

**Globalization Strategy of Assemblers and Changes in
Inter-firm Technology Transfer in the Thai
Automobile Industry**

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Abstract

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This paper investigates the actual mechanism of ‘inter-firm’ technology transfer in the Thai automobile industry and its evolution caused by the development of the industry per se as well as the current structural changes of the industry. The pattern of ‘inter-firm’ technology transfer is explained and examined, based on the findings of two prominent case studies. The case studies indicate that the areas of technological support are equivalent to the ‘process engineering’ capability, which is the area that local suppliers lack and in which they have had less opportunity to accumulate adequate experience. Then, current changes in the production strategies of assemblers are discussed and linked to the evolution of the pattern of ‘inter-firm’ technology transfer. The assemblers’ global purchasing and production policies impose difficulties upon local parts makers. Survey results indicate that local firms have been found lacking in ‘process engineering’ and ‘design’ capabilities, due mainly to the geographic distance between the product development and manufacturing activities. These changes affect the assemblers’ technical requirements for suppliers and the content of inter-firm technology transfer. In this respect, this paper finds that, prior to the year 2000, the contents of inter-firm technology transfer had gradually evolved from simple technology - ‘operational’ technology - to a higher level - ‘process engineering’ technology. Since 2000, the current strategic changes have shifted the content to include ‘product engineering’ capability. However, only some potential local suppliers, which have had long-term relationship with assemblers and indicated an interest in participating in the ‘product development’ stage in Japan, will be given such opportunities and will benefit from the higher level of technology transfer. The suppliers’ own efforts in human-resource development seem to be the most crucial factor in maintaining and continuously developing their technological capability, which in turn will help them benefit from inter-firm technology transfer.

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1. Introduction

Because technological development does not originate in one particular nation, the economic growth of all countries depends upon the efficiency and success of the adoption of technology (Kuznets 1966, p. 287) and technology transfer (Mansfield 1987, p. 680). This is especially true for developing countries, in which international technology transfer has been an important engine for their economic development. Economists have long recognized that the essence of economic growth lies in the increase in the stock of knowledge and the extension of its application, i.e., the development of technological capability (Kindleberger 1966, Teece 1977).

Among several known means, foreign direct investment (FDI) and licensing agreements by multinational corporations (MNCs) have been important channels of technology transfer to developing countries.¹ A vast body of research has focused on these voluntary forms of technology transfer, e.g., Teece (1977), Yamashita (1991), Ramachandran (1993), and Urata and Kawai (2000), and their empirical findings significantly improve our understanding of the transfer process of these predominant forms. In the end, the main contribution of these studies has been their clarification of how the complicated process of technology transfer has been made by foreign firms to their affiliates.

However, there is another channel for technology transfer that so far has been regarded as an important channel for promoting the technological capability of local firms. This is the relationship between large, foreign and smaller, local-based firms in the manufacturing sector, which in this paper is called “inter-firm technology transfer.” Since

¹ In the case of FDI, it is sometimes called “intra-firm” technology transfer, while technological licensing is known as the “arms’ length” trade of technology (Capannelli 1997, Urata and Kawai 2000). Intra-firm technology transfer refers to instances in which foreign firms teach the technology and train local workers in their overseas affiliates or joint ventures, and the owner of the technology receives dividends as a return from the transfer of the technology. The “arms’ length” trade of technology describes a situation in which the technology is acquired through a commercial agreement and the payment is made in the form of a royalty fee.

the 1980s, scholars have recognized the possibility that host countries might benefit from FDI through this channel. Among the earliest researchers, Lall (1980), Mead (1984) and Hill (1985) emphasized that these linkages could have significant impacts on the technological development of ancillary industries in the host countries. Some empirical studies, e.g., Wong (1991), Capannelli (1997) and Kriengkrai (1997), found evidence of the existence of such linkages, which confirmed the importance of technology transfer through “inter-firm” linkages as important sources of technology for local small- and medium-scale enterprises (SMEs). Still, none of these works has offered a clear explanation of how these linkages have been created and the results of such technical linkages. The actual process seems to be obscure, and some effort is required to bring it to light. One possible reason for the lack of detailed research may lie in the fact that the inter-firm technology transfer process usually lacks any formal agreement, making it difficult to identify and observe.² Because of the dearth of empirical studies, it is essential to amass more case studies, especially of the actual practices of inter-firm technology transfer, considered in detail.

Therefore, this paper attempts to evaluate and ascertain the actual mechanism of technology transfer in the Thai automobile industry.³ The main intent of this research is to improve understanding of the process of technology transfer to locally based auto-parts suppliers in Thailand via ‘inter-firm’ technical linkages with automakers.⁴ It is of value to investigate what activities a foreign firm has had to perform when investing abroad, how it

² In fact, even with voluntary forms such as “intra-firm” and technological licensing, which have quite clear stipulations in terms of the agents (the source and the recipient), the technology to be transferred, and the forms of payment, the transfer activities as well as resources (or costs) expended, and the way to make the process successful are all obscure (Choi 2001).

³ The automobile industry is the subject of this research because, by its nature, its manufacturing process comprises various production processes and requires thousands of parts and components, and strong backward linkages could potentially create technological benefits to local parts suppliers.

⁴ ‘Inter-firm’ linkages are defined as relationships between a buyer and an independent supplier, i.e., not an equity relationship between the two, but one in which the former orders parts from the latter. This will be discussed in the next section.

transferred technology to local people and suppliers, and how it has accomplished this task. This paper will offer two specific case studies of inter-firm technology transfer.

The Thai automobile industry has been in the process of becoming a more export-oriented industry since the mid of 1990s. The Thai economic crisis forced assemblers to adjust their plans, and their significant strategic changes include the global sourcing strategy, a new trend toward using Thailand as an export base for some specific models of automobiles, and the move toward partially transferring product development to Thailand. The industry now faces global competition. The competition is significantly greater for both parts makers and assemblers. Accordingly, this paper will also discuss the current plan of automobile assemblers in Thailand, in the context of their process of restructuring after the economic crisis and their global strategic plan to make Thailand their global production base. It will examine the effects on local parts makers caused by the changes brought about by the globalization strategies and the changes in 'inter-firm' technology transfer of assemblers. The findings of this paper strongly indicate that automakers required higher capability levels on the part of the suppliers; hence, local firms need to increase their awareness of the importance of this change and improve their production accordingly, even if they continue to face limitations in meeting the three basic requirements of cost, quality and delivery. In the long run, suppliers need to find strategic technological partners; that is, they must make contractual technical agreements, or form joint ventures, to improve their technological capabilities and competitiveness.

The organization of this paper is as follows. The next section discusses the conceptual framework relevant to this study. Section 3 describes the practice of inter-firm technology transfer, including the introduction of the project studied, followed by an illustration of the actual practice of technical assistance in the two case studies of firms that received direct assistance, and an attempt to provide useful general observations about the

pattern of inter-firm technology transfer based on the case studies. Section 4 discusses the major changes in the Thai automobile industries, paying special attention to the post-crisis period (since 1997). It investigates the globalization strategies of assemblers and the effects of globalization on local suppliers and illustrates the prospect of making changes in inter-firm technology transfer. Section 5 provides concluding remarks.

2. Conceptual Background

This section will discuss three important concepts pertinent to this study: ‘technology’, ‘forms of technology transfer’, and ‘the completion of technology transfer’ at both intra- and inter-firm levels. However, it pays greater attention to the latter. Earlier works have discussed the nature of technology, noting that it can take two primary forms, namely, ‘hardware’ and ‘software’ technology.⁵ When it uses the term “technology”, this study refers to ‘skill’ or ‘software’ technologies that are necessary to perform an activity or to achieve a good quality in a part produced. To perform an activity is thought of as the ability to use tools and/or equipment to perform a particular stage of production, to test the quality of the part produced, or to manage the inventory, production flow, delivery, and such things.⁶ However, forms of technology transfer at the intra-firm level are considerably different from those at the inter-firm level. Furthermore, the willingness to transfer at the intra-firm level is theoretically higher than that of inter-firm technology transfer because of the benefit appropriability.⁷

⁵ These terminologies are also referred to using other terms. For example, Nonaka and Takeuchi (1995) call parts of ‘hardware’ technology, such as production manuals, academic papers, books, technical specifications, designs, or the like that have been codified and are transmittable in formal or systematic language as ‘explicit’ knowledge, while they call ‘software’ or ‘skill’ ‘tacit’ knowledge, which makes it, by definition, difficult to transfer. Kim (1997) adopts this concept to analyze the South Korean firms in the process of technological development. See also, Teece (1977), Samli (1985), Hayashi (1990), David (1997).

⁶ Many scholars emphasize the importance of ‘software’ or ‘skill’ or ‘tacit’ knowledge. For example, see Nelson and Winter (1982), Koike and Inoki (1990), Nonaka and Takeuchi (1995), Shin (1996), Lall (1996), Kim (1997), David (1997), Ernst, Ganiatsos, and Mytelka (1998), and McKelvey (1998).

⁷ According to Tran (1993, p. 245), MNCs prefer having majority ownership as the means of transferring technology to their affiliates at ‘arm’s length’, because such ownership allows them to control the use of technologies and to prevent possible leakage to other competitors. Ramachandran’s (1993) independent work also offers empirical results that support this point.

Looking at the intra-firm level, previous studies have defined forms of technology transfer with slightly different meanings. Still, they may be grouped into three major forms of technology transfer, as follows: 1) operation technology, 2) improvement technology, and 3) development technology (the creation of new knowledge). Each category can include several types of technology, depending on the researchers' observations.⁸ By contrast, the forms of inter-firm technology transfer do not assume the same aspect as their intra-firm counterparts. One of the main reasons is that inter-firm relationships emerge only after the supplier has been selected and approved by an input buyer. The supplier needs to possess sufficient skills to respond efficiently to the specific needs of the input buying firm (Asanuma 1989). In other words, the supplier should already have the capability to produce the ordered parts; otherwise, the buyer has no incentive to conclude a business agreement with that supplier company.⁹ Because suppliers need to possess certain skill levels, different forms of technology transfer should be observed at the inter-firm level.

In this area, previous studies, such as Lall (1980), Hill (1985), Wong (1991), Capannelli (1997), and Kriengkrai (1997), have pointed out the importance of inter-firm technical linkages. Among these researchers, Wong (1991, p. 15) has suggested the forms of technology transfer through this channel, citing both direct and indirect forms. He notes that the direct type of technology transfer, taking forms such as the giving of technical advice or even the providing of specific training courses, was not commonly observed, and he believes that the indirect types of technology transfer, such as spillover, learning facilitation, and investment inducement, are more important (Wong 1992, p. 53).

⁸ For instance, Yamashita (1991 p. 14-20) classifies technology transfer in 'nine stages', while Kuroda (2001, p. 38-40) divides the technology into ten categories.

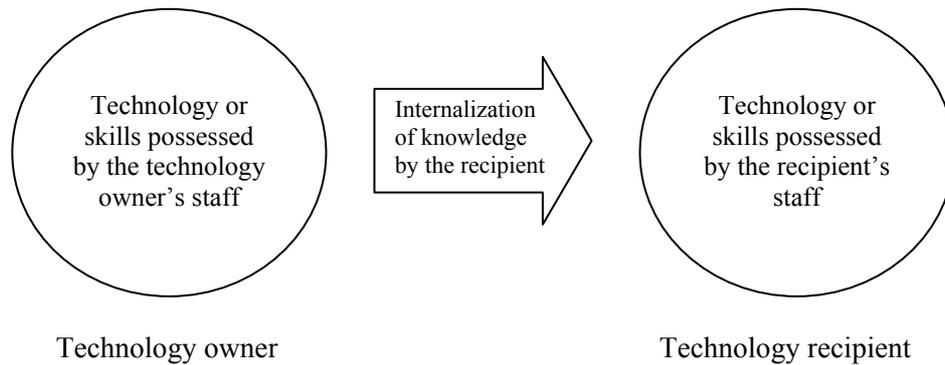
⁹ This statement is easy to agree with. Previous studies have mentioned this point; for example, Mingsarn (1993) points out that automobile assemblers in Thailand do not want to train suppliers from scratch. Kriengkrai (1997) reported that in the Thai television industry, a parts supplier does not get an order from TV makers unless it passes the evaluation process. A theoretical explanation of this process is offered by Asanuma (1989, p. 21-25), who states that a supplier need to possess a certain level of production capabilities, which are of crucial for suppliers to be selected by the input buyer.

Nevertheless, in contrast to Wong observation, some studies such as Capannelli (1997) and Kriengkrai (1997) have observed deliberate technology transfer, mostly taking the form of dispatching experts to give advice to suppliers, and, to a lesser degree, of training suppliers' staff. This implies some specific transfer costs borne by the input buyer; those costs should have a direct impact on technological improvement on the supplier's side. While the direct forms of inter-firm technology transfer are apparent, they have received inadequate scholarly attention.

While forms of technology transfer differ at the intra- and inter-firm levels, researchers have attributed more importance to the transfer of 'software' technology than they have to that of its 'hardware' counterpart. Because the terminology regarding technology has relied upon such broadly conceived definitions, the term 'technology transfer' refers to the process of skill formation experienced by the recipient, as a result of contributions from the technology source. According to Cohen and Levinthal (1989), Jensen and Meckling (1992), the transfer process is said to be complete only if the recipient of the technology understands and is able to operate, maintain, and make effective use of what has been transferred. Therefore, evidence of the success of the technology transfer would be an increase in the knowledge level of the employees of the recipient firm and an enhancement of the ability and efficiency of its production process as a whole¹⁰ On the recipient side, the process of technology transfer can be regarded as the process of the internalization of knowledge from the owner (or transferor) to their own business (at the firm level), see **Figure 1** below.

¹⁰ In their analysis of the Knowledge-Creating Company, Nonaka and Takeuchi (1995, Chapter 3) emphasize that knowledge (or technology) is not restricted to an individual, but must be possessed by all of the human resources of the firm. This concept is similar to that suggested by the "routines" concept of Nelson and Winter (1982, Chapter 5). It is reasonable to adopt the concept in the technology-transfer process because it is the process of one party's imparting of a skill to, and the recipient needs to absorb or convert the knowledge transferred, both 'tacit' and 'explicit', into its own 'tacit' and 'explicit' knowledge. This concept is also supported by McKelvey (1998, 161-162), who maintains that the recipient is said to have successfully learned a technology if it can transform the codified knowledge (which is similar to explicit knowledge) into its tacit knowledge (at the organization level). Such transformation process requires purposeful effort and resource allocation to make it successful.

Figure 1 Technology Transfer as a Knowledge-Internalization Process



Source: By the author, based on ideas of Nonaka and Takeuchi (1995) and McKelvey (1998)

Although the concept of technology transfer is easily illustrated in **Figure 1**, it is not easy to ascertain what is going on inside this ‘black box’. It is important to establish a clear scope of investigation and to choose an appropriate method of data collection to pursue this topic to improve understanding of this ‘internalization’ process. This is the main reason that field survey and the case-study approach have been deemed suitable for this study, in particular for its “inter-firm technology transfer” aspect. To achieve this goal, it is essential to understand the point at which technology has been completely transferred, as discussed above.

With regard to the effect that should be expected on the recipient side, there are several situations or effects to be observed if technology is to be considered successfully transferred. For instance, in a new establishment of an overseas project, such as the case considered in this paper, the reference point can be the time at which mass production has been launched. If the project has already been established, the effect of technology transfer can be identified as some specific objectives concerning the effort, such as the improvement of productivity, which could take a variety of forms such as the reduction of the defect rate, production time, or cost.

However, this paper looks only at the firms that have received direct technical training. Establishing this criterion is reasonable because the provider incurs a direct and substantial cost by undertaking this activity, yet the effects of training are readily apparent. It is assumed that if the source firm decides to bear some of the costs of training an independent supplier without any monetary compensation in return, it would have a clear objective in doing so. Possible objectives would be the improvement of the capability of the supplier as regards production techniques, quality of parts or delivery time. However, this result could not be assured beforehand. In-depth field survey, especially of the part of the provider, is necessary to discover its underlying reasons for undertaking such training.

3. Practice of Inter-firm Technology Transfer

3.1 General information and scope of the project studied

Before discussing the practices and effects of technology transfer further, this section will explain the scope and characteristics of the project studied. This project is a new established assembly factory in Thailand, called T-firm project, a joint venture between a Japanese firm (called J-firm) and an American firm. The plan was for the plant to commence mass production in 1998. As a result, this section focuses on inter-firm technology transfer that occurred within a specific time frame, namely, from the start of the project (in 1995) until the T-firm launched mass production for export.¹¹ The overall relationship of this project, which is important for constructing the analytical framework and the scope of this study, can be illustrated as in **Figure 2**.

As an example of an overseas automobile assembly project, T-firm's success did not rely only upon the success of the technology transfer from the parent company; it also depended crucially on the success of the activities performed by its suppliers in Japan with

¹¹ Because this paper will specifically discuss the actual practice of inter-firm technology transfer, it will present only relevant information. Details about the research methodology and the criteria for selection this project are reported in Kriengkrai (2002a).

their affiliates or joint venture firms in Thailand.¹² This is because a large part of the heuristic product development process was done in Japan, with close relationships with Japanese suppliers (or their *keiretsu* suppliers), as well as with other foreign firms.¹³ Kriengkrai and Yamashita (2001; p. 217) have argued that inter-firm technology transfer occurs because technological gaps exist between the manufacturing capability of locally based suppliers and the technical requirements of the assemblers due to the geographical distance between the product-development and manufacturing activities. Arguably, this is the main reason inter-firm technical linkages exist.¹⁴

In practice, all of the selected suppliers were basically responsible for performing all of the manufacturing tasks in accordance with the quality standards and master schedules of the buyers. However, the story is different in the case of suppliers whose parent companies had participated in the development stage in Japan and those independent joint ventures or Thai firms that had not. In the former case, J-firm's keiretsu suppliers, which had their operational bases in Thailand, were responsible for imparting manufacturing capability to their affiliates or joint-venture partners. This is the main reason that intra-firm technology transfer to foreign affiliates prevailed in Thailand (indicated by dotted arrows in **Figure 2**).¹⁵

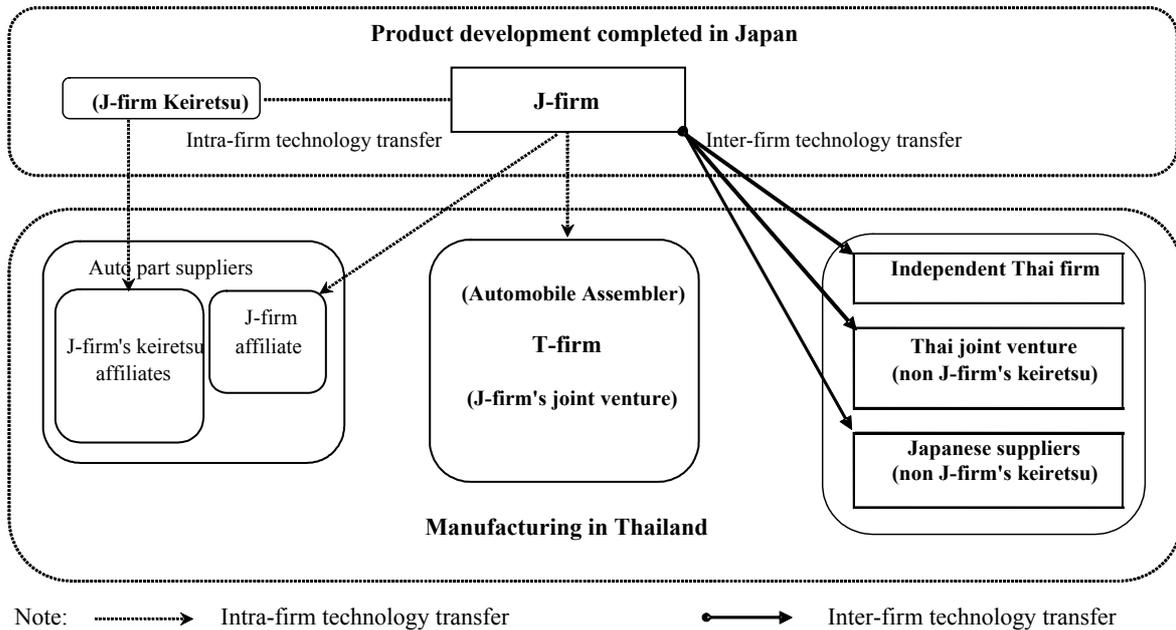
¹² The application of this statement is not only confined to an establishment of new project, but it is also true to the case of an existing company that decides to introduce a new model of automobile in Thailand, regardless that particular model might be in production in home or other countries.

¹³ See the upper part of this figure. However, it shows only the main parts of technology transfer, i.e., intra-firm technology transfer from J-firm to T-firm and by J-firm's keiretsu group, and inter-firm technology transfer.

¹⁴ As remarked by Von Hippel (1994), technological knowledge tends to 'stick to' the surroundings in which it is developed, utilized and refined. The stickiness attribute of technology per se can be illustrated by the difficulty of transferring technology, even at the intra-firm or intra-organization (Nonaka and Takeuchi 1995) level. Thus, at the inter-firm level, for local suppliers that did not participate in the development stage, the technology gap prevailed, and this in turn called for the creation of inter-firm technical linkages.

¹⁵ In fact, T-firm may import parts manufactured by some suppliers in Japan. However, this activity is not included here because it would complicate the figure.

Figure 2 A Case of Intra- and Inter-firm Technology Transfer in the Thai Automobile Industry (Case of T-firm project)



Source: Modified from Kriengkrai and Yamashita (2001)

However, some parts developed by J-firm could be outsourced to other independent suppliers, including independent Thai, joint-venture, and foreign firms.¹⁶ For foreign suppliers, there might be no problem, as discussed the previous section. But, for those independent Thai firms or joint ventures that were new to J-firm, there might have been limitations, and those firms were probably unable to prepare for mass production by themselves. Thus, inter-firm technology transfer needed to be created to ensure that all suppliers would achieve strict quality and timely delivery of parts. With this project in particular, J-firm set up a team, called the “Supplier Technical Assistance” team, to provide technical support to suppliers of T-firm.¹⁷ In the following subsections, two

¹⁶ Because these parts were developed by the automaker, suppliers had no opportunity to participate in the development stage. These parts may be called “detail-controlled” parts or “drawing supplied” parts (Asanuma 1989, Clark and Fujimoto 1991). Following Lall (1980), Asanuma (1989) and Clark and Fujimoto (1991), Kriengkrai (2002a) has argued that the types of parts seem to have influence on the inter-firm technical linkages. Since this aspect is beyond the objectives of this dissertation, it will not be discussed in the main text. This point is discussed elsewhere, in Kriengkrai (2002a).

¹⁷ Details of the STA team are discussed in Kriengkrai (2002b). However, interviews with some major assemblers in Thailand indicate that they all have this kind of activity to assist their suppliers during the

specific case studies of the actual practice of inter-firm relationships that J-firm created in the project of T-firm will be presented.

3.2 Case 1: Supplier A (A casting company)

Supplier A, a joint venture between Thai and Japanese businesses, was established in 1990 and has been producing casting parts for motorcycles. The main source of technology comes from its Japanese partner. The company diversified its business to produce auto parts by acquiring a technical assistance agreement with a Japanese casting company in order to produce parts for Isuzu Motor Company (Thailand) (IMCT). After a thorough evaluation, J-firm selected Supplier A to produce an important casting part for the T-firm project. Supplier A had to prepare the casting process and working standards in accordance with the requirements specified by J-firm; all relevant tasks for the successful launch of mass production in accordance with the schedule are listed on the left-hand side of **Figure 3**.

However, this company had rather limited experience, since it undertook the project only few years after it entered into auto-parts business. Because of this limitation, J-firm needed to provide technical support for this company. The types of support are shown on the right hand side of **Figure 3**.¹⁸ The process started in July 1997. It was essential to rebuild the systematic manufacturing process, mainly through the preparation of necessary documents such as those prescribing working standards and inspection standards, process charts, and lists of quality check points from the beginning. The target recipients were the factory manager and a designated group of engineers, with a view that they could then maintain control of the overall preparation of the project.

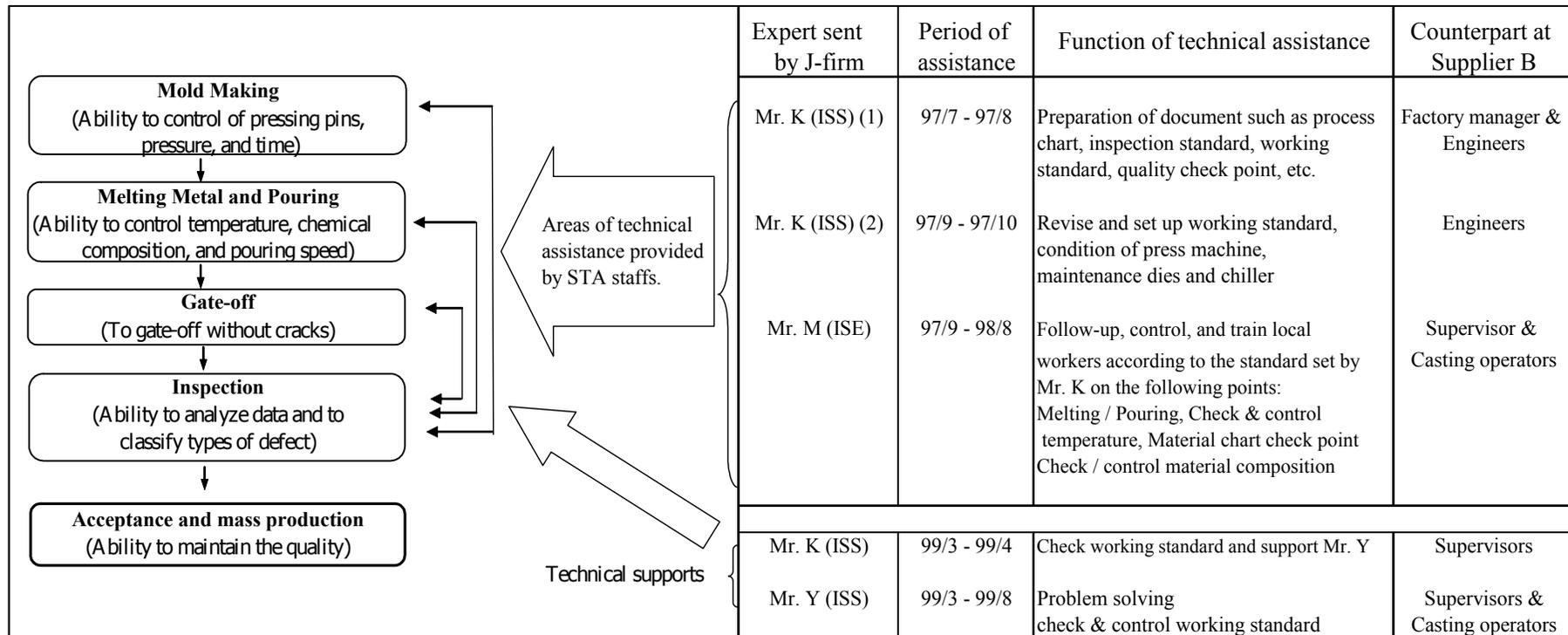
preparation period. Discussion of the actual practice in this paper should shed some light on how assemblers assist their suppliers in general.

¹⁸ See Kriengkrai and Yamashita (2001) and Kriengkrai (2002b) for a detailed discussion of technology transfer practice from J-firm to this supplier. The present paper will include some relevant parts of that study and will include an in-depth analysis to explain the pattern or step of inter-firm technology transfer in the Thai automobile industry prior to the year 2000.

The STA staff collected information from this supplier and prepared the support plan for the entire process in Japan. Starting in September 1997, one expert was sent to work at Supplier A for one year. This expert's roles were to continue controlling, working together with, giving advice to and assisting Supplier A to solve the production problems that arose, based on the standards set forth by the first person. During this period, this expert played a significant role in making Supplier A capable of controlling the quality of casting parts. His work warrants some explanation.

As seen in **Figure 3**, the most important process in determining whether a casting part is of good quality is the second stage, the melting and pouring of the molten iron. At this stage, casting operators have to master a high level of skill because, even if a good mold built but the operators poured bad molten metal, all the works would have defects. Therefore, it was very important to train shop floor operators to be able to control the condition of the molten metal, the chemical compositions, and the pouring speed. Only if all these things are well controlled would the molten metal form pieces of work of good quality. If that did not take place, all of works would be defective. Hence, casting operators were required to make keen decisions to control this process adequately. In other words, to produce good casting parts, Supplier A needed competence in managing the casting process, and this was the most important technical area that the STA team needed to provide assistance with. They tried to develop a good production system in order to improve the efficiency of the casting process as a whole.

Figure 3 Characteristics of Preparation Process of Supplier A and Technical Support from J-firm



Note: 1) August 1998 was the end period of technical assistance since every process was already confirmed. But support in 1999 was necessary because supplier B could not maintain the system and the defect was increase. For the term ISS and ISE see table 1.

- 2) Activities, In parentheses are abilities required for each activity
 Problem-solving and feedback loop to confirm working standards
 Technical supports by J-firm

Source: Based on information obtained from interview with supplier A and J-firm

To achieve this objective, the STA staff trained operators on an OJT basis. That was considered the most effective way to develop the skills of the operators within the limited time span, which was about one year. Operators could learn by doing the job, solving the daily problems that arose. Using the advice of the Japanese expert, they (the operators, supervisors, and managers) were able to learn how to identify the problems and how to solve or prevent such problems. Because of this long-term support, Supplier A was able to improve production capability and quality control and could deliver the parts on time. It was reported that ‘on-site’ defect rates,¹⁹ which were quite high before the support, were improved to meet T-firm standards.²⁰

3.3 Case 2: Supplier B (A stamping company)

Supplier B, an independent Thai firm, was established in 1986. This company acquired technology through technical agreements with many foreign companies (almost all of them Japanese firms) that specialized in the manufacture of particular products. In addition, it had a long business relationship with and had received technical support from Mitsubishi Motor Corporation (MMC). It produces a wide range of products, such as stamping dies, press parts, bumpers, chassis frames, door hinges, fuel tanks, car bodies, and exhaust pipes and mufflers, and it supplies its products to almost all automobile manufacturers in Thailand. J-firm concluded an agreement to order 87 stamping parts from this supplier. However, as shown in **Figure 4**, the product that the T-firm project planned to produce was a newly designed model. Supplier B was provided only drawings of each part by the J-firm. This was reportedly a departure from the previous production experience of Supplier B; normally, its customers provided the master model and sometimes the stamping dies as well. (This example refers to the case of production of

¹⁹ According to interview results, ‘on-site’ defect rate refers to the defects found by the quality control section.

²⁰ However, this company faced quality problem and it was necessary for J-firm to send an expert to assist. This story indicates the degree of difficulty in maintaining the production technology in question.

components of car models that were previously produced abroad, in countries such as Japan, transferred to Thailand.) In this case, information assets such as drawings, master models, and engineering solutions could be easily transferred to suppliers because all the technical issues were already resolved.²¹ Thus, in the case of this project, it seemed that the technical requirements were higher than Supplier B could meet. The different production techniques and the tight schedule for the huge number of orders accounted for the signs of delay detected by the STA team. Accordingly, there were, on average, seven staff members working long-term, that is, for about two years, at Supplier B's factory, and nearly 40 experts came to provide support in the short-term at each stage of preparation (see **Figure 4**).

Technical support was provided through the OJT method to provide training in all the processes step by step, from planning, designing, drafting a drawing, die-making, finishing, and stamping, trouble shooting, and running mass production, because that was believed to be the best and fastest way to develop the necessary manufacturing skills. The STA team requested that Supplier B set up a team, denoted as the Thai team in **Figure 4**, consisting of three sub teams, each of which comprised six to eight people. Its main function was to maintain close communication with STA, and it took responsibility for three major technical aspects, namely, the stamping process, die assembly and quality control. This request reflected a desire on the part of the STA staff to develop a spirit of teamwork and project management within the operations of this supplier.²²

²¹ This was a special characteristic of automobile models assembled in Thailand before 1995. It is also known as production of "copy model".

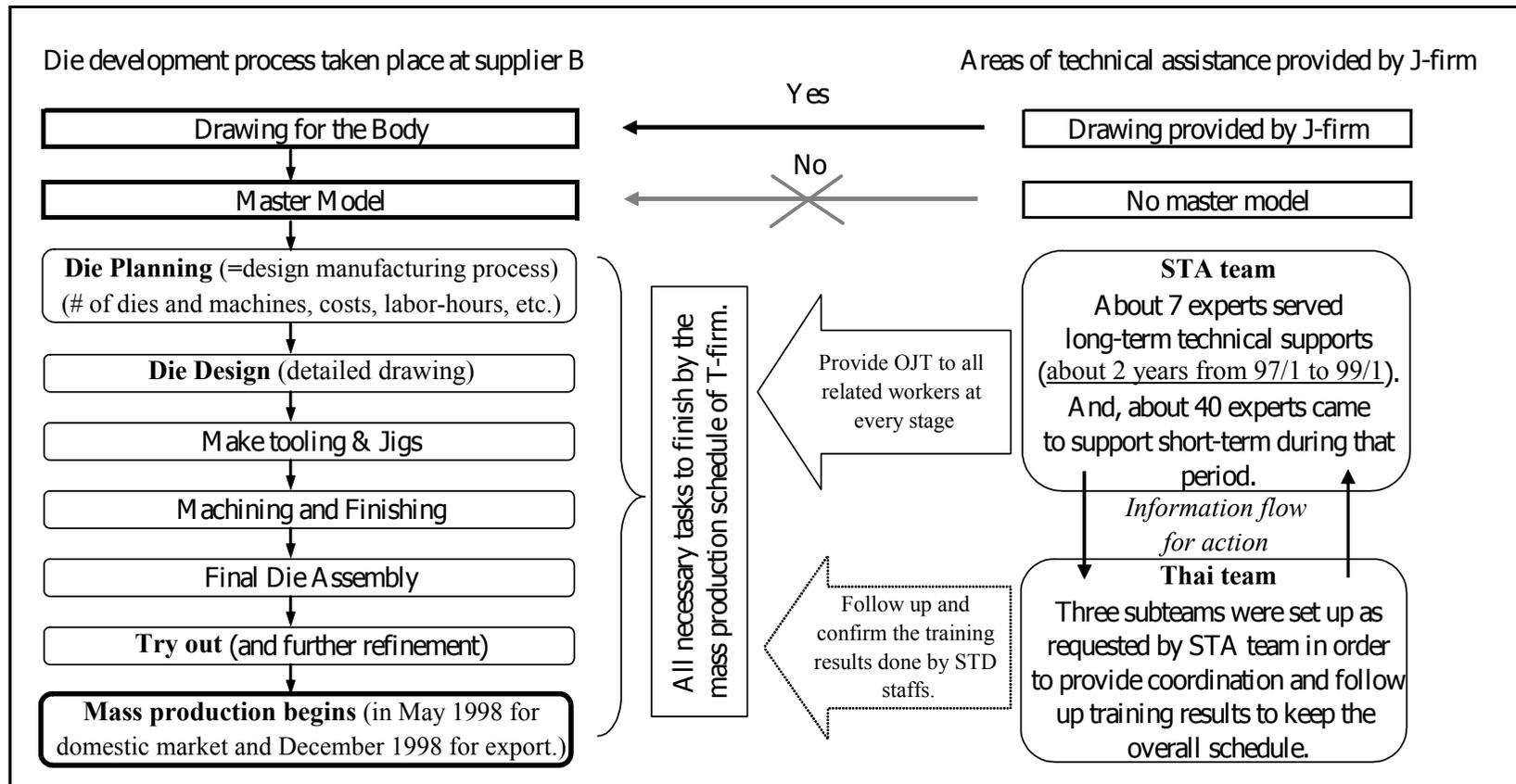
²² The technology transfer method has proceeded in a similar manner as in the case of Supplier A. It began with "socialization" process, during which the STA members shared their knowledge with Supplier B's employees. Then, the STA staff helped the Thai workers create working standards (externalization) and revise its working process through the trial process (combination). Once the conditions were met, operators were trained in that specific knowledge (internalization) and the knowledge was made part of its production routine. The process started from the first task (die planning) and continued until the last task (mass production), as shown in Figure 4.

Because of the technical support from J-firm and the internal efforts of Supplier B, this supplier was able to accelerate the schedule and deliver parts to the T-firm on time. Therefore, it can be said that technical assistance from the STA staff effectively enhanced local workers' skills. Improvement of the operators' skill resulted in a significant reduction in the defect rate. As the manager of the QC department has disclosed, the average on-site defect rate of this company has been significantly improved. In particular, Supplier B has been able to decrease the defect rate in parts supplied to the T-firm project from 400 ppm (part per million) in 1998 to about 40 ppm in 2001.²³ Moreover, the company has made exceptional improvements in its project-management capability,²⁴ and it has acknowledged that it was accredited QS9000 because of the knowledge acquired from STA support. These examples clearly show that there has been a significant improvement of Supplier B's technological capability as a result of inter-firm technology transfer.

²³ Interview with the quality control manager of Supplier B, on March 21, 2001. He also acknowledged that this improvement resulted not only from the technical assistance before the mass production began but also from the technical relationship with T-firm afterwards. It was reported that T-firm regularly sent staff members to the company and gave instructions about the T-firm's specific methods, called the "quality operating system". However, according to T-firm, this activity is a part of its supplier-evaluation program.

²⁴ It was reported that the project-management practice the STA members trained became the company's routine. The company is using J-firm's project-management and planning practices to prepare new orders from T-firm as well as other customers. Interview with assistant manager of engineering department on March 13, 2003.

Figure 4 Characteristics of Preparation Process of Supplier B and Technical Support from J-firm



Note: Information assets that may be provided by the customer Technical supports by STA staffs.
 Activities Follow up and confirm by Thai team.

Source: Based on information obtained from interview with J-firm and Supplier B

3.4 General observations about inter-firm technology transfer through the STA system

The actual practice of inter-firm technology transfer explained above supports the argument that the transfer process is complete only when the recipient can understand, perform, and maintain the production system, or production “routine”, to use Nelson and Winter’s (1982) terminology. This section will discuss the nature of STA’s training program and attempt to make general observations about the role of technology transfer by the STA taskforce, including the strategies of the STA team, the objectives in providing the assistance, the targeted suppliers, and the support methods. It should be emphasized again that the inter-firm technology transfer that took place in this project happened before mass production actually began and that such technological linkages were created to monitor and guarantee the quality of the preparation process performed by suppliers.

The process of technology transfer occurs in ways similar to the process of knowledge conversion from Japanese experts to the supplier’s employees, discussed by Nonaka and Takeuchi (1995). It proceeds from the transfer of the ‘tacit’ of STA to the ‘tacit’ of the suppliers’ staff, a process called ‘socialization’, in which the tacit knowledge of one individual is shared by another through training or actual work experience. In the first stage, the STA staff had prepared many documents concerning the project management, process charts, inspection standards, working standards, and quality check points, all in Thai. This process is called “externalization”, whereas the ‘tacit’ skill of the Japanese experts imparting

knowledge to the Thai staff was first translated into a piece of ‘explicit’ knowledge for the supplier. Then these documents were used during the trial, and some parts were revised to create other counter measures. This process of revision of these documents is called ‘combination’, wherein a discrete piece of ‘explicit’ knowledge (such as a production manual or working standard developed at the beginning of the process by the Japanese expert and the Thai team) is transformed into a new piece of ‘explicit’ knowledge (i.e., a production manual or a set of standards for the suppliers). Then, in the later stage, the working standards developed by the STA team and suppliers’ staff were introduced and utilized. The quality problems that arose from this trial were then taken into account for the revision of the working standards and training points that the STA had to provide. The process continued until immediately before the mass production began.

Carefully considered, a series of preparation processes for the successful launch of mass production is comparable to a ‘process engineering’ activity.²⁵ The cycles of modification and improvement in product-process design proceed, and the conditions require approval by the customer before the commercial production begins. Hence, it can be argued that, the ‘process engineering’ capability of every supplier is a precondition for the successful launch of mass production. Although all the suppliers had already been judged as having the required operating capability, the findings of direct technical support suggest that good operating

²⁵ Clark and Fujimoto (1991, p. 122) define a ‘process engineering’ activity as “a series of [preparation] cycles [in which the] usual progression is to develop a plan for the entire production system; develop plans for individual processes...; and conduct detailed design of tools and equipment; procure or construct and install tools and equipment; try out and test tools and equipment; and conduct a pilot run.”

capability may not be sufficient to assure the successful accomplishment of the preparation.²⁶

To validate the argument just presented, it is necessary to examine the practice of inter-firm technology transfer thoroughly by consolidating all the evidence presented earlier. As has been discussed, the fundamental role of the STA team was to monitor suppliers through periodical “company visits”. In the cases in which suppliers demonstrated sufficient capability to prepare the order, either because they already had the capability or because they could get support from their foreign parent company, the STA team would not have to exert any effort other than routine visits, communication with the suppliers’ employees, and checks of the overall preparation processes.

There were seven major preparation steps that each supplier in the two case studies had to accomplish, step by step: 1) creation of a management plan for the project overall, 2) design of the manufacturing process, 3) the designing and fabrication of the tooling, 4) the designing and fabrication of the jigs and fixtures, 5) the design and preparation of the production facility, 6) the actual operation of mass production, and 7) the control and improvement of productivity. These are the processes that the STA team checked and confirmed. For some suppliers that the STA team deemed in need of support, such support might come either by asking the parent company of the supplier, in cases in which there was one, for

²⁶ According to the interview with J-firm staff members who participated in supplier evaluation at Supplier A and B, these suppliers were found to have good reputations and excellent operational capabilities. However, these suppliers were found to possess insufficient ‘process engineering’ skills, and direct support was necessary for the preparation of a newly developed automobile model. An underlying reason for this is the higher technical requirements inherent in such a model.

support. In other cases, the STA had to provide assistance with some technical matters.

However, for some suppliers, that process signaled the possibility of delay, either because of a lack of specific technological capabilities or the absence of a foreign partner to provide intra-firm supports, so the STA team had to directly create technical linkages.²⁷ They initiated technical support from the first kind, management capability, to the last, the ability to operate and control quality in mass production. Project management is crucial in determining the success of the preparation, because inappropriate planning leads to inefficient preparation of the production process, equipment, facilities, and the like, and, as a result, the overall project suffers a setback caused by delays on the parts of a few suppliers. This explains why inter-firm technical assistance was necessary from the first step to the last.

Direct efforts were made by sending a number of STA staff members to work at the suppliers' factory for a period of time; the training was provided mainly on the job. To improve the management capabilities of these suppliers, the STA requested that they set up a team to be exclusively responsible for the T-firm project. This was the first step in making sure that all the preparation and assistance they provided would lead to real progress in the project. After that, they assisted the suppliers in designing the manufacturing process, tooling, dies, and preparation of the production facility, such as the setting up of the machines, confirmation of quality standards, and confirmation of the tested production lot,

²⁷ This fact was confirmed by the two cases of companies that were unable to obtain support from their technology partner, as discussed earlier.

until these suppliers were able to produce and deliver parts of sufficiently good quality to the T-firm. This series of preparation processes is analogous to the definition of ‘process engineering’ suggested by Clark and Fujimoto (1991). Based on these findings, it can be said that the inter-firm technology transfer process focuses on augmenting some areas of ‘process engineering’ capabilities that a supplier lacks; once the supplier can manage mass production, the inter-firm technical support ends.

From the above explanation, it can be argued that the first-priority task of the STA team was to establish a *systematic management system*, necessary for the preparation of their project as well as to transfer other essential technology, such as the working standards, operating procedures, quality-control methods, inspection techniques, and so on.²⁸ All of these information assets are crucial for further deployment in the preparation process. However, transfer of such codified technology alone cannot guarantee the effectiveness of the preparation process. This is because the effectiveness of transferring ‘process engineering’ technology requires close interaction between the supplier and the product designer who developed the part in question (Clark and Fujimoto 1991, p. 122). As in the two case studies, there was no involvement in the product development, and the parts they produce were developed by J-firm. Hence, the existence of and the ‘socialization’ between Japanese experts and local staff were extremely important

²⁸ In particular as regards Supplier B, the STA team had taught them about how to design the die, jig and fixture. This information, though hardly sufficient to be transformed into a body of codified knowledge, is believed to have brought significant benefit to this firm.

to the whole process of technology transfer.²⁹ By employing OJT, the STA staff came to understand the actual situation and then could determine the source of the problems that needed to be corrected. Close communication with the suppliers' staff members enhanced the efficiency of the skill transfer because face-to-face communication improved the quality of the information flow. Although Supplier A and B produced different parts and used different technology,³⁰ inter-firm technology transfer methods shared a similar pattern, i.e., they built a systematic management system, then promoted technical skills, and finally maintained the system.

These findings indicate that the main technical areas in which the STA staff were responsible for providing support were largely in the first five steps of the 'process engineering' discussed earlier. This is because the suppliers might not have been able to perform mass production on schedule without extensive support, according to the STA evaluation. Process engineering capabilities are prerequisites for successful mass production afterwards. Technical support by the STA staff

²⁹ This result is consistent with Cyhn's (2002) findings on technology transfer through OEM in the Korean electronics industries. Because of the tacitness of technology, the writer acknowledges the importance of interactive learning between the staff of the technology owner and that of the recipient in the process of technology transfer.

³⁰ The technology concerning Supplier A's product is casting, while Supplier B's is stamping. In the casting field, although the quality of the mold is important, it seems less so than with the stamping dies. Casting molds are formed by a mixture of sand and resin, and they can be used only one time to make a casting part, which will then be machined to make the precise dimension using another process. In contrast, stamping dies can be used for stamping more than a thousand parts, and the quality and dimensions of the part are determined by the accuracy of the die. Another significant difference between casting and stamping technology is that, particularly in these two cases, the production routine of Supplier A is repeated from making molds, melting and pouring, gate-off, and inspection, as in Figure 4, in everyday of operation, while in the case of Supplier B, each process needs to proceed step-by-step. A finished plan for the die is necessary for die design, and die design is necessary for the preparation of tooling, jigs, and machining process. In other words, an earlier process is the predecessor for the subsequent process, and once the final stamping die has yielded good quality, there is no need to reverse the process again, unless for the making of a new model. Therefore, it is clear that these two cases use completely different technologies of production.

would come to an end once the mass production could begin successfully. Then, suppliers could subsequently take sole responsibility for maintaining and even improving their productivity by themselves, if they wished to carry on future business with their customers.

4. The Globalization Strategy of Automobile Assemblers and Its Effects on Local Suppliers

The discussion in the previous section indicates not only the actual practice of inter-firm technology transfer but also the technical status of the local and independent parts suppliers in the Thai automobile industry. There are at least three main reasons for the creation of such direct linkages. First, when the project was conducted, the ‘local content requirement’ (LCR) policy was still in effect. This assembler needed to procure parts from locally based suppliers to achieve the requirement that required that 70 percent of the parts in pickup trucks be made locally. Second, historically, automobiles produced in Thailand were fundamentally the same as those produced elsewhere, called ‘copy models’. This explains why ‘process engineering’ was taught and trained in both cases. Last, it is believed that the geographic separation of the product development and manufacturing stages made it necessary for the assembler to supply technical assistance, in direct and indirect forms, for suppliers that did not participate in the development stage.

There have been significant changes in the industry since the Thai economic crisis. In addition to the general adaptations necessitated by the economic crisis, one of the most important changes has been that Thailand has

been selected as an export base for several assemblers and thus has become integrated into the global production network (GPN). New models will be produced in and exported from Thailand. In addition, the industry has become more liberalized since the abolition of the LCR after January 1, 2000. As a result, there is no requirement for assemblers to use local parts unless they are cost-competitive and their quality is acceptable. All these changes are likely to produce substantial effects on local parts firms. Because of the change in production of new models in Thailand, it is expected that there will be changes in the pattern of inter-firm technology transfer. Thus, this section, based on a field survey done by this author in 2002 and 2003, will discuss the major strategic changes of assemblers and will examine their impacts on local parts firms as well as the pattern of inter-firm technology transfer. The discussion will focus only on the post-crisis period, because it has been the period that created many of the conditions that local firms as well as policy makers should be aware of.³¹

Since the economic crisis erupted, automobile assemblers in Thailand have adjusted themselves by changing their production plans, reducing their production, temporarily stopping production, and reducing the number of workers as well as operating and working time (BOT 1999, Nipon and Chayanit 2000, and Thamavit et al. 2002), and by exporting their production overstock (Nation, October 29, 1997, and November 23, 1998), see Table 1 and Table 2.³²

³¹ Many studies have provided fairly complete documentation of the historical development of both automobile assembly and its supporting industries prior to the economic crisis. See for example, Doner (1991), Noppadol (1995), Thamavit (1997), Abdulsomad (1999), and Kriengkrai (2002b).

³² For instance, Toyota began to export Thai-made pickup trucks to Australia and New Zealand in October 1998. Nissan exported pickup trucks from Thailand in 1999. Honda began to export small passenger cars (Honda City) to Singapore and Brunei in July 1997 and to export the Honda Accord to Australia and New Zealand in 1998. In 1999, Honda exported about 7,000 to 8,000 units

Table 1 Thailand's Automobile Exports (1997-2002)

	1997	1998	1999	2000	2001	2002		
							Y on Y change	Share
Mitsubishi Motor	40,072	63,797	60,986	63,541	60,027	75,581	25.91%	41.86%
GM	-	-	-	6,283	48,987	33,276	-32.07%	18.43%
AAT	-	1,213	42,785	49,977	42,077	47,333	12.49%	26.22%
Toyota	1,563	1,819	12,151	16,031	12,027	11,882	-1.21%	6.58%
Honda	570	2,910	6,361	6,183	6,900	10,371	50.30%	5.74%
Isuzu	-	20	516	5,689	3,683	1,348	-63.40%	0.75%
Nissan	-	-	1,912	4,590	1,206	555	-53.98%	0.31%
Others	-	48	380	541	n.a.	n.a.	n.a.	n.a.
Total	42,205	69,807	125,091	152,835	175,299	180,553	3.00%	100%

Source: Source: Mori (2002), Table 3, pp. 32, Prachachart Thurakit (February 10-12, 2003), and Thailand Automotive Institute

Table 2 Vehicles and Parts Export (1996-2002)

Year	Total	CBU		Engine	Spare Parts	Jig & Die		O.E.M. Part		Others
	Amount	Unit	Amount	Amount	Amount	Unit	Amount	Body Part	Compo. Part	Amount
1996	6,295.55	14,020	4,253.36	801.98	215.44	-	43.66	373.62	602.16	5.33
1997	20,722.84	42,218	16,226.99	2,023.89	505.28	17	56.34	1,037.60	845.16	27.58
1998	34,110.33	67,857	28,125.55	1,536.77	722.79	6,013	63.7	1,347.27	2,288.36	25.89
1999	60,105.53	125,702	50,187.21	3,731.81	883.42	177	141.35	1,424.40	3,678.86	58.48
2000	83,245.46	152,835	63,349.15	7,106.22	1,245.65	-	119.96	1,556.45	9,531.17	336.86
2001	107,110.60	175,299	83,894.70	7,481.38	1,758.56	5	141.19	1,989.49	11,748.57	96.71
2002	107,729.72	180,554	82,474.66	6,087.28	1,796.41	18	145.26	2,879.77	14,196.28	150.06

Note: Amount million Baht

Source: The Thai Automotive Industry Association

(Thamavit 2001). This strategy was adopted to circumvent the insufficient domestic demand brought about by the economic slump. Automobile exports increased significantly from 14,020 units in 1996 to 42,218 units in 1997, and grew continually to 67,857 and 125,702 units in 1998 and 1999, respectively. In addition to automobile exports, a number of parts and components firms succeeded in breaking into the export markets, especially those for safety glass, ignition coils, wiring harnesses, air and oil filters, and related products.

The industry has been recovering since 1999, as can be seen in Table 3. During 2001 and 2002, the domestic market grew by 37.84 percent while domestic production grew 27.32 percent. Domestic sales increased from 144,065 units in 1998 to 409,362 in 2002, while domestic production grew from 158,130 units in 1998 to 584,951 units in 2002, which broke its previous highest record of 1996. It is expected that total production may reach one million units in 2006 (Thansettakij, March 23, 2003). The surge in domestic production is because many assemblers have decided to use Thailand as their export base, and their projects will commence in the next few years. As will be elaborated below, this period can be regarded as the turning point of the Thai automobile industry, which in turn has had considerable impacts on the industry overall.

Table 3 Production and Sales of Automobile in Thailand (1991-2002)

Year	Production				Sales			
	Passenger car	Commercial car	Total	% growth	Passenger car	Commercial car	Total	% growth
1991	76,938	206,177	283,115	(7.13)	66,779	201,781	268,560	(11.68)
1992	104,565	223,393	327,958	15.84	121,441	241,546	362,987	35.16
1993	144,449	275,582	420,031	28.07	174,169	282,299	456,468	25.75
1994	109,830	325,231	435,061	3.58	155,670	330,008	485,678	6.40
1995	127,640	398,040	525,680	20.83	163,371	408,209	571,580	17.69
1996	138,579	420,849	559,428	6.42	172,730	416,396	589,126	3.07
1997	112,041	248,262	360,303	(35.59)	132,060	231,096	363,156	(38.36)
1998	32,008	126,122	158,130	(56.11)	46,300	97,765	144,065	(60.33)
1999	78,538	248,695	327,233	106.94	66,858	151,472	218,330	51.55
2000	103,089	308,632	411,721	25.82	83,106	179,083	262,189	20.09
2001	156,066	303,352	459,418	11.58	104,502	192,483	296,985	13.27
2002	169,321	415,630	584,951	27.32	126,353	283,009	409,362	37.84

Source: Federation of Thai Industries
The Thai Automotive Industry Association

4.1 Thailand as a Production Hub and Export Base

Based on the automobile assemblers' globalization strategy for production efficiency, Thailand was selected to be a production hub in the region and in some cases the export base for destinations beyond the region as well. This is because

the country has considerable growth potential in its domestic market. The recent crisis accelerated this trend. Many firms have decided to make Thailand their export base and production hub in Asia. Currently, there are three major exporters, as shown in Table 1. Mitsubishi Motors Corporation in Thailand is the largest exporter of CBU cars. In 2002, it exported 75,581 CBUs, about 25% more than in 2001. The second and third largest exporters are Auto Alliance Thailand and GM, newcomers that began operations only in 1998 and 2000, respectively. Their exports have grown rapidly since the launch of mass production. In 2002, AAT and GM had already exported 47,333 and 33,276 units, respectively (Prachachart Thurakit, 10-12 February 2003).

In line with their restructuring plans, in particular the switch to making one-ton pickup trucks, many Japanese assemblers will shift their production to Thailand. For instance, in 2003, Isuzu will transfer all of its pickup production in Japan to the Samut Prakan plant and plans to produce 160,000 units in 2004, for Thailand and Australia, while GM's Rayong plant exports 145,000 units (50,000 CBUs and 95,000 CKDs) to other markets (www.auto-asia.com, March 3, 2001, The Nation, May 17, 2002). Similarly, as a part of the global strategy of Toyota headquarters, that company reportedly plans to shift all pickup production from Japan to Thailand. As a result, Toyota Motor Thailand's (TMT) annual production of pickups and multipurpose vehicles will rise to 200,000 units by the end of 2004.³³ It currently exports 12,000 units annually but has plans to increase that figure to 100,000 units in the next three to four years (The Nation, December 20, 2001). Moreover, Mitsubishi has announced a definite plan to expand its pickup-

³³ From http://www.toyota.co.jp/IRweb/corp_info/pr/2002/0919.html

truck production capacity in Thailand. It will invest more than 20,000 million baht for this project and most of the production will be for export. Accordingly, Thailand has been integrated into global production network of automobile production.

4.2 Globalization Policy and the More Deliberate Launching of New Models from Thailand

Globalization and the resulting intense competition in the world market are forcing automobile assemblers to improve their efficiency and competitiveness. As discussed above, Thailand has been selected as production hub in Asia by major automobile assemblers, which is a part of their global strategy to build regional divisions of labor. In order to compete successfully in the world market, every assembler needs to produce at the highest efficiency level. Products manufactured in and exported from Thailand have to meet international standards of quality, price, and timely delivery (QCD). Furthermore, automobile assemblers will implement a more aggressive cost-reduction plan for purchased parts and raw materials in Thailand over the next three years.³⁴ This means that local suppliers can expect pressure in the arena of cost reduction. In addition, as a part of their global strategy, many assemblers plan to launch new models of cars on the

³⁴ For instance, MMC Sittipol is discussing with suppliers a 22% cost reduction in the next three years (Bangkok Post, 16 January 2003, and <http://www.mitsubishi-motors.co.jp/inter/NEWS/0210-03/0303.html>).

worldwide market simultaneously (Mori 2002, pp. 33).³⁵ As regards the projects in Thailand in particular, details are provided in Table 4.³⁶

Table 4 New Model Launches Plans in Thailand (Since 2001)

Toyota	April 01 ~ New Corolla
	2002 ~ New Camry
	2003 ~ NBCS (Compact)
	2004 ~ 1tPU/IMV (vehicle for developing countries)
Honda	2003 ~ Fit derivative vehicle (compact)
	2002 ~ CR-V (multipurpose vehicle)
GM	Aug 2001~ Subaru (minivan, OEM supply)
	2002 ~ Alfa Romeo (passenger car)
	2003 ~ Isuzu 1tPU (for export to makets other than Australia)
Isuzu	2003 ~ new 1tPU
Ford, Mazda	2002 ~ Escape/Tribute (SUV)
Mitsubishi Motors	Oct. 01 ~ New Lancer (passenger car)

Note: Models in bold squares will be supplied within ASEAN 4 region (Thailand, Malaysia, Indonesia, and the Philipines). Shading indicates the models that are planned to export to outside ASEAN 4 region. "1tPU" stands for one-ton pickup truck

Source: Modified from Mori (2002, pp. 30)

³⁵ In fact, since 1996, automobile assemblers have been more conscious about introducing the production of new models in other countries, outside Japan; this pattern is especially prevalent in Thailand. See a recent study by Kriengkrai (2002b).

³⁶ In particular, as regards the Toyota IMV project, Toyota production facilities in Thailand will fill the role of supplying pickup trucks, multipurpose vehicles and diesel engines globally. Annual production of pickup/multipurpose vehicles will increase to 200,000 units, and about half of that number will be exported to more than 80 countries within and beyond ASEAN. Moreover, it was reported that Toyota will increase diesel engine production in Thailand to 240,000 units a year and plans to export 130,000 units annually. (from http://www.toyota.co.jp/IRweb/corp_info/pr/2002/0919.html)

As Thailand is gradually being integrated into automobile assemblers' global production network for some of the new models, the technological requirements for producing automobiles and auto parts will be raised, along with production volume. Therefore, it can reasonably be expected that a higher level of technology will be transferred by assemblers, not only at the 'intra-firm' level, but also at the 'inter-firm' one, to accomplish this plan.³⁷ Information in Table 5 sheds some light on the areas of technology that will be transferred at the "intra-firm" level. Apart from simple technology such as assembly, automakers need to transfer production management, supply-chain management, process engineering, engineering change to local condition, and, surprisingly, the product engineering as well.³⁸ These functions are crucial to assure the success of the launch of new models in Thailand, since they will make possible the modification of blueprints prepared by parent companies in order to use local parts (Mori 2002; pp. 32).

Japanese automobile assemblers have plans to transfer portions of the production development technology to increase the localization of engineering functions and to raise the ratio of localization (in the region). So far, the majority of product-development processes of vehicles produced in Thailand have been carried out by parent companies in Japan, while plants in Thailand have played only a limited

³⁷ When integrated into global production network of multinational firms, a country will have an opportunity to benefit from technology transfer. This happens because it provides multinational firms access to resources and capabilities that are complementary to their core competence (Ernst and Kim 2002, p. 1420). In particular as regards Mitsubishi's plan, the company is considering establishing an 8-billion baht research and development unit for a new pickup model, but it is undecided about whether it will be conducted in Thailand or in Japan (Bangkok Post, January 16, 2003).

³⁸ Product engineering refers to a series of cycles that proceed from the development of detailed blueprints for each component and major systems, after which prototypes of components and vehicles are built based on those preliminary drawings, following which prototypes are tested against established targets, and, finally, the tests are evaluated and the designs modified as necessary. The cycle is repeated until an acceptable level of performance is achieved (Clark and Fujimoto 1991: 116-117).

role.³⁹ This is true even for models that are currently produced mainly in and will be exported from Thailand, such as pickup trucks and some models of passenger cars such as Toyota Soluna and Honda City. In the future, it is likely that product engineering and engineering changes to local specifications will be transferred. Transferring the engineering function to Thailand would facilitate the in-depth information-sharing between production processes and engineering processes that allows for some modifications by Thai plants reflecting the view of Japanese automobile assemblers to make their operations in Thailand more self-sufficient.⁴⁰ Nevertheless, the transfer of product development and design will depend on corporate strategies, and the centralization of product development in Japan seems to be most economical in the current globalization trend.⁴¹

³⁹ Similar to the findings of Farrell and Findlay (2001), they note that Japanese assemblers operating abroad tend to be specialized in more labor-intensive production, while their design and research activities are quite limited.

⁴⁰ This, in turn, will affect the pattern and characteristics of inter-firm technology transfer to local parts suppliers, as will be discussed in the next subsection.

⁴¹ Interviews with Japanese automobile assemblers revealed that most product-development and design activities will remain at headquarters. Although the assemblers have a clear intention to transfer some parts of the development function, such as drawing and engineering capability to make change for local condition, to Thailand, that plan may be specific to some models. Additionally, it is more likely that those functions of the one-ton pickup truck will be the first model to do so.

Table 5 Processes that are Likely to be Transferred to Thailand

Process Stages	Individual processes	Present	Future
Product Development	Concept generation	J	J
	Product Planning	J	J
	Product Engineering	J	T
	Engineering change for local specification	J	T
Process engineering		J/T	J/T
Production stage	In-house production management	T	T
	Supplier management	T	T

Note: Product engineering is a process consisting of repeated engineering, prototype making, and testing cycles that lead to the completion of formal drawings for products and parts. J = Japan; T = Thailand.

Source: Mori (2002); Fig. 2, pp. 33

4.3 Effects of the Changes of Assemblers' Globalization Strategies on Local Parts

Firms and Inter-firm Technology Transfer

Changes in assemblers' production strategies had serious impacts on local parts suppliers, especially those without foreign partners. The impacts are generally in the form of more stringent technical requirements in the process of supplier selection. This in turn affects the contents of 'inter-firm' technology transfer, as will discussed in this section. There are at least three reasons for this. First, as discussed in Section 3, local firms normally lack 'process engineering' capability, while new models normally feature better or improved technological requirements; not only the specifications but also the design and production methods are more sophisticated and require higher manufacturing capabilities. These factors impose greater pressure on the industry, but the effect is expected to be particularly high for local parts makers. To maintain their businesses, local parts makers must improve quality and offer competitive prices to the buyers.

Second, assemblers may need to deal with suppliers that have adequate design capability. This is due to the fact that, once the product engineering processes are transferred to Thailand, it is possible that the suppliers in Thailand will have to participate in the assemblers' product-development processes and that parts will be developed jointly, as is now the case in Japan. If local suppliers cannot provide this service, they might invite their home-based suppliers to locate in Thailand. That would result in downgrading the status of local suppliers with respect to their automobile assemblers.

Third, demand for parts will increase substantially, coupled with heightened quality requirements and tighter deadlines. According to an assembler that will begin its mass production for a new worldwide export model, its demand for mold and die for the project is four-time higher than the overall capacity of mold and die making companies in Thailand. Increasing demands for molds and dies have resulted from the plan to produce new models of vehicles in Thailand. Consequently, because of the newness of the project, no mold and die are available; therefore, the mold and die industries have been impacted strongly by the rocketing demand within a limited time span.⁴²

Because of these reasons, changes in production strategies have impacts on the content of inter-firm technology transfer. As has been seen in recent field survey findings and in the discussion in this paper, from time to time, inter-firm technology transfer has evolved gradually as regards its specific contents. Based on the historical development of the industry, it is believed that the characteristics of vehicle production, i.e., 'copy' or 'new' models, determine the aspects of inter-firm

⁴² This situation is similar to the case studies presented earlier. However, based on this author's interview with local suppliers in 2002 and 2003, they reported that current situation is more severe than the past five years. Increase in both quantity and technical requirements made some of them downgrading their status with assemblers.

technology transfer.⁴³ As shown in Table 6, the technical requirements have increased from a ‘fair’ level of operational capability in 1986 (and before 1986) to a ‘good’ operational capability in 1996, and inter-firm technology transfer has been changing from the provision of ‘operational’ capability only to include ‘process engineering’ capabilities during the same period as well.⁴⁴

Table 6 Characteristics of Vehicles Assembly, Technological Requirement, and Contents of Technology Transfer

Years	Types of model assembly	Technological Requirement	Technology transfer at inter-firm level
1986-	Copy model	Operational capability (fair)	Operational capability (QCD)
1996-	Start production of new models	Operational capability (good)	Operational and process engineering capabilities
2003+	Many new models will be produced in Thailand	Operational and process engineering capabilities	Operational, process and product engineering capabilities

Source: Based on several interviews with assemblers and local suppliers in Thailand

Nevertheless, for the foreseeable future, the changes in globalization strategy have made it clear that only suppliers with good ‘operational’ (QCD) and ‘process engineering’ (E) capabilities will be selected; i.e., they must be real tier-1 suppliers. This implies that only the suppliers that could retain their status as tier-1 suppliers will continue receiving benefits from inter-firm relationships. Interviews with major assemblers in Thailand reflect the view that some potential local suppliers, which

⁴³ In addition, the level of local suppliers’ technological capabilities as well as the technological opportunity (whether or not a supplier can acquire ‘intra-firm’ technology transfer) also determine the necessity of technology transfer. That is, high-performance suppliers should be able to develop their own ‘process engineering’ capability; hence, there is no need for assemblers to make the transfer of such technology. Nor is a supplier that has a parent company or technical partner in need of the transfer of such technology.

⁴⁴ The reality of assemblers assisting suppliers to acquire operational capability was prevalent in Thailand during the end of 1980s because the LCR policy was in effect. This author has seen evidence that an assembler transferred production technology to suppliers in Thailand with formal contractual agreement (licensing agreement) as well as without (inter-firm technology transfer). Kuroda (2001) has also provided many cases of this situation. Interviews with the ‘supplier technical assistance’ team of J-firm in 2000 also confirmed this fact. They reported that only suppliers with ‘good’ operational capability were selected, and, as discussed in section 3, ‘process engineering’ capability was provided to suppliers. However, this situation applies only to suppliers of assemblers that introduced new models during that period, who then did not number as many as there will be in the near future.

have had long-term relationship with assemblers and good records as regards QCD+E and that indicate an interest in participating in the 'product development' stage will be given such opportunities. Accordingly, the content of inter-firm technology transfer will improve to include 'product engineering' capability. Nevertheless, the techniques that local suppliers would benefit from will be significantly different from the case studies presented earlier, in which the assembler sent experts to assist suppliers at their plants. Instead, to benefit from learning 'product engineering' capability through inter-firm linkages, local firms must continuously develop their 'engineering' skills and make plain their attempts to take a more active role by sending their staff to participate in the development stage with their customers in Japan. By participating in this stage, local firms will learn interactively how to improve their design through the feedback loop during the prototype development stage.

However, developing 'engineering' skills is a time- and resource-consuming activity, for which assemblers cannot wait. Therefore, at the request of their customers (automobile assemblers in their home country), several Tier-1 global suppliers of US Big 3 and Japanese assemblers have established their own subsidiary companies in Thailand or purchased the majority share of Thai companies, due to the liquidity shortages faced by local part makers after the financial crisis. They regard their operations in Thailand as part of their global network. These global suppliers have formed their own networks, including Tier-2 and Tier-3 suppliers in Thailand. For example, Delphi has formed its own network with about 20 suppliers in Thailand. All of the suppliers are joint ventures, and none is a purely Thai-owned company (Thamavit et al 2002, pp. 219). One reason is that, in accordance with their plans to

transfer production of new models to Thailand, they prefer to deal with suppliers that have design capability.⁴⁵

It is expected that local suppliers cannot be of the bona fide global Tier-1 category. This is because the trend of procurement is moving toward “modular” or “system” parts.⁴⁶ There are three major additional reasons. First, local firms have limited potential to become Tier-1 suppliers.⁴⁷ According to GM and Isuzu, a global Tier-1 supplier must have the ability to supply parts to all of their global strategic production locations in which the vehicles will be produced (Mori 2002, pp. 38). More specifically, while automobile assemblers have plans to shift the responsibility of design to suppliers, local firms usually lack design capabilities. Second, global suppliers (Japanese, US, and European firms) came to Thailand to supply parts to their customers, and these suppliers – far superior to local firms in terms of technology, management, and finances – assumed Tier-1 positions that often moved local firms to Tier-2 status.⁴⁸ Third, many local Tier-1 suppliers have been taken over by global suppliers or foreign firms after the recent economic crisis. Undoubtedly, there will be greater pressure on local parts firms because they need sufficient “process engineering” capability, which they have had less opportunity to accumulate because of the characteristics of the technical requirements of the parts ordered in the

⁴⁵ In fact, the trend of launching new models from Thailand started only in the latter half of 1990s. Previously, car models assembled locally were those produced elsewhere, such as in Japan or Europe. Interviews with some major vehicle assemblers as well as some Thai suppliers indicate that intrinsic technological requirements of the ordered parts placed by carmakers have changed rapidly because of the launch of new models from Thailand.

⁴⁶ ‘Modular’ is the word used by American assemblers, whereas ‘system’ is the term used by Toyota.

⁴⁷ Suppliers that supply ‘modular’ parts to assemblers will need to possess abilities to coordinate their suppliers of ‘sub-modules’ and to manage and ensure the overall quality of ‘modular’ parts. Moreover, they must have capabilities to ensure large volume orders as well as to participate in the early stage of heuristic product development with automobile assemblers, meaning that they need to have excellent design and engineering capabilities (Farrel and Findlay 2001).

⁴⁸ Due to its lack of design capability, a local supplier of Isuzu has been downgraded its status from Tier-1 to Tier-2 after the establishment of the global Tier-1 supplier in Thailand. Interview on June 22, 2002.

past. As a result, most of the local auto parts makers will have to downgrade themselves from Tier-1 to Tier-2 suppliers, or from Tier-2 to Tier-3 suppliers.

5. Concluding Remarks

This paper presents the actual practice of inter-firm technology transfer by a foreign assembler to local suppliers in Thailand, in the period prior to the economic crisis and the abolishment of the LCR policy. This finding confirms the willingness of a Japanese firm to make technology transfer. Japanese firms were widely criticized by Thais for their hesitancy in doing so. There was clear evidence that direct inter-firm technical linkages were provided to independent suppliers, in which cases the transferor had to bear explicit costs without receiving any monetary return. Inter-firm technology transfer is believed to continue in cases in which there is a decision to launch mass production of new assembly project in the country.

Regarding the changes after Thailand's financial crisis, the automobile industry has become more liberalized and has been forced to become more export-oriented. Moreover, assemblers have accelerated globalization strategies, including global sourcing, modularization, and the integration of models and production sites. As a result, Thailand has become the production hub in the region and the export base even outside region in the case of one-ton pickup trucks.

Most local suppliers have not been able to deal well with this change, at least in the short term. They are stepping down to a lower tier, or may lose orders in the future if they remain at the same QCD+E level they currently maintain. These changes affect the assemblers' technical requirements for suppliers as well as the content of inter-firm technology transfer. The suppliers have to upgrade QCD to survive and grow, and possibly E to be more profitable and finally become global suppliers, in which event they can benefit from a higher level of technology transfer

to include ‘product engineering’ capabilities. In some instances, internal efforts and endeavors may not be enough to reach the desired levels, thus, alliances with foreign partners could be a good way to attain these targets.⁴⁹ In total, suppliers’ own efforts in human-resource development seem to be the most crucial factor in maintaining and continuously developing their technological capability, which in turn will help them benefit from inter-firm technology transfer.

More case studies are necessary to achieve a better understanding of this issue. With more case studies, some hypothesis or theory of the ‘inter-firm’ technology transfer may be developed, in a similar manner to the ‘nine-stage’ of technology transfer proposed by Yamashita (1991). Further studies should pay attention to this changing environment in order to bring the evolution of ‘inter-firm’ technology transfer to light.

⁴⁹ In the short run, local firms should remain focused on and attempt to retain their business they have, i.e., to maintain the orders from assemblers or global Tier-1 suppliers. Since they lack both financial resources and technology, they should not be over-concerned about being Tier-1 or Tier-2, or attempting to maintain their majority ownership if their financial and technology status is fragile. In the long run, because many Thai firms still do not have their own indigenous production technology, they inevitably must search for an appropriate technology partner, even if that entails entering into types of acquisitions such as striking deals regarding technical assistance or entering joint-venture agreements.

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