transplant in the United States from the mid-1990s to the early 2010s: the low troubleshooting skills of production workers, their limited control over production workers exercised by team leaders, and the practice of manufacturing engineers performing only partial roles related to the production process. These unchanged work practices distinctively contrast with the reinforced work practices at the J mother plant in Japan.

Management at the JA transplant introduced the production expert position in order to address difficult troubleshooting in 1999. Yet the troubleshooting skills of production workers at the JA transplant, on average, remained much lower than those of the production workers at the J mother plant. The production workers at the JA transplant resolved few production problems in the early 2010s, as was the case in the mid-1990s. According to the American and Japanese production managers at the JA transplant, the low troubleshooting skills of production workers affected productivity at the JA transplant, which operated on two (day and night) shifts in 2010. There were no periodic shift changes for production workers, such as weekly based changes. Job transfers between the two shifts were determined by workers' individual choices via the job-bid system based on the seniority rule, not by management control. Many production workers wanted to work the day shift. New production workers almost always had to start off by working the night shift. Therefore, as of July 2010, the average number of service years of production workers on the night shift was 8.3 years, whereas the average service years of production workers on the day shift were 15.8 years. Production workers with shorter service years generally possessed lower level troubleshooting skills than did those with longer tenure. As a result, productivity on the night shift was much lower than that on the day shift. Although management at the transplant wanted to take control of shift changes, the production workers resisted management's proposals.

The number of team leaders who had been promoted from the shop floor increased at the JA transplant. In the mid-1990s only 17.0 % of team leaders were promoted from within, whereas in 2010 75.7 % of team leaders were promoted from the shop floor. As a result, team leaders as well as maintenance workers gradually improved their troubleshooting skills from the mid-1990s to the early 2010s. However, team leaders retained limited control over job transfers and the skill formation of production workers in the early 2010s as was the case in the mid-1990s. This was mainly because the American production workers, as well as the production experts, had the right to exercise their individual choices on their own job transfers using a seniority-based job-bid system. Concerning the job-bid system at the JA transplant, job transfer applicants were first ranked based on their applicants' seniority (service years) from the same work area when job openings appeared. Production workers in other work areas then could apply for any vacant job positions. Among them, applicants with the longest service years (seniority) were given preference. The empty job positions created by the job-bid system were filled by new employees from the outside. Notably, the American managers at the JA transplant strongly opposed seniority-based rules but were in favor of workers' individual choices via the job-bid system. In contrast, at the J mother plant in Japan, production workers could convey their preferences to assistant first-line supervisors regarding job transfers. At the J mother plant, however, the workers' choices were not determining factors in the job assignment process. The assistant first-line supervisors at the J mother plant decided the job transfers of production workers based on the principle of "the right person should be in the right place."

In addition to the role of workers' individual choices, a less-effective performance appraisal system made it difficult for team leaders at the JA transplant to control the skill formation of production workers. A performance appraisal system for production workers which was linked to wages was suspended at the JA transplant in 1995. Following that, a new performance appraisal system was introduced for production workers. Yet the performance appraisal system was very simple and did not provide effective incentives to the workers. Specifically, at the JA transplant there were only five evaluation points for production workers: attendance, safety, job knowledge, quality of work, and teamwork. The workers were evaluated for each point only by "good" or "not good". Because there was no forced distribution for the evaluation, 98–99 % of the workers received evaluations of "good". By contrast, at the J mother plant in Japan, the performance appraisal system was strictly applied to production workers as well as to white-collar employees.

Although manufacturing engineers at the JA transplant participated in modifying new automatic transfer machines, the roles of the American manufacturing engineers were partial to a greater degree than the roles of the manufacturing engineers at the J mother plant. The JA transplant maintains two manufacturing engineering divisions: a production-process engineering division and a machinery and tools division. Regarding the four main roles of manufacturing engineers, specifically (1) production line design, (2) production method development, (3) production preparation, and (4) production improvement; the production-process engineering division at the JA transplant played partial roles in production line design, production preparation, and production improvement; and a limited role in production method development. The machinery and tools division at the JA transplant played a partial role in production preparation and a limited role in production method development. By contrast, the production-process engineering division and the machinery and tools division at the J mother plant played full roles in production line design, production preparation, and production improvement; and a partial role in production method development. Manufacturing engineers at the JA transplant resolved fewer difficult production problems than did manufacturing engineers at the J mother plant. The linking roles of manufacturing engineers at the JA transplant with product design engineers, team leaders, and production workers were more limited than those at the J mother plant.

One of the main reasons for the partial roles of manufacturing engineers at the JA transplant concerns their lower skill levels. The skill levels of the American manufacturing engineers at the JA transplant varied more widely than those at the J mother plant. Nevertheless the average skill level of the manufacturing engineers at the JA transplant was much lower than that of their Japanese counterparts at the J plant in the early 2010s as well as in the mid-1990s. Japanese manufacturing engineers whom I interviewed at the JA transplant pointed out that the main cause for the lower skill level of the American manufacturing engineers was their higher turnover. As of August 2010, the production-process engineering division at the JA transplant retained 19 manufacturing engineers, only five of whom had worked since 1997. The average tenure of the engineers was just 5 years. The manufacturing engineers with longer tenure often voluntarily left the transplant. At the J mother plant in Japan, almost none of the manufacturing engineers terminated their employment until they reached the mandatory retirement age of 65.

American manufacturing engineers at the JA transplant insisted that there were two main reasons for the higher turnover rate of the American manufacturing engineers. First, management at the JA transplant wanted to hire a smaller number of white-collar employees, including manufacturing engineers, for the sake of cost reduction. Therefore, the number of the American manufacturing engineers was reduced by 25 % from 2007 to 2010, although production volumes of the car component at the JA transplant in 2010 were lower by only 10 % than those in 2007. As a result, the manufacturing engineers at the JA transplant had to work long hours and often worked until very late at night. Second, the skills and work experience of the American manufacturing engineers at the JA transplant was highly valued by other American firms, often resulting in the American manufacturing engineers being induced to move to other American firms by recruiting agencies.

2.7 Summary

Utilizing similar automatic transfer machine systems and similar parts, the J mother plant in Japan and the JA transplant in the United States have manufactured the same standard type of car component. Yet, productivity and work practices (i.e., production workers' skills, assistant first-line supervisors' control, and manufacturing engineers' roles) at the J mother plant and the JA transplant showed only limited convergence from the mid-1990s to the early 2010s. Total productivity, which includes an accounting for the production system's ability to cope with changes in production volumes and product variety, was 10 % lower at the JA transplant than that at the J mother plant in the early 2010s.

While management at the J mother plant maintained stable employment, integrated work practices (i.e., production workers' skills including troubleshooting skills, middle-up-down decision-making executed by assistant first-line supervisors, and full/linking roles of manufacturing engineers) were reinforced from the mid-1990s to the early 2010s. In contrast, management at the JA transplant has faced frequent and voluntary job transfers of employees. Key work practices (production workers' skills separated from troubleshooting skills, less control over production workers by team leaders, and partial roles performed by manufacturing engineers) remained unchanged. Due to the reinforcement of the integrated work practices at the J mother plant and the reliance on work practices at the JA transplant that promoted independence, work practice gaps between the plants have actually widened.

Production workers at the J mother plant have fewer choices with regard to jobs and work practices. Still, the trusting relationships between production workers and assistant first-line supervisors have complimented the workers' limited choices and have contributed to productivity improvement. In contrast, at the JA transplant, utilizing their individual choices via seniority-based job-bid systems, production workers and production experts have voluntarily transferred to other higher wage jobs. Their individual choices on work practices are inconsistent with the improvement of plant productivity.

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