Practices of Intra- and Inter-Firm Technology Transfer in the Thai Automobile Industry

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Abstract

The main objective of this paper is to investigate actual practices of technology transfer in a recent automobile assembly project in Thailand and investigations are done at both intra-firm level - from the Japanese automaker (J-firm) to its affiliate (T-firm) - and inter-firm level - from J-firm to T-firm's suppliers. Necessary information was collected through field surveys, including factory visits and interviews with J-firm, T-firm and suppliers, and a questionnaire survey on suppliers. Major findings can be summarized as follows: 1) technology transfer was not limited only to intra-firm but also inter-firm levels, 2) at both levels, technology transfer process required substantial resource allocation, especially human resources exchanges and training, 3) formal training in Japan and on-the-job training (OJT) at T-firm were main strategies to develop local workers' skill at intra-firm level, 4) at inter-firm level, technical assistance by J-firm normally took the form of advice rather than direct support, 5) direct support would be provided only to suppliers that revealed possibility of delay, aiming to establish *systematic management practices* and to instruct specific technical aspects necessary for successfully preparation. These findings suggest that foreign direct investment not only promotes technology transfer at intra-firm level but inter-firm level as well.

1. Introduction

Inter-firm linkages between large-foreign and local-based-small firms in manufacturing sector have received widely recognition from scholars that these linkages have significant impacts to technological development of ancillary industries of many host countries (Mead 1984, Hill 1985, Blomstrom and Kokko 1999). Such linkages have been recognized as important sources of growth in small- and medium-scale enterprises (SMEs) as a mechanism for promoting technology transfer through subcontracting relationship or inter-firm relationship (Wong 1991, Capannelli 1997). Inducements from substantial strict standard requirement by foreign firms in terms of quality, timely delivery, and cost down policy, drive local firms to improve their technical capability. However, the customer also has to impart some specific knowledge to its suppliers, hence, through this interaction, local suppliers are exposure to new knowledge and can have an opportunity to improve their capability accordingly.

Despite this growing recognition of the potential for accelerating technological development through buyer-supplier relationships, there have been surprisingly little empirical case studies of the actual situation and practice of how this relation can lead to such improvements. It is true that a vast body of study

Journal of International Development and Cooperation, Vol.8, No.1, 2001, pp. 179–196

on technology transfer has been offered, but many of them focused only at intra-firm level, e.g. Teece (1977), Yamashita (1991), Ramachandran (1993), Urata and Kawai (1998). Lack of empirical research in respect of inter-firm technology transfer is one of major motivations of this paper.

In Thailand, as a recipient country of foreign direct investment (FDI), the government has exerted enormous efforts to attract FDI. Automobile industry is one of the target industries and has developed significantly due to government intervention (Doner 1991, Poapongsakorn and Fuller 1998, Abdulsomad 1999). Industry-wide has not developed only in the final assembly of automobiles, but also in supporting industries.[1] However, doubts still reside with people. They are skeptical and suspicious about the willingness to transfer technology by foreign firms. For instance, Ichiro Sato has commented Thai people as follow: "they are always anxious to have modern technologies transferred to their country, but they neglect to appreciate what technology transfer concretely and specifically comprises",[2] implying that Thai people may misunderstand the actual meaning and practice of technology transfer. They seem to view the topic as a once-and-for-all affair, but in fact, technology transfer is not and never characterizes in that way. It is rather a continuous process of knowledge accumulation and it normally takes time (Rosenberg 1982, Yamashita 1991).

Therefore, to improve understanding of Thai people, and hopefully those in other recipient countries, this study aims to contribute to the literature by doing research on a recent project of automobile assembly in Thailand at both intra- and inter-firm levels. Open-ended interviews and questionnaires were used in order to understand that to which aspects and by what methods were employed by a multinational firm in transferring manufacturing capability to an overseas project. Findings support that technology transfer is a complicated and time-consuming process. In addition, the assembler has had rendered technical assistance to suppliers, and inter-firm relationship with assemblers is considered as an important source of technological improvement by all suppliers.

The organization of this paper is as follows. Section 2 briefly describes the field research carried out in Thailand and characteristics of the sample firms. Section 3 presents research findings on a case of intra- and inter-firm technology transfer practices. Discussions on strategies of skill formation at both levels are based upon information disclosed mainly by and interviews with J-firm's staff. Section 4 concludes.

2. Analytical Framework and Source of Data

This study relies mainly on primary information. I conducted two field surveys, from March to May and from September to October 2000. After objectives were set to tracing technology transfer process in a recent automobile assembly project, called T-firm project,[3] the first step of this research entailed visiting factories and interviewing with staff of the selected firm, i.e. headquarter plant (J-firm) in Japan and the affiliate (T-firm) in Thailand. I visited T-firm and was able to interview with many staff of several departments. Information received from this survey clearly revealed that, in particular to this case, J-firm once decided to invest in Thailand, it had to accomplish transferring manufacturing capability not only to its affiliate (intra-firm level), but also to suppliers (inter-firm level).

This firm is appropriate for study because of two major reasons: firstly, among all new automobile assembly projects, this firm has the largest production capacity, and secondly, it set an ambitious goal to export Thai made products at the very early stage. With considerably large capacity and a goal to export, it would be discernible that considerable efforts would be allocated to develop production capa-

bility of local people and local suppliers. Hence, studying this firm would be able to offer a more appreciable explanation about actual practices of technology transfer by a foreign firm.

Based on findings from the first round survey, I construct a general structure of relationships between J-firm and the T-firm project (see **Figure 1**). It was discovered that J-firm had to create various relationships not only at intra-firm level, the relationship with its overseas affiliate (assembling firm, shown by the upper block arrow), and its part maker affiliate (if any), but also with all suppliers in Thailand. Relationships with suppliers are prevalent because J-firm wanted to ensure that all suppliers could achieve the required quality level and timely delivery schedule of the project. Expected benefits accruing to J-firm from this attempt are in forms of higher quality of parts or cost reduction, rather than monetary returns (like the intra-firm or arms' length case). However, information exchange taking place during this process might result in technological improvement in the recipient sides if they could adopt some of valuable information from their customers (Lall 1980, Wong 1991, Capannelli 1997). Given this possibility, this channel is called inter-firm technology transfer, which has been argued that contributions to host countries in term of technological development from this channel may be higher than other means (Blomstrom and Kokko 1999).

In addition, there were many suppliers, both Japanese and non-Japanese, that participated in the heuristic product development stage taking place in Japan. Some of them may already have a plant or joint venture agreement with a firm in Thailand, while some that received sufficient volume order may decide to set up a new facility. In either case, if they were approved to be a supplier for this overseas project, they would be responsible for building up manufacturing capability of firms in that host country. This is the main reason for the prevailing of this intra-firm linkage, represented by the lower block arrow of Figure 1.[4] However, this study is not directly concerned with this channel but gives more emphasis only on investigating two major parts, to the first, the main route of technology transfer that the assembler has created with its overseas affiliate, and to the second, with its suppliers. It is expected that by so doing this study can shed some light on a concealment aspect of contribution of FDI to host countries particularly in term of technology transfer.

From the first survey, I observed that J-firm had provided technical assistance to some suppliers in Thailand. Thus, the second round survey was conducted to extract more comprehensible information from the recipient side. I interviewed with T-firm staff again to get more precise information regarding intra-firm skill formation practices,[5] and requested for the supplier list. There are about 100 suppliers, consisting of 85 percent Japanese firms,[6] 10 percent independent Thai firms, and 5 percent non-Japanese firms. To avoid a sampling biased and to get overall picture how these firms accomplished preparation and were able to supply parts for T-firm, questionnaires were sent to all suppliers in September 2000. The questionnaire was required production, sales, and/or personnel managers to fill in. Main questions were designed to understand general information, characteristics of their relationship with customers and their technological capability status. Questions include how they acquired production technology, sources of technological improvement, what kinds of technical linkages J-firm had provided, and linkages with other customers.

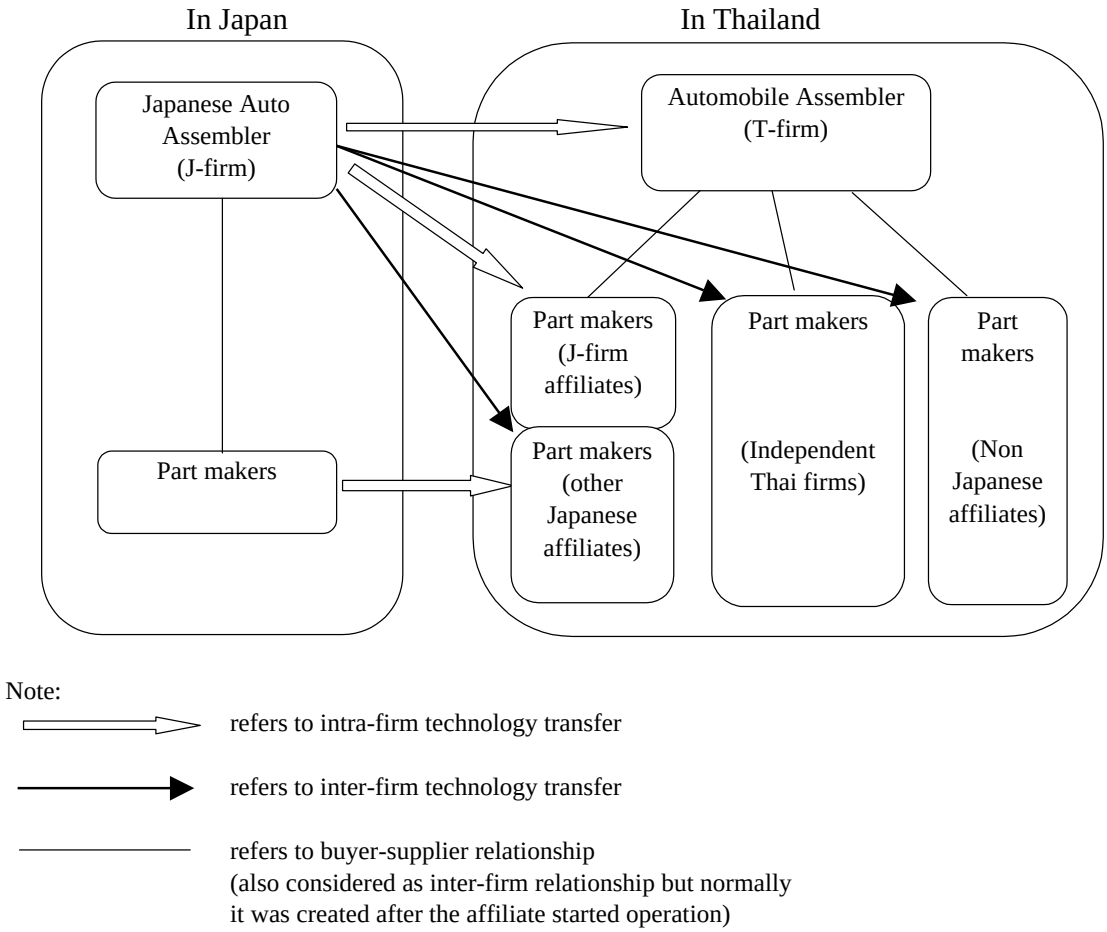

Figure 1 An Analytical Framework of Intra- and Inter-firm Technology Transfer

2.1 Characteristics of Respondents

From the total 100 sets of questionnaires sent to T-firm's suppliers, I got replied from 26 companies, making the response rate to be 26 percent. Following J-firm's classification, the sample firms comprise 19 Japanese (including wholly owned Japanese and Japanese joint venture) firms, four Thai firms, and three non-Japanese foreign firms. However, since almost all non-Thai suppliers are Japanese firms,[7] I will classify three ownership types, which are 1) 'Foreign' for firms with foreign ownership more than 80 percent, 2) 'Joint venture' for firms with foreign ownership between 20 and 79 percent, and 3) 'Thai' firms for otherwise. Characteristics of T-firm suppliers that replied the questionnaire are shown in Table 1. Among these, I could interview with managers (purchasing, sales, factory and production managers) of four suppliers

As shown in Table 1, ten firms (out of 26 firms) just established their production plant in Thailand in 1990s. Considered in terms of employment and sales volume, the majority of firms in my study are large firms. Almost all of them employed more than 200 workers and about half of them had sales volume higher than 500 million baht (in 1999 figure). Regarding export figure, only three firms currently

have no export, while the rests are exporting different percentages of their production. From the returned questionnaires, some of them just started export in 1998, representing adaptation of their policy to attenuate the downturn of the domestic market. In addition, concerning types of parts and/or services that these firms are supplying to T-firm, it appears to cover a wide range of products and technological requirement. Not only did it include system parts or marketed products, such as fuel tanks, exhaust system, oil pumps, water pumps, radiators, audio equipment, accessories, carpets, but also those assembly and/or sub-assembly and discrete treatment, such as transmission assembly, machining of engine gears, casting of engine parts, stamping parts, plastic injection parts. Given these varieties, it is expected that this study would be able to provide general information of inter-firm technical linkages created under the relationship between T-firm and its suppliers.

Table 1 Characteristics of Respondents

Type of firms	Foreign firms (12 firms)	Joint venture firms (10 firms)	Thai firms (4 firms)	Total (26 firms)
Establishment				
1960s	3	3	1	7
1970s	—	1	2	3
1980s	3	2	1	6
1990 - 1995	4	3	—	7
1996 onwards	2	1	—	3
Employment				
Less than 100	1	1	—	2
100 - 199	1	2	—	3
200 - 499	7	2	1	10
500 - 999	2	—	1	3
More than 1000	1	3	2	6
N.A.	—	2	—	2
Sales (in 1999)				
Sales less than 50 mB.	1	—	—	1
50-99.9 mB.	1	—	—	1
100-499.9 mB.	6	3	1	10
500-999.9 mB.	1	2	1	4
1000-3000 mB.	2	1	1	4
more than 3000 mB.	1	2	1	4
N.A.	—	2	—	2
Percentage of export				
0%	3	—	—	3
0.1 - 10 %	7	4	3	14
10.1 - 20 %	—	2	—	2
20.1 - 50 %	—	—	—	0
More than 50%	1	1	—	2
N.A.	1	3	1	5
Total	12	10	4	26

Source: Survey by the author, during September and October 2000
Note: N.A. = Data not available

2.2 Existence of Inter-firm Technical Linkages

The second-round survey's results reveal the existence of inter-firm technical linkages created by J-firm. Results indicate that only some of the sample firms had received some assistance from J-firm during the time prior to the launch of mass production for export, December 1998. Note that, there was a team, called 'supplier technical assistance or STA team responsible for creating such inter-firm linkages with suppliers, and the questionnaire was conducted to investigate this activity. Questions were asked all firms to report that during the concerning time period, 1997 - 1999, which types of technical support they received from J-firm. Answers can be classified into three types which are: 1) "received direct support", which refers to the case that suppliers report to have some Japanese STA staff working for a certain period of time at their plant during the period concerned; 2) "received only indirect support" or "getting only technical advice", referring to the situation that respondents answered to have received some forms of advice from STA staff; and, 3) "received nothing" is straightforward, referring to the situation that suppliers considered they did not receive anything from J-firm. As shown in Table 2, from 26 firms, only 18 firms reported to have received some assistance, either direct or indirect forms. Interestingly, among 18 firms, four firms explicitly stated that they have got direct assistance from J-firm during the period concerned, while the rest, eight firms, reported that they did not receive any assistance from J-firm (see Table 2 below).

Table 2 Number of Respondents Receiving Technical Assistance from J-firm

(Number of firms)

Degree of assistance \ Received by	Foreign firms	Joint venture	Thai firms	Total
Received technical assistance from STA team	2	1	1	4
Received only technical advice	6	7	1	14
Not at all	4	2	2	8
Total	12	10	4	26

Source: Survey by the author, during September and October 2000

According to interviews with STA staff, it was found that a real and explicit function of STA team was to support T-firm by monitoring all locally based suppliers to ship all ordered parts on time. In practice, STA staff had scheduled to follow up the progress of the preparation that suppliers had accomplished, by visiting each company from time to time, usually once a month. In many cases, they did only regularly 'company visits' and communication with suppliers to ensure that every thing was on track. Some suppliers that had only communication with STA staff might realize they were not receiving direct assistance but only indirect one. Indirect technical linkages include advice about quality control, maintenance, design drawing to make die or tooling, advice about project management, and lending equipment.[8] While those firms that could finish preparation by themselves and STA staff only did visit and check the progress, they indicated received nothing. Only four suppliers were found to have received direct assistance, i.e., a certain period of stay by STA staff.

For those 18 firms that reported to have received either direct and/or indirect assistance, Table 3 shows that all of them obtained advice about quality control practice and 12 of them reported to receive advice about project management practice. Nine suppliers got advice how to make and design drawings for dies and/or tolling necessary for producing parts for T-firm. Only few firms reported that their customers lent machine or equipment. These results in particular suggest that the J-firm's preferred forms

of technical cooperation that was mainly on information sharing.

Table 3 Technical Assistance Respondents Received from Automobile Customers

(Number of firms)

Types of technical assistance \ Received by	Foreign firms	Joint Venture firms	Thai firms	Total
1. Quality control practice	8	8	2	18
2. Maintenance	0	2	2	4
3. Design drawing to make die or tooling	4	3	2	9
4. Advice about project management practice	7	3	2	12
5. Lending machine or equipment	2	0	1	3
Total number of firms	8	8	2	18

Source: Survey by the author, during September and October 2000
Note: This table excludes eight firms that reported to receive nothing

After acquiring these results, I then reconfirmed with J-firm about STA activity and resources allocated for this purpose. This point will be discussed in details in the next section. However, it should note here that results from interview with J-firm staff and a set of disclosed documents indicate that STA staff had given substantial efforts to some suppliers. From information disclosed by J-firm, it was reported that there were two suppliers that had received largest amount of resources (about 80 percent) spent by STA staff, in term of person-months. However, in this paper, I attempt to explain the real practice of inter-firm technology transfer created by J-firm by relying on interview with and information disclosed by STA staff, see section 3.2.3.

3. Research Findings

Before proceeding to present research findings, it would be better to describe the objective of T-firm project in order to understand its initial objectives and its current situation, which would reflect how successful this project is. T-firm project is a project of pickup truck assembly established in the mid of 1995. A mission set initially was to "build and deliver world class quality vehicles and vehicle components in an efficient and timely manner to meet… customer's needs world wide" within the first year of operation. To achieve this goal, three priority tasks that J-firm had to accomplish before the launch of mass production of T-firm include, 1) to recruit and develop manufacturing skill of new employees, 2) to search for good suppliers that were already located in Thailand, and then 3) to keep close relationship with all suppliers in order to ensure that they could meet all deadlines scheduled for the T-firm production plan.

This project had quite limited time span given its ambitious goals. It was planned to run mass production in May 1998 and to export in December of the same year. From the beginning, there were only three and a half years to start production for export. As planned, the production for local market commenced in May 1998 with only 398 units and it cumulatively increased to 3,912 units in December 1998, while the production for export was totally 1,848 units at the end of 1998.[9] Until the end of 1999, T-firm could export totally 43,928 units and sold domestically 15,380 units. At present, it was reported that T-firm aims to export about 70% of total annual production capacity of 90,000 units. Hence, it seems clear how success this project is and why this firm is interesting to do research.

In following, this paper studies skill formation at two major levels (i.e., intra- and inter-firm levels) that J-firm had to take part in building up manufacturing skills. To make discussion more appreciate, as mentioned, I scope my study on a specific time frame, from the establishment of the project in 1995 to December 1998 when export began. This time frame also applies to the case of inter-firm technical assistance. Regarding resources allocated for T-firm project, this study focuses on duration of overseas training received by Thai staff and performed by Japanese staff.[10] Each activity will be separately discussed. First, I will present intra-firm practices, and next, move to inter-firm ones. In each part, I try to generalize the practice of skill formation process at both levels. Discussions were based on results of interview and questionnaire survey.

3.1 Intra-firm Technology Transfer Practice

Efforts to build up manufacturing capabilities of T-firm firstly started in August 1995, when the first group of Japanese staff was delegated to take care of the project.[11] The training plan for local employees was complete early February 1996. The plan was to promote and build up skills of local workers in all classes necessary for the efficient mass production. According to documents disclosed by J-firm, training practices for T-firm employees were carried out in the following manners. Japanese staff were delegated to prepare training courses for Thai staff coming to receive training in Japan. Not only being trainers, but in many cases they were also assumed a superior position to their trainees. After training in Japan completed, they together with Thai trainees went back to T-firm to prepare for launching mass production. Until the end of period concerned, December 1998, totally 83 Japanese staff had been training local staff in Japan and working at T-firm in Thailand.[12] Training courses consisted of three major aspects, which were production, quality assurance and production control. Resources expended by Japanese staff for this purpose, were in total 2,136 person-months (see Table 4).

Table 4 Total Time Japanese Experts Train T-firm Employees

Workplace / Type of technical assistance	Training at HQ plant in Japan	At T-firm	Total (person-months)
Production	543	674	1217
Quality assurance	199	460	659
Production control	74	186	260
Total	816	1320	2136

Source: Calculated from Information of J-firm

In the part of Thai staff trained in Japan, 187 core members, which were the first group of recruited staff, including production managers, assistant production managers, engineers, supervisors (or foremen), leaders, and technicians (including operators and staff), were scheduled to receive training at the headquarter plant. These staff were sent to Japan from time to time in accordance with the schedule set by the J-firm's master training plan. These members were expected as inexperienced labor forces, presumably due to specific manufacturing characteristics of J-firm. Hence, training these staff had been the most important key to guarantee a successful launching. In total, these staff had received training in Japan 1,549 person-months, on average 8.28 months per person, see Table 5. However, managers, assistant managers, engineers, and supervisors, who would not involve in direct operation, had received longer training duration than those responsible for direct production, indicating how crucial J-firm considered in building up these people skills.

Table 5 Total Time Thai Trainees Trained in Japan: Classified by Positions

Position	No. of staff	Time (person-months)	Average
Production managers	8	84	10.5
Assist. production managers	8	68	8.5
Engineers	31	309	9.97
Foremen	35	292	8.34
Leaders	20	146	7.3
Technicians, operators, staff	85	650	7.65
Total	187	1549	8.28

Source: Calculate from Information of J-firm

Generally, when thinking of a transfer of a production process to an overseas facility, one may envisage only simple assembly or operational skills, which may be misleading. At least, as shown above, results of T-firm project suggest that in order to be efficient in production of automobiles various skills must be promptly promoted. What kinds of skill have been formed up can be seen in Figure 2. Before these workers were sent to Japan, they had been appointed to take care of ten different types of technical aspects. However, from total person-months of training, it seems that J-firm gave more emphasis on six technical aspects, which are press shop, quality assurance, maintenance, body shop, paint shop, and final assembly shop. All of these are the main functions for automobile assembly. It was observed that staff in charge of maintenance and quality assurance received on average longest training in Japan. These capabilities are very critical in determining the smoothness of operation thereafter.

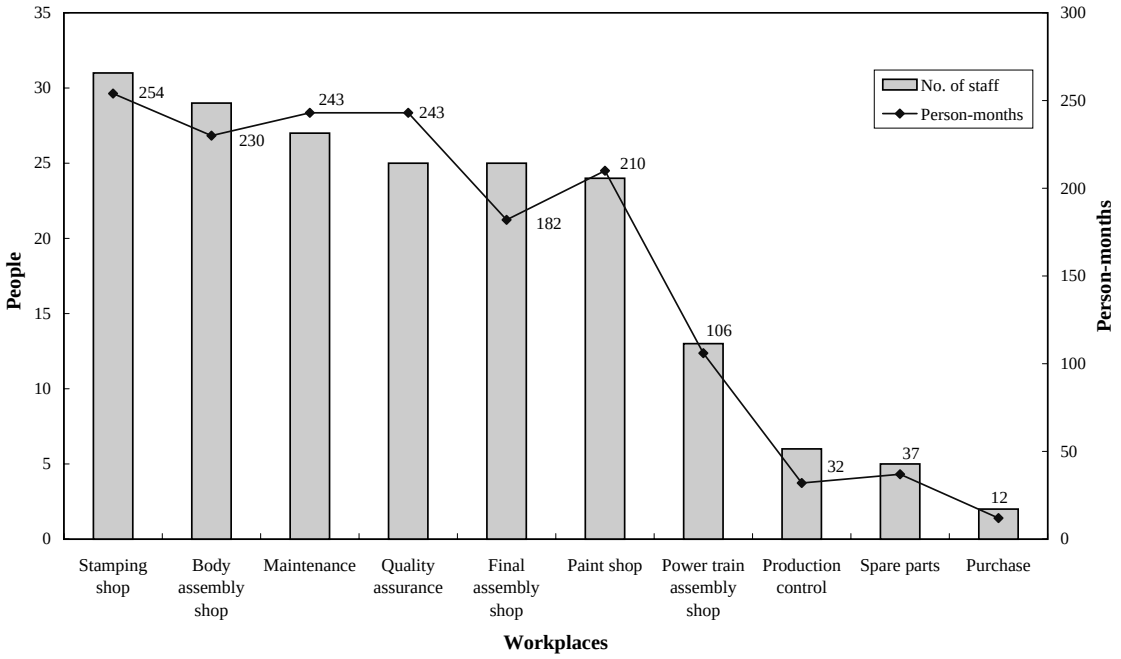

Figure 2 Thai Staff Trained in Japan: Classified by Workplaces

3.1.2 J-firm training strategies

Presenting only how many resources expended for T-firm project in forming up local employee skills may not be appreciate without discussing how J-firm successfully accomplished this task. It was found that at the very early stage the most important strategy to impart manufacturing skills was to create "multipliers." A "multiplier" is a staff in any production department that was trained and evaluated to be capable of training other staff in that area of works. Probably it was because of a very limited time span for the project, a more promising way was to produce as many capable staff as possible from the beginning. Specifically, training target stipulated by J-firm has three levels as follow:

Level 1: be able to carry out the basic operation in accordance with a trainer's instruction;

Level 2: be able to carry out the production operation, *being a trainer for the on-site training* and being a trial member for the machines in accordance to a trainer's instruction; and

Level 3: be able to carry out production operation, kaizen (continuous improvement) and *training newly hired employees*.

Regarding definitions given above, the skill of employees would be accumulated from level 1, 2, and 3. In other words, a higher level attained by a trainee indicates the higher skill level and capability of the trainee. In order to achieve this goal, J-firm consider that training would not be success if language barriers were not reduced. With a paucity of language difficulty, all core members were assigned to study Japanese language about six weeks. Interview results with these members proved the significance of this course as it helped them to understand and improve communication with Japanese trainers. In addition, among the first group of core members, production managers and assistant managers of each department were sent first. Their priority duties, after learning Japanese language, were to develop training manuals concerning their department. As they aware of the language barrier, these members worked out translation these manuals into Thai language, in order to deploy them efficiently afterwards.

Taking one example of the power train assembly section,[13] a Thai manager reported that he and another engineer were in the first group sent to Japan. They worked very hard in translating training course written in Japanese into Thai language. Support in forms of translators, each took care of 10 trainees, and related English documents during this stage were of crucial in determining the success of this preparation. What each Thai manager would do was to thoroughly consider how all required tasks would be codified into Thai language so that their subordinates who came later could understand and be able to perform these tasks efficiently. He, as well as other managers, not only had to prepare for every single station of engine assembly, but also to consider how to set a quality system in order to be best control the actual production. To be sure, Japanese trainers played a pivotal role in this process.[14]

Translated training manuals developed by each department were utilized according to the curriculum to train employees who followed. These documents were utilized in training basic and technical skills necessary for each department. Also, the on-the-job training (OJT) practice was extensively adopted to make trainees understand exactly their responsible duties. This is because specific (or tacit) skills of J-firm staff are in nature hardly to articulate. In addition, due to language problem, difficulties and ambiguities remained when insisting to rely only on codified documents like production manuals. These problems can be overcome when the communication takes place in a face-to-face manner. Errors or misunderstandings can be promptly corrected by personal feedback.

However, learning from such codified documents and using OJT practices might not lead to successful skill formation. By nature, learning is a mechanism necessary for transforming codified knowledge to tacit knowledge of individuals or firms (McKelvey 1998), and the process takes time (Rosenberg

1982). A prudent way would be to assess the trainees' ability whether they sufficiently accumulated expertise from the training or not. According to the J-firm plan, all trainees would be evaluated to acquire manufacturing skills step-by-step from being able to perform tasks under supervision of a trainer (level 1), to be able to perform operation tasks by themselves and able to train new workers in their work stations (level 2) and to be able to carry out production, make improvement, and train newly hired workers (level 3), except those staff in class skilled operators and maintenance staff (see Table 5) were required to obtain only "level 2".[15]

The assessment was done by requesting all trainees to articulate their understanding over aspects they were trained. This method was proved as an important impetus for completing the skill formation process during this stage. According to the interview results, Thai staff had praised high evaluation to this scheme in that it was a good way to elicit their efforts in order to understand clearly what the verbal or codified knowledge (training manuals) is, and how to perform their responsible tasks efficiently. Following this criterion, Thai trainees reported that they became clearly understand the technical knowledge of J-firm and being able to train lately employed staff.

About 75 percent of the core members as well as their trainers came to Thailand in September 1997, when T-firm was preparing for launching first trial production in October. All members, both Japanese and Thai staff, worked together in this process, and, at the same time, they were responsible for training new employees. However, for Thai staff, only the core members participated in the preparation of first and second trial production. New employees took part in only from the pre-mass production and mass production in May 1998. Based on the schedule to export in December 1998, more employees were recruited and trained. Training new staff was accomplished mainly through the OJT basis. After one or two days of general training, about the company policies, new workers would be immediately transferred to the department they will later on work for. Each department has its own training courses but generally it was done exclusively through OJT.[16]

These findings, to a certain extent, shed some light on how costly the process of technology transfer is, and what kinds of activities were promoted and by what mechanisms during the early stage of a new project. Though relying upon only one intra-firm project, results show how complex and multi dimensional skills that this technology source must transfer to local employee if efficient mass production is the ultimate goal. Management of technology transfer is not an easy matter. Success cannot be determined only at the beginning but also afterwards. Roles of local people and Japanese staff in continuous improvement are strongly important. Hence, skills are continuously transferred, suggesting that technology transfer process is never end.[17]

3.2 Inter-firm Technology Transfer Practice

3.2.1 Supplier technical development program

To assure that all suppliers would be able to produce and supply parts in accordance with the project schedule, a special team, called "supplier technical assistance" (STA) team, was set up to take care this task. The STA team was sent into Thailand to monitor and evaluate all suppliers manufacturing capability. After gathering information from factory visits, they could distinguish firms between capable and probably incapable ones. They had to keep close monitoring on suppliers that were new to J-firm, i.e., those that had no business relationship with before, because these firms might not be quite familiar with specific manufacturing techniques of J-firm. The STA master plan was concluded in September 1996, and 33 core members were delegated for this purpose. These members were appointed to support three

major technical areas, which were forging/casting of power train and engine parts (13 people), trim parts or interior parts (seven people) and stamping of body parts (13 people). The length of period of supplier technical assistance program was from January 1997 until January 1999.[18]

Not all members worked full time in Thailand for supporting locally based suppliers, however. Some worked as a support team while staying in Japan (denoted as 'Home service employees'; HSE), some temporarily served direct support to suppliers (denoted as 'International service specialists'; ISS), and some stayed long-term in Thailand to work with suppliers (denoted as 'International service employees'; ISE). These three classifications were taken from J-firm criteria in which STA staff were divided into three major types, according to geographic boundaries and duration of stay. Job descriptions were as follows:

1. HSE were those who stayed in Japan and were delegated to give support to T-firm project. In other word, HSE staff were standby to provide coordinates and to conclude what types of assistance or which people would be sent to support T-firm suppliers.

2. ISS were staff who, at that time, were actually working full time for J-firm in Japan but were delegated to give technical support to suppliers in Thailand. They had a specific schedule to go back and forth Thailand and Japan, and period of stay was short term, less than one year.

3. ISE were staff who were designated to provide technical assistance to suppliers in Thailand, as same as ISS. However, the period of stay in Thailand was longer than one year.

These staff were obliged to provide technical support to suppliers and to assure their production capability because these firms would supply parts incorporated into T-firm's export vehicles. Totally 333 person-months were spent by STA staff, see Table 6, and assistance to suppliers in area of body parts appeared to be highest in term of total person-months, followed by interior parts, and power train & engine parts.

Table 6 Person-months of Japanese Staff Providing Technical Assistance to Suppliers in Thailand

Type of staff / Technical aspects	HSE	ISS	ISE	Total (person-months)	Average
Forging and casting parts	12	27	36	75	5.77
Trim parts	38	18	49	105	15
Stamping parts	21	82	50	153	11.77
Total (person-months)	71	127	135	333	
Average	5.07	9.77	22.5		10.09

Source: Calculated from Information of J-firm
Note: HSE, ISS and ISE see definition in text.

This table shows that resources were allocated unevenly among three main categories; however, it cannot tell what factors determining such allocation. According to Samli (1985), a technology owner will do transfer any technology if it 'wants to' and 'is capable' to do so. Hence, in the situation that J-firm, as a technology source, had deliberately set up STA team in a sense may imply that in which areas of technology J-firm is specialized in. Nevertheless, to be sure, it needs additional information especially on the receiver side. The next subsection will discuss about roles of STA staff in assisting suppliers to accomplish the preparation process.

3.2.2 Inter-firm technical linkages

As just shown, STA resources were concentrated in three specific technical aspects. However, a remaining question is what determines such concentration. Taking a clue from Clark and Fujimoto (1991), we may be able to answer this point. In their comparative study of product development performance among Japanese, USA, and European car makers, they observed that on average reliance of Japanese assemblers on supplier involvement in the process of product development is as large as 70 percent of total purchased parts, indicating that only some fields that the assemblers have expertise. According to their study, parts can be divided into three major types; namely supplier proprietary parts, black box parts, and detail-controlled parts. Japanese assemblers usually have capability to carry out all development stages - from basic concept, draft drawing, prototype making, testing, approving and producing only the last type - detail-controlled parts,[19] while the first two types they rely on engineering capability of suppliers. Hence, when some detail-controlled parts were subcontracted out, the assemblers would be able to provide useful information to suppliers whenever necessary. Therefore, in this respect it makes clear then that J-firm can provide assistance in only some technical aspects that it actually has specialization.

3.2.3 STA's training strategies[20]

This part will describe the nature of STA's training plan. It includes strategies of STA team, i.e., objectives of assistance, targeted suppliers, and support methods. According to initial objectives of J-firm, it required that suppliers would have to succeed in preparing for production in accordance with the master schedule. And, the main responsibility of STA team was to assure that all suppliers would be able to supply parts for the launch of mass production of T-firm. Hence, a fundamental role of STA team was to monitor suppliers from timely schedule set in advance. In other word, STA staff were doing mainly "company visit". But by doing so, they had to have conversation with suppliers' staff (i.e., a designated responsible team). In the circumstance that suppliers had enough capability to prepare for the order, either because of they were capable or they could get support from their foreign parent company, STA team would not have to exert any effort other than routinely visit, communicate with suppliers' employees, and monitor the overall preparation processes. However, for some suppliers that revealed a possibility of delay, either because of lack of specific technological capabilities or absence of a foreign partner to provide intra-firm support, the STA team had to directly create direct linkages.

In general, the STA team was to observe and monitor seven major steps of activities that each supplier had to achieve step-by-step in order for the successful launch of mass production, which are: 1) management plan for overall project, 2) design of manufacturing process, 3) design and make tooling, 4) design and make jigs and fixtures, 5) design and prepare for the production facility, 6) operating actual mass production, and 7) control and improve productivity. From the beginning until the mass production, it had been the sole responsibility of STA team to monitor and ensure that all suppliers were able to prepare all these processes. In short, the main function of STA, if it was necessary to provide assistance, was to fill in some technical capabilities that suppliers lacked.

In the case of direct support, STA staff reported that linkage creation was aimed at suppliers that were lack of management and specific technical capabilities. And technical support was initiated from the first, management capability, to the last, being able to run and control quality in mass production. The project management is of crucial in determining the success in preparation, because inappropriate planning would lead to inefficient preparation of production process, equipment, facility, and so on, and then

the overall project would suffer a setback from delay of few suppliers. This is explaining why inter-firm technical assistance proceeded from the first to the last step. Direct efforts were accomplished by sending a number of STA staff to work at the suppliers' factory for a certain period of time. Support was provided on the job basis.[21] STA staff reported that in order to improve the management capability of these deficient suppliers, they requested them to set up a team to be exclusively responsible for the T-firm project. This is the first step to make sure that all preparations and assistance they provided would lead to a progress of the project. After that, they assisted the suppliers to design the manufacturing process, tooling, dies, and to prepare for the production facility such as set up the machine, confirm quality standard, and to confirm the tested production lot until these suppliers were able to produce and deliver good quality of parts to T-firm.

From the above explanation, it showed that deficient suppliers lacked well-systematical project management and some specific areas of technology required to produce J-firm parts. Hence, it can be argued that the priority task of the STA team was to establish a *systematic management system* necessary for the preparation of their project. In addition, due to time limitation, the most promising way of skill promotion was through the OJT basis. By employing OJT, STA staff could understand the actual situation, and then could determine the source of problems that needed to be corrected. Close communication with suppliers' staff could enhance the efficiency of skill transfer because face-to-face communication improved the quality of information flow.

My findings indicate that the main technical aspects that STA staff would be responsible for giving support lie mostly in the first five steps explained above. This is because of the fact that the sixth and seventh steps, to operate actual mass production and to control and improve productivity, could not be attained, at least by the schedule of T-firm, without direct support by J-firm. The first five steps or capabilities were prerequisites for successful mass production afterwards. Once the mass production could successfully start, technical support by STA staff would come to an end. Then, suppliers take sole responsibility to maintain and even to improve their production productivity by themselves later on, if they wish to sustain the future business with T-firm.[22]

4. Conclusion

In this paper, I have discussed actual practices of technology transfer which took place in a recent automobile project in Thailand. By looking at one project, this study found that substantial amount of efforts in promoting technological capabilities of local workers and suppliers were allocated. Findings of intra-and inter-firm practices support to Yamashita's "nine-stage of technology transfer" hypothesis, explaining that technology will be transfer from lower to higher level, and the process never ends. It was discovered that the first four levels of technology, in Yamashita's "nine-stage" model, were likely to be promoted simultaneously but an easier competence must be comprehended before the higher ones. In accumulation of such skills, OJT was an effective way at both intra- and inter-firm levels. However, at the intra-firm level, a criterion of evaluation employees' skills adopted by J-firm (explained in section 3.1) seems to have positive effect on the effectiveness of the skill formation, while to implement this practice at the inter-firm one was beyond the authority of J-firm.

Regarding technology transfer at the inter-firm level, resources were unevenly distributed among suppliers. Based on my findings, I may conclude that inter-firm technology transfer is essential for automakers but resources allocated for this purpose would concentrate in areas that the source has spe-

cialization, and lower capability suppliers are likely to receive higher amount of these resources. As the actual STA technical assistance practices presented in 3.2.3, it was observed that technical problems lie on two major areas, on the one hand, the specific technical requirement of the order itself, and on the other hand, the systematic management of the production activity. These two capabilities were not easy to observe at the early stage of search and evaluation done by J-firm. Hence, after specific relationship has been created and problems were evident, technical assistance was necessary and method of imparting skill to suppliers was to fill in technical aspects that suppliers were lacking and to create a more systematic preparation system.

Although inter-firm technical linkages can be regarded as an important means to improve technological capability, suppliers need to be aware of the importance of their internal efforts aiming at improving their technical capabilities. As suggested by Cohen and Levinthal (1989), investment in enlarging technological capability will make learning from outside (such as inter-firm relationship) becomes more likely and easier. Without conscious resource allocation, not only are benefits deriving from inter-firm relationship becoming irrelevant, but also internal improvements are hardly to achieve. Although this study focused only to a specific case, it can provide relatively new and inside information of the transfer process. More efforts should be done in this area by taking a larger number of firms or by studying other industries.

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[1] The industry is under restructuring process due to a drastic change in environment in recent years. See discussions in Thamavit et al. (2000) and Poapongsakorn and Wangdee (2000).

[2] In Yamashita (1991: 237)

[3] This is a joint venture project between a Japanese (J-firm) and an American firm (A-firm).

[4] "Intra-firm" technology transfer at the supplier level should also have significant influence on the nature and degree of inter-firm technology transfer created by the J-firm, because it is responsibility of foreign suppliers in building up their affiliates or partners in Thailand. In other word, this represents 'technological opportunity' to acquire specific production knowledge for preparing the order. However, this study is not directly concerned with this aspect, as it is beyond the scope of this study. Analysis on this aspect will be offered in another opportunity. For explanation about the effect of foreign ownership on degree of technology transfer, see Ramachandran (1993) and Urata and Kawai (1998).

[5] In addition, I was able to interview with three automobile assemblers. These interviews were to observe and compare general information about intra-firm technology transfer practice.

[6] Including 100 percent and Japanese joint ventures that use Japanese technology.

[7] There were only three non-Japanese firms replying the questionnaire, one is 100 percent owned by USA company, one by a French company, and the other one is a joint venture between French and Thai company.

[8] These inter-firm technical linkages were adopted from Hill (1985) and Kriengkrai (1997)

[9] In fact, mass production for export started in November 1998 in order to export the first lot in December 1998 as scheduled.

[10] For Japanese staff, it includes time spent in training Thai workers in Japan and in Thailand during the period concern. This idea was based on theoretical concepts and Ramachandran's (1993) in that resources expended on internationally transfer of human resource between the source and the recipient in order to bring the technology on line.

[11] Indeed, right after the project of T-firm was established, planning for construction, equipment installation, supplier searching and training plan were set up in accordance with the overall project schedule. However, results presented here were based only on activities relating to training or skill formation.

[12] At the end of period concerned, 80 Japanese staff remained working at T-firm.

[13] Information was drawn from interview with a manager of T-firm, in October 5, 2000. Note that, he was a core member in engine assemble department.

[14] Interview with two managers, one from production engineering and the other from paint shop, in March 13 and 23, 2000, also reflected a similar view. They stated that Japanese trainers always asked them to perform almost all related tasks, even a simple job like turning a screw of bolts and nuts. Underlying objectives were that, in their opinion, the trainers would like them to understand the actual work environment their subordinates will perform. And, they acknowledged that by doing in that manner, they could take all details of work into account when writing training and production manuals.

[15] Skilled operators and maintenance staff usually have to engage in daily operation so at the early stage they were required to achieve only "level 2". However, in a later stage, they were encouraged to acquire "level 3", as an incentive scheme of career path promotion.

[16] In some departments like trim and final and engine assembly, new operators would receive training their job through the use of 'training jig' located next to the production line. Trainers - experienced operators, line leaders or

supervisors - teach how to perform tasks. This process usually takes about one week or less, then new workers will be transferred into the production line where OJT really takes place.

[17] Interviews with managers of other three automakers also support this view. Interviews were done in September and October 2000.

[18] Note that, STA program was ended one month after the export schedule because J-firm wanted to assure that all suppliers were capable to supply good quality parts. Thus, the time frame of analysis will extend to cover this addition month as to include those resources spent by J-firm.

[19] Of course, core technological parts like engine and transmission, and concept design would also be performed in-house.

[20] Information in this part is based on my interview with a leader and four core members of STA project in February 20, 2001, from 14:00 - 16:00, and on the results questionnaire survey and interview with some suppliers in Thailand, during September and October 2000.

[21] Interviews with STA staff and two corresponding suppliers that replied the questionnaires confirm this fact. However, I would like to postpone detailed discussions about how J-firm accomplished technical support to these two firms to the future occasion.

[22] This is confirmed by information obtained from J-firm and interview with STA staff.