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Roles of Japanese Assemblers in Transferring Engineering and Production Management Capabilities to Production Network in Thailand

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1. Introduction

Multinational corporations (MNCs)[1] have played crucial roles in the process of economic development and industrialization of many countries. When making a direct investment abroad, i.e., foreign direct investment (FDI), by establishing overseas affiliates, these multinational firms inevitably must transfer technology to and upgrade the existing skills of the local population to assure the efficiency of their foreign operations. MNCs, through FDI, can bring about indirect benefits through technology transfer and diffusion, skills upgrades and the development of local ancillary industries from backward linkages creation (Dunning 1983, Borensztein et al 1995, Markusen and Venables 1999). Therefore, FDI can act as a catalyst for knowledge diffusion and the provision of local capability formation in the recipient countries of FDI.

Since 1990s, progressive global competition, driven by trade liberalization, deregulation of trade and investment, and the revolution of information and communication technology (IT), have changed global competition by making it more dynamic. These changes have prompted multinational firms to view their global

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[1] Multinational corporation (MNC) is defined as an enterprise that controls, coordinates and manage production or operation in at least two countries. (Kohpaiboon 2005).

production as a network rather than as "stand-alone overseas investment projects" (Ernst and Kim 2002). Their operation and management need to be leaner and their supply chain network be more consolidated. Asian countries, especially China, have been selected by many leading firms to be a center or hub for their integrated production network, bringing about the geographic consolidation of some industries, such as electronics, electronics and electrical appliance, and automobiles (Yusuf 2004). This trend is expected to proliferate, and the host countries of FDI stand ready to adapt appropriately to benefit from such changes. However, there is still a lack of understanding of the impacts of being a global production network on technology transfer. Specifically, GPNs will expand inter-firm linkages and create the need for technology transfer, at both 'intra' and 'inter-firm' levels. This will create new opportunities for host economies to upgrade their industrial sectors and promote technological capabilities of locally based firms. Hence, the principal motivation of this research is to investigate the issue by looking at Thailand's automotive industry as a case in point.

The Thai automotive industry is selected as a case here because its industrialization is of relatively short duration historically. Among manufacturing industries that have been promoted there, the automobile industry is probably the only industry that the Thai government has had specific and clear goals to promote. From the beginning of its industrialization process, the Thai government has relied heavily on FDI. It regulated the industry by imposing several protective and rationalized policies to promote the automobile manufacturing activity, which in turn, triggered down to the development of supporting industries in Thailand.[2] The most important and influential policy was the Local Content Requirement (LCR) regulation, which

[2] See Doner (1991), Busser (1999), Abdulsomad (2003) and Techakanont and Terdudomtham (2004a) for more detail about the Government policies and the response of Japanese companies.

was in effect from January 1975 to December 1999. The ratio of LCR revised from time to time and it had been increased to a level of 54 percent for passenger cars and 70 percent for pickups, the level of which was maintained until the end of 1999. Several studies indicated that these rationalized policies, including LCR, high tariff protection, import ban on small cars, etc., has forced foreign assembling firms to become catalysts in promoting the growth of local supporting industries (Busser 1999, Techakanont 2002, Abdulsomad 2003). In less than 40 years, the Thai automobile industry has been transformed from an import-substitution industry to a more export-oriented one, and currently it has been integrated into part of the global production network of some specific models by many world manufacturers.

It is reasonable to anticipate car manufacturers may change their strategies in response to global competition, hence, the more strict requirements on quality and cost they impose on local suppliers can be expected. Their relationship with supplier network in Thailand may change significantly after the liberalization in 2000. Thus, it is necessary to investigate to what extent these strategies affect the content of technology transfer, how automobile manufacturers respond to such changes, how they create and enhance technological capabilities of their employees and local suppliers are of important. This study aims to contribute to the literature by examining the current technology transfer activities by a Japanese assembler and offering a new look at the technology transfer at the network level of the Thai automobile industry.

2. Global production network and knowledge transfer: a conceptual framework

According to Ernst (2004, p. 93), a global production network (GPN) covers both intra-firm and inter-firm transaction and forms of coordination, hence, it increases the need for knowledge sharing among member in the network. There will be a 'lead firm' that dominates the network, because it has capacity for integration various members within across national boundary. For automobile industry, the lead firm derives strength from its capabilities to create knowledge and mange the exchange of knowledge between different network nodes (Ernst 2004). For example, the lead firm may have several research and development or training centers, or production facilities, in many countries. Thus, it can concentrate in particular activities that are strategically important to its competitive advantage. To be successful, it is necessary for the lead firm to create and diffuse its organizational 'routines'.

In this study, we are interested in technology transfer in a 'production network'. Most scholars divide technology into two types, 'explicit' knowledge or information and 'tacit' knowledge or 'know-how' (Kogut and Zander 1992). However, researchers have found the transfer of 'tacit' knowledge or 'software' technology more important than that of its 'explicit' counterpart. Accordingly, the term technology transfer refers to the process of skill formation as experienced by the recipient as a direct result of the contributions of the technology source. The transfer process is said to be complete only if the recipient understands and is able to operate, maintain, and make effective use of the technology that has been transferred (Cohen and Levinthal 1989). Therefore, evidence of the success of any technology transfer would be an increase in the technological capabilities of the employees of the recipient firm and the enhancement of the efficiency of the firm's production process as a whole. On the recipient side, the process of technology transfer can be regarded as a learning process, i.e., the process of the internalization of knowledge (both explicit and explicit elements) from the owner (or transferor) to the recipients own businesses at the organizational level. However, only capable organizations can translate individual learning and acquired capabilities into organizational routines.

A concept that helps explain this complex issue can be found in the analysis of how Japanese companies create knowledge. Nonaka and Takeuchi (1995) maintain that knowledge (or technology) is not restricted to an individual but must be shared by all of the human resources within the firm, an idea that is comparable to the "routines" concept of Nelson and Winter (1982). This study applies this concept to the process of technology transfer because it is the process of one party's imparting a skill to another, after which 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.[3]

Nonetheless, our understanding of the ways that knowledge is transferred at the network level is far from complete. Existing literatures have mainly focused on the transfer at firm level, through formal mechanisms, such as joint ventures, foreign licensing and technical assistance agreements (Reddy and Zhao 1990). Very few studies have investigated the dynamic process of technology transfer and technological capability-formation at the network level (Dyer and Nobeoka 2000). To receive benefit from technology transfer from the network, however, the supplier needs to have sufficient technological capacity to respond efficiently to the specific needs of the input buying firm; otherwise, the buyer has no incentive to finalize a business agreement with that supplier (Asanuma 1989; pp. 21-25).

Accordingly, to explore this issue thoroughly, this study will analyze technology transfer as a process of knowledge conversion, which takes into account dynamic

[3] However, it should be noted that such successful transformation process requires purposeful effort and resource allocation (Lall 1996, Kim 1997).

factors such as time, space and the environments in which firms operate. Therefore, the conceptual framework for this study has been developed by relating the idea of technology transfer to the idea of knowledge conversion put forth by Nonaka and Takeuchi (1995). Two diagrams have been developed to represent the technology transfer at two levels, the intra-firm and the inter-firm levels. In each diagram, it proposes two major categories of knowledge, i.e., explicit and tacit knowledge, and two major performers within the technology transfer process, i.e., the technology source and the technology recipient to show the various channels through which knowledge can be communicated and created. At the intra-firm level,[4] the source, in this example, is a Japanese assembler (headquarter in Japan) and the recipient is its affiliate company in Thailand (see Figure 1). At the inter-firm level, the technology source is Japanese assembler in Thailand and the recipient is local suppliers (see Figure 2).

Theoretically, assembling plant in Thailand will receive full ‘intra-firm’ support from its parent company; therefore, it can be argued that the technology transfer and learning process of the recipient side of these two levels are different. It is reasonably to believe that the learning process at the inter-firm level would be more complicated. Conceptually, local suppliers can acquire technology in two major ways, by creating or improving their own knowledge (i.e., knowledge created inside the company) and/or by learning or expanding upon technology that has been transferred from its source (knowledge created from having a relationship with an external entity). In other words, for suppliers, internal efforts and specific investments to expand their

[4] Intra-firm technology transfer is defined as a situation in which technology is intentionally transferred by the technology source, a foreign-parent company, to its overseas affiliate. Intra-firm technology transfer is crucial because the success or failure of its overseas affiliate is determined by the quality of its transfer attempt (Sedgwick 1995). Typical transfer practices involve provision of training to the affiliate’s local people, at home and/or in the host country, and instruction and training at the work site (or on-the-job training).

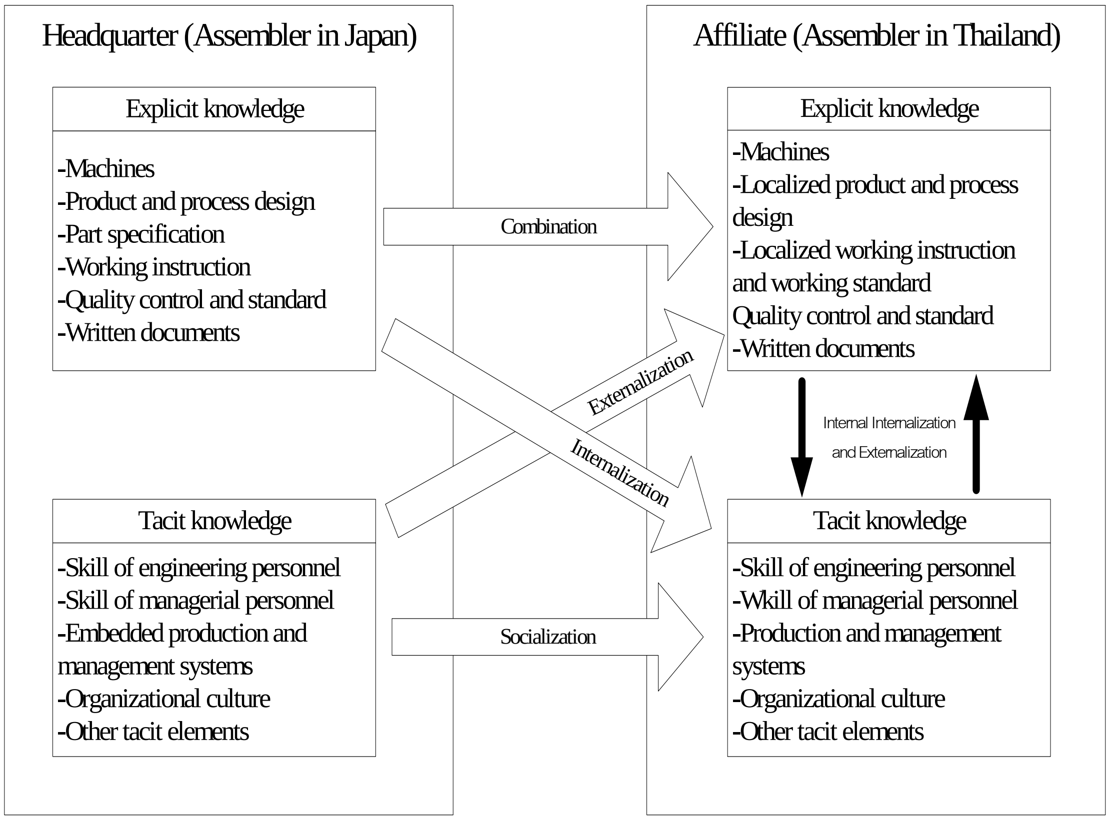
absorptive capacity are crucial factors for the efficacy of knowledge conversion. That is, local parts firms can internalize knowledge through the creation of both explicit and tacit knowledge and through the dynamic process of conversion between two dimensions of knowledge; i.e., explicit and tacit knowledge (Nonaka 1991). This is the main reason for including the absorptive capacity only in the framework of inter-firm technology transfer (as shown in Figure 2).[5]

The knowledge conversion process that takes place in both levels can be described as follows; conversion from tacit to tacit (called socialization) takes place when one individual's tacit knowledge is shared with another individual through training or face-to-face communication, whereas conversion from explicit to explicit (combination) takes place when discrete pieces of explicit knowledge are combined and made into a new whole. Conversion from tacit to explicit (externalization) occurs when an individual or a group is able to articulate his or her tacit knowledge into an explicit format, while conversion from explicit to tacit (internalization) occurs when new explicit knowledge is internalized and shared throughout a firm and other individuals begin to utilize it to broaden, extend and reframe their own tacit knowledge. As more participants in and around the firm become involved in the process, such conversions tend to become both faster and larger in scale (Nonaka and Takeuchi 1995). Nevertheless, effective knowledge conversion requires two important elements: an existing knowledge base (especially the tacit element) and an intensity of effort to develop that knowledge base. This is known as 'absorptive capacity', and it is crucial in determining how fast and successfully local suppliers can internalize the transferred technology and make it their own. Intensity of effort and commitment to the process are more important than the knowledge base because

[5] This is by no mean to neglect the importance of absorptive capacity of the Japanese affiliate. The author did not include it because it will more complicate. Technological capability of the affiliate company in Thailand can be improved by the technical support from the parent company.

the former creates that latter, but not vice versa. Thus, intensity of effort enables a firm to improve its absorptive capacity, which in turn helps it achieve technology transfer from its customers effectively.

Figure 1 Intra-firm Technology Transfer and Knowledge Conversion

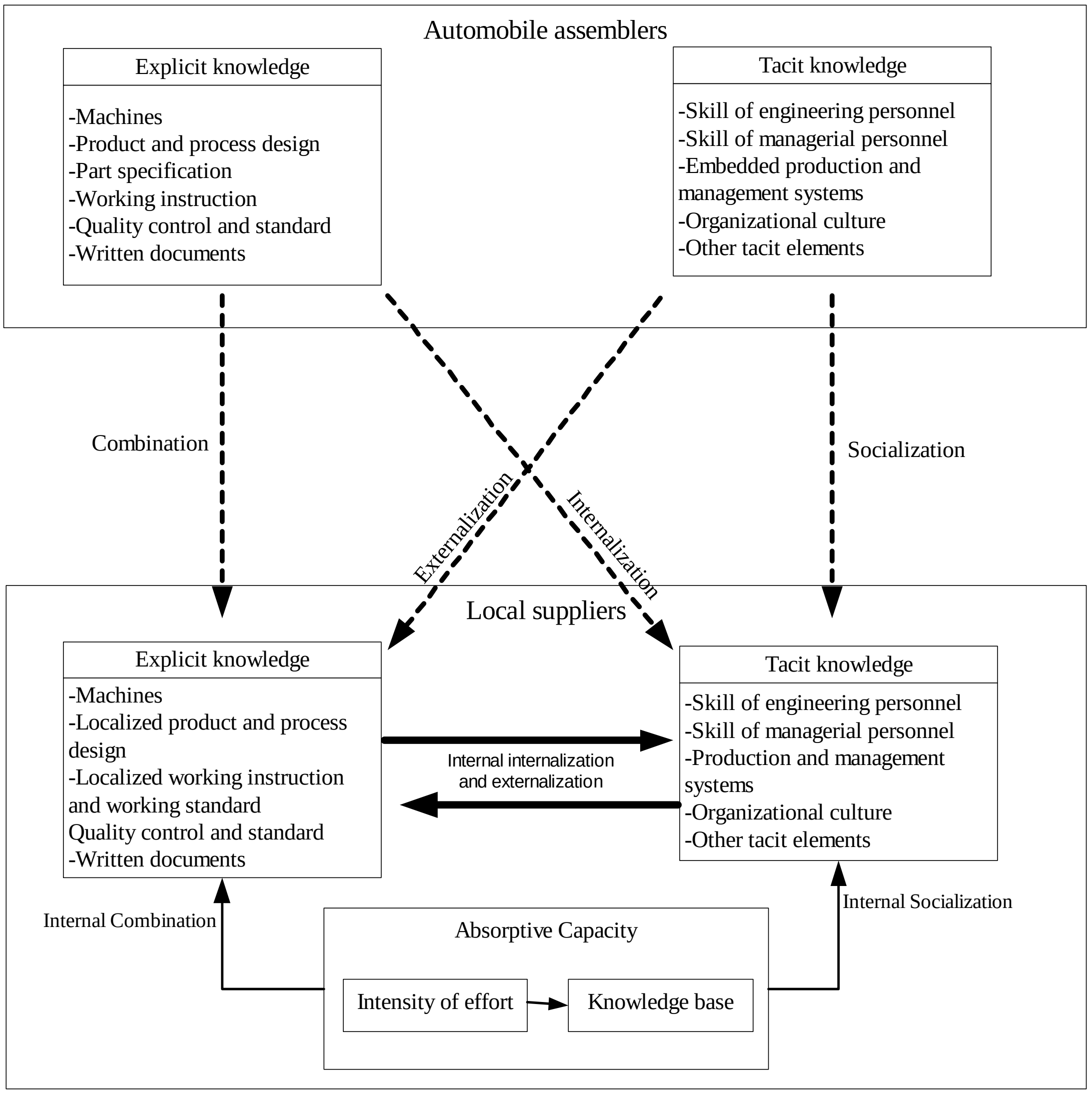


Note: ⇒ Knowledge transferred from the headquarter (Assembler in Japan)

→ Knowledge conversion within the companies (Assembler in Thailand)

Source: By the authors, based on ideas of Nonaka and Takeuchi (1995), Kim (1997) and Ernst and Kim (2002)

Figure 2 Inter-firm Technology Transfer and Local Capability Formation



Note: - - - - → Knowledge transferred from automobile assemblers

——→ Knowledge conversion within the companies (local suppliers)

Source: By the authors, based on ideas of Nonaka and Takeuchi (1995), Kim (1997) and Ernst and Kim (2002)

3. Research Methodology and General Information about Firms Studied

The main purpose of this paper is to examine the roles of automobile assemblers in promoting the technological capability of their affiliate and their local parts suppliers, or their production network, in Thailand. To enrich our understanding of the current issue, the primary data seems to be more appropriate. Thus, the author tried to obtain the 'first hand' information through several field surveys both in Thailand and in Japan. A series of exploratory interviews were undertaken to gauge the extent to which the changes within the industry would have an impact on the automobile-supplier relationship. This author visited five major Japanese assemblers in Thailand (during 2000 and 2003) and two assemblers in Japan (in 2006), and interviewed their engineers and management staff members. Main questions were about their strategies towards their operation and relationship with suppliers in Thailand. The survey results suggested that car manufacturers were changing their purchasing and production strategies in the direction of globalization, i.e., the adoption of global sourcing policy and the integration of Thailand into their global production network. This had created substantial pressure on parts suppliers, especially in the area of engineering capability, and resulted in changes in the inter-firm relationship. Basic information of firms' status in 2003 can be seen in Table 1.

Table 1 Basic Information of Assemblers Interviewed in 2003

Company	Establishment	Main products	Production capacity	Market orientation
Toyota	1960s	Passenger cars and pickup trucks	240,000	Domestic
Isuzu	1960s	Pickup trucks	189,600	Domes
Mitsubishi	1960s	Passenger cars and pickup trucks	190,200	Export
Auto Alliance	1990s	Pickup trucks	135,000	Export
Honda	1990s	Passenger cars	80,000	Domestic

Source: Information obtained from field survey during 2002 and 2003
Note: In 2003, all firms currently export their products, and some firms expand their production and export recently. They are classified as Export if they export more than 50 percent of total production capacity, otherwise, as Domestic.

In order to select an appropriate case, this author relied on secondary information, such as the plan for export and the investment strategies of assemblers in Thailand. By comparing the export of automobile from Thailand in 2004 and 2005, interesting evidence has been observed. In 2004, it was reported that export of automobiles was 332,053 units, growing 41 percent from 2003. Mitsubishi was the largest exporter, followed by Auto Alliance, Toyota, General Motors, and Isuzu (see Table 3). However, in 2005, Toyota became the largest exporter, around 150,000 units of its new HILUX VIGO, new models of pickup trucks. VIGO is a part of the Innovative International Multi-purpose Vehicle (IMV) project that was launched in 2004. Mitsubishi was the second largest exporter, follows by Auto Alliance (Thailand), General Motors and Isuzu, and Auto Alliance Thailand (AAT), see Table 2 and Table 3.

Table 2 Exports of Automobiles during 1997 and 2005 (classified by assemblers)

	1997	1998	1999	2000	2002	2004	2005
Mitsubishi Motor	40,072	63,797	60,986	63,541	75,581	88,033	88,152
GM	-	-	-	6,283	33,276	45,248	83,836
AAT	-	1,213	42,785	49,977	47,333	73,842	77,551
Toyota	1,563	1,819	12,151	16,031	11,882	52,682	151,824
Honda	570	2,910	6,361	6,183	10,371	44,564	45,216
Isuzu	-	20	516	5,689	1,348	26,954	42,938
Nissan	-	-	1,912	4,590	555	301	829
Others	-	48	380	541	n.a.	n.a.	n.a.
Total	42,205	69,807	125,091	152,835	180,553	332,053	440,715

Source: Mori (2002), Prachachart Thurakij, February 10-12, 2003, and Thai Automotive Industry Association.

Table 3 Production Capacity and Export Plan from Thailand in 2005

Company	Year of announcement to use Thailand as export base	Annual production capacity (units)	Export in 2005	Main export market
Toyota	2002	450,000	151,824	Asia, Australia, New Zealand, Ocenea
Mitsubishi	1990s	208,000	88,152	EU, Africa, Middle East
Auto Alliance (Ford & Mazda)	1996	155,000	77,551	EU , Australia, New Zealand, Ocenea
Isuzu	2001	200,000	42,938	Middle East and EU
GM		160,000	83,836	Australia, New Zealand, and Asia

Source: Compiled by the author, Thai Automotive Industry Association

To a certain extent, rapid expansion of production and export, as shown in Table 2 and Table 3, can confirm the success of the industry and the effort of foreign assemblers (especially Japanese firms) in transferring technology to their affiliates.

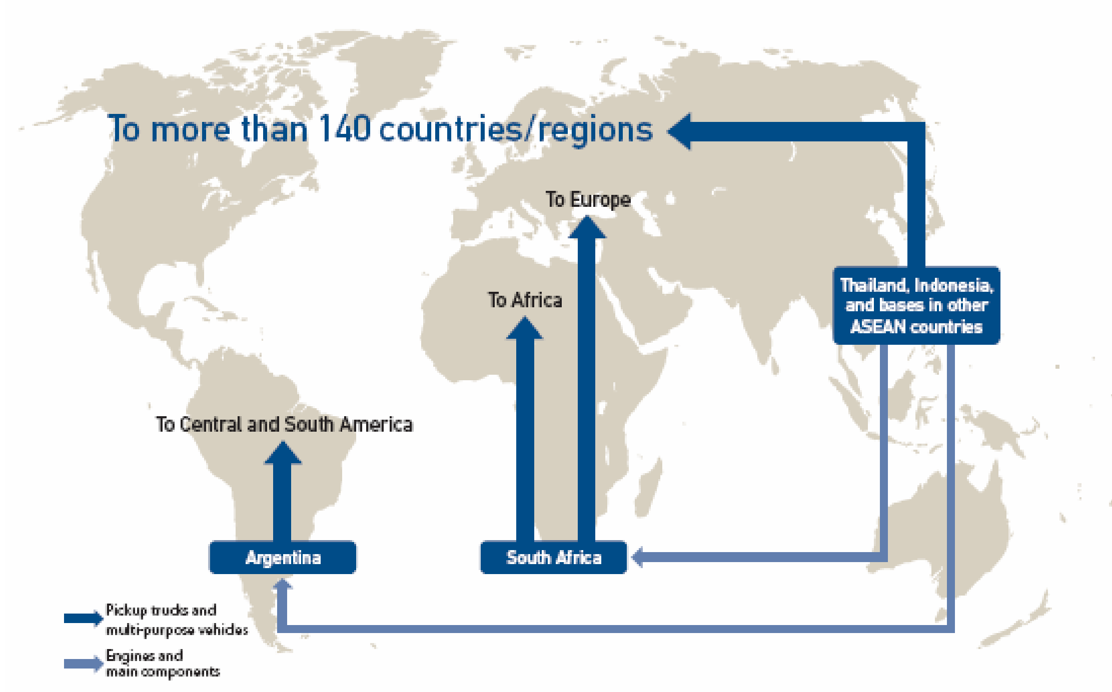
Based on several interviews with assemblers, and secondary data published by many associations as well as in newspapers, the IMV project of Toyota emerges as the most interesting case for several reasons, such as the newness of the project (which needs additional investment), the surge in production and export in the past few years, and these newly designed models are launched first in Thailand. The success of this project leads us to expect the massive of technology transfer by Toyota, hence, studying this project will contribute to the literature by adding new evidence and improve our understanding of the issue. Thus, this author had visited and interviewed management staff (both Thai and Japanese) in purchasing and human resource department Toyota Motor Thailand (TMT) during 2005 and 2006, in order to learn about the roles of Toyota in promoting engineering and design technology at the Thailand plant under the IMV project. Moreover, in February 2006, the author had visited and interviewed one Japanese manager at Toyota Motor Corporation (TMC) in Japan and interviewed with four engineers of TMT who were sent for training and working at TMC. Information obtained from this survey provided a vivid image of Toyota effort in promoting their operation in Thailand and thus confirmed the status of TMT as an important part of GPN under the IMV project. Toyota's effort will be discussed in the next section.

4. Roles of a Japanese Automobile Manufacturer in Transferring of Product Engineering and Design Technology

4.1 Background of Innovative International Multi-purpose Vehicle (IMV) Project

Toyota Motor Corporation (TMC) announced the Innovative International Multi-purpose Vehicle (IMV) Project in 2002 by launching sales of a new-type pickup truck in Thailand. The project includes 5 models newly designed for sale in more than 140 countries and customer demands for high levels of durability and comfort. It was reported in the Toyota's website that this project represents an unprecedented approach under a "Made by Toyota" banner that will rely fully on the resources and potential of outside-Japan global production and supply bases for both vehicles and components. Production will start almost at the same time at its four main production bases of Thailand, Indonesia, Argentina and South Africa, which will supply vehicles to countries in Asia, Europe, Africa, Oceania, Latin America and the Middle East. In addition, the project also includes the production of some major components in various locations, such as diesel engines in Thailand, gasoline engines in Indonesia and manual transmissions in the Philippines and India, and their supply to the countries charged with vehicle production (See Figure 3). Hence, this fact clearly confirms the status of the IMV project as a GPN.

Figure 3 Toyota's Production and Supply Network (IMV project)



Source: Annual Report 2005, Toyota Motor Corporation

Table 4 IMV Project Production Plan

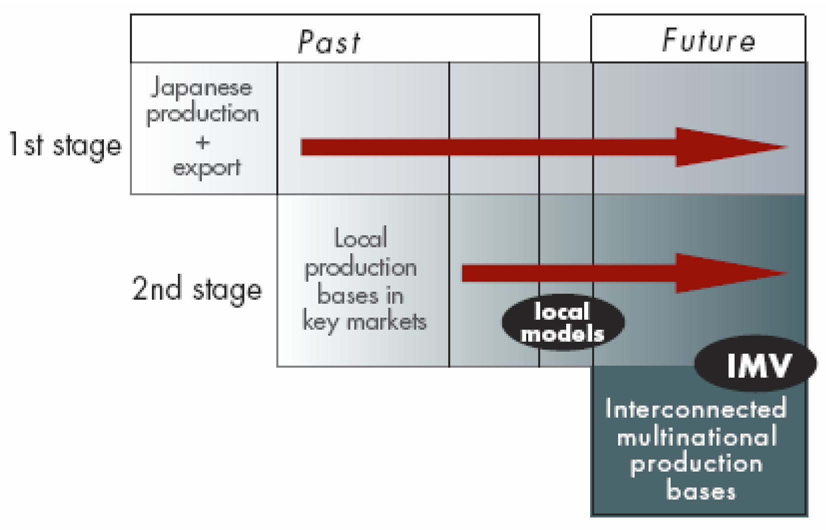
Country	Production model	Start of production	Annual production capacity	Export market
Thai	Pickup trucks	August 2004	350,000 (in 2007) (152,000 export)	EU, Asia, Oceania, Middle East, and others.
	SUV	November 2004		
Indonesia	Minivan	September 2004	100,000 (12,000 export)	Asia and Middle East
South Africa	Pickup trucks/SUV	April 2005	120,000 (in 2007) (60,000 export)	Regions including Europe and Africa
Argentina	Pickup trucks/SUV	February 2005	65,000 (45,000 export)	Central and South America

Source: Toyota Motor Corporation, Annual Report 2005

On a geographical and historical scale, the IMV project represents an advance stage of global automobile manufacturing of Toyota (see Figure 4). In the first stage, Toyota, as well as other Japanese manufacturers, made vehicles only in Japan and exported the units to world markets. This was followed in the second stage by local manufacturing in key market areas. Supported by trade liberalization, such as CEPT (Common Effective Preferential Tariff) in the ASEAN countries, many carmakers may also export from these locations, as in the case of Thailand that many firms export their pickup trucks to the world market.[6] However, Toyota has entered the third stage by taking up the challenge of building a more efficient production and supply system on a global scale. With this initiative, the globalization of Toyota’s attitude towards “making things” and “quality” is becoming more important than ever. Therefore, it is essential for Toyota to transfer technology, not only the operative levels, but also management, engineering and design capabilities to its affiliate and supplier network in Thailand. The roles of Toyota in transferring technology will be discussed in the subsequent sections.

[6] For instance, Mitsubishi and Auto Alliance (a joint venture between Ford and Mazda) have set up their export base of pickup trucks in Thailand in 1990s. They export to all over the world. However, they are different from Toyota case as they set Thailand as the main assembly of pickups, while Toyota assemble pickup trucks in four countries, with some countries producing major parts and components.

Figure 4 Stages of Toyota's Global Production



Source: http://www.toyota.co.jp accessed in July 2005.

4.2 From Product Development to Mass Production: Basic Concepts

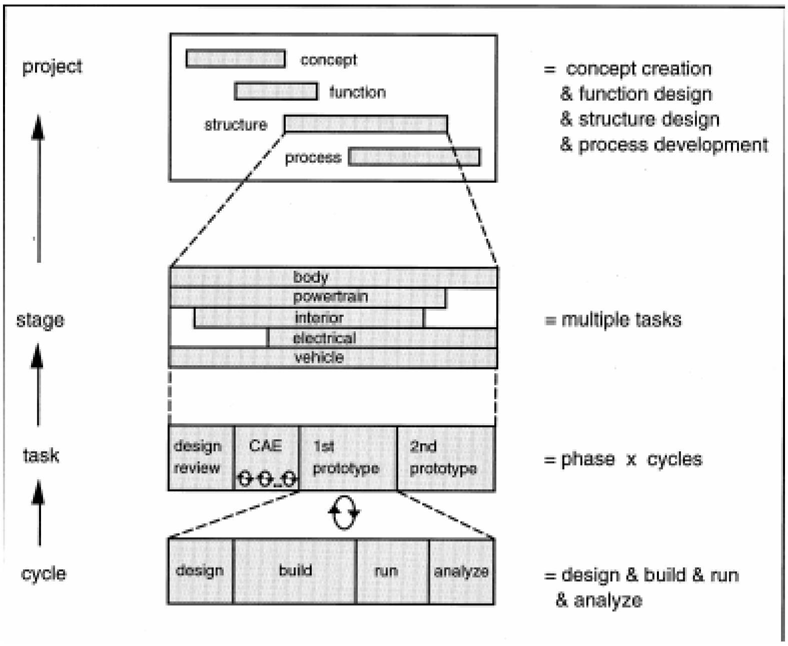
Technology transfer is necessary when a foreign assembling firm plan to launch a new model of automobile in another country. This is because the most important task, i.e., product development, must be accomplished before transferring the manufacturing of automobiles abroad. Product development activity may be divided into four major stages, namely, concept generation, function and structure design,[7] process development (or process engineering), and, finally, when these activities were complete, mass production will be launched (as shown in Figure 5).

According to Aoki (1988) and Clark and Fujimoto (1991), Japanese automobile manufacturers normally develop new products and/or new models in Japan, at their R&D center, in close collaboration with many part suppliers, both Japanese and foreign firms. Intensive information exchange between the assembler and parts suppliers normally takes place at this stage, because the assembler relies on

[7] According to Clark and Fujimoto (1991), these two stages may be referred to as "product planning" and "product engineering." In a recent study, Thomke and Fujimoto (2000) explain the these two stages were normally carried out simultaneously, hence, it is sometimes known as "simultaneous engineering."

engineering capability of the suppliers in both parts design and development. This process is usually performed in Japan because the assembler can maintain an efficient flow of information with all the suppliers.[8] Mass production would have no serious problem if it were launched in home country, because of the proximity to its suppliers and similarity of management routine. However, if this product will be produced in another country, problem and difficulty generally arise, which in turn requires the assembler to spend more resource to transfer technology to its affiliate as well as to local suppliers.

Figure 5 Stages of Product Development Activities



Source: Thomke and Fujimoto (2000), Figure 2, p. 131

In the case of Toyota's IMV project, as mentioned earlier, there were 5 newly designed models. Although Toyota has terminated its production of pickup trucks in Japan and moved production to other countries, it still handles majority of product

[8] According to a study, Kimbara (1996) reported that a supplier with design capability spent about eight months designing and developing the first prototypes for the customer, and it needed about six months for adjustments and to make the second prototype. This example can express the high degree of collaboration between the two parties, and it supports why this process still remains in Japan.

development, design, and product engineering activities in Japan. From its formal announcement, it took less than three years for launching all models in 2004, which was considerably shorter than other projects in the past. In addition to intensive technological transfer and support, improvements in information technology, such as computer-aided design (CAD), digital engineering, internet and intranet, are main factors accounting for this success.[9] Based on interviews with many assemblers, the transfer of production to overseas facilities normally occurs when the technical issues of the product engineering stage were almost complete. The most important task is to prepare for the mass production at the affiliate and to follow up all suppliers to meet the overall project schedule.[10]

For the sake of simplicity, the contents of technology transfer to Thailand may be classified into three parts, namely, 1) product development (which includes concept generation, product planning, product engineering, and engineering changes) 2) process preparation (or process engineering) and 3) mass production, as shown in Table 5. In this section, roles of Toyota in transferring engineering and design capabilities will be explained.

[9] According to Liker (2004), Toyota could shorten lead time to market, i.e., time required from product development to mass production, to only 12 months. However, the author did not explain or gave information about general characteristics or design complexity of such projects. It is believed that for the IMV project, it would require more time and resources because Toyota would have to provide technical assistance not only to its affiliates but also for suppliers in the host countries.

[10] In a similar investment project, Techakanont (2002) observed that Japanese assemblers need to provide technical support to suppliers in Thailand. A main reason is the geographic isolation between product development and production activities. Therefore, many local suppliers that had no participation in the development stage could not understand some technical requirements, and, hence, technical assistance was necessary. Currently, assemblers require that suppliers should provide some development or engineering services, thus, supply chain management becomes more critical to maintain competitive advantage. As stated in a report, Vaghefi (2001) notes that engineering and development reliance on suppliers tend to be more important for assemblers because it accounts for about 85 percent of direct production cost. This strategy can provide some benefits to assemblers, such as avoiding investment, lower associated risk, and lower costs of development and production, especially when suppliers gain more specialization. (from http://www.toyota.co.jp/en/special/toyota_philosophy/ accessed in July 2005)

4.3 Technology Transfer in Product Engineering and Design Capabilities

According to Takayasu and Mori (2004), there was clear evidence in the strategic changes and investment policies of Japanese assemblers in Thailand after 2000. Important changes were that they would increase their production in and export from Thailand, and, to accomplish that, they will transfer higher level of technology to their affiliates, especially product development, design, product and process engineering technology (see Table 5). In 2003, Toyota and Mitsubishi announced the plan to establish a research and development center in Thailand (Krungthep Thurakij, June 16, 2003), which confirms Takayasu and Mori's observation. Although, at that time, it was not clear if that would entail a new and higher wave of technology transfer, several interviews by this author showed that some assemblers already made the progress in transferring some aspects of product and process engineering to their employees, such as capability to revise some engineering design of body parts and some components that are not safety parts.[11]

Under the IMV project, Toyota took a lead by setting up a research center, called "Toyota Technical Center Asia Pacific Thailand" or TTCAP-TH, which is one of the two research centers (the other one is in Australia).[12] During the early stage, there were about 290 staff members. Most of them were engineers. After recruitment, they received training in Thailand on average three to six months, then they were sent to Japan to work with Japanese engineers in product development division about one to two years. (Prachachart Thurakij, June 16, 2003). This program is called the "Inter-company transfer" or ICT program, which is a part of Toyota Global Human

[11] An interview with Thai engineers of a Japanese assembler who were being trained at the headquarter plant in Japan indicated that they were able to do analysis and revise some engineering changes. Although each case needs to receive final assessment and approve by engineering division at headquarter, every 'engineering change notice' has to be written systematically and thoroughly evaluated before submission. Without sufficient knowledge transferred, this could not be possible (Interview on March 16, 2004, in Japan)

[12] The center is located at Amphur Bangbo, Samutprakan Province. It was reported that Toyota invested more than 2,700 million baht and commenced operation in April 2005.

Resource Development strategy (Toyota 2005). This system allows employees from overseas to work at TMC for a certain period in order to develop both business culture and technical skills in advance areas, such as product development, design, and product engineering.[13]

Table 5 Processes that are Likely to be Transferred to Thailand

Process Stages	Individual processes	Before 2002	2002 onwards
Product Development	Concept generation	J	J
	Product Planning	J	J
	Product Engineering	J	J/T
	Engineering change for local specification	J	J/T
Process engineering		J/T	T
Production stage	In-house production management	T	T
	Supplier management	T	T

Source: Adapted from Mori (2002); Fig. 2, pp. 33, and from the author's interviews with manufacturers.
Note: J and T stand for location that each process was mainly operated; where J = Japan mainly; T = Thailand mainly; J/T = Japan and Thailand almost equivalent.

Normally, each assembler has its own way to develop new product, i.e., it is the company's specific knowledge. Most of technologies and skills are embodied in organization routine and human resources, which are difficult to transfer. For Toyota, it has its own development system, called "Toyota Development System."[14] Therefore, it is necessary for TTCAP-TH to have their engineers worked and trained in Japan. On-the-job training is probably the most effective method to transfer 'tacit' skill of Japanese expert to Thai engineers through 'socialization' process. After learning such skills, Thai engineers have to transform their skill into a more explicit form, such as to develop documents into Thai language (externalization) or to improve the knowledge they have learned into a new standard (combination). This set

[13] Interview with Thai engineers and two executives of Toyota Motor Thailand, on January 10, 2006.
[14] For details about product development of Toyota, see Fujimoto (1999), Amasaka (2002) and Liker (2004)

of explicit knowledge would then be crucial for sharing with and training to other staff at TTCAP-TH (internalization).

Examples of technology that need to be transferred to Thai engineers are Toyota's development software such as CATIA (Computer-Aided Three-Dimensional Interactive Application), and digital engineering software that Toyota collaborated with Delmia (Digital Enterprise Lean Manufacturing Interactive Application), in which the project is called V-Comm (Virtual & Visual Communication). Thomke and Fujimoto (2000) reported that this software help Toyota to shorten lead time for product development because it can efficiently simulate and analyze the feasibility of design, which is the Design-Build-Run-Test cycle in Figure 5 at the very early stage of product development.[15] This digital manufacturing is changing the way Toyota and other larger manufacturers develop and create new products with advanced 3-D simulation, promising to dramatically speed the time-to-market for new products while cutting manufacturing costs considerably. Thus, these are areas that Thai engineers have to comprehend, and training in Japan was crucial in determining the success.

Interview with a Thai engineer, Mr. M, who had been working under ICT program for 2 and one half years at TMC, also support this view.[16] He was the first group of engineers recruited by TTCAP-TH in 2003. After received training about Japanese language and general technical courses of automobile production, he was sent to Japan and had been working at Toyota Development Center from January 2004 to the mid of 2006. He was a member of the development team and was

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[15] However, it is also because of Toyota's systematical record about the success and failure of design, development and engineering related issues, which enables Toyota to avoid 80% loss from inappropriate design in prior to the production of the first prototype. Accordingly, Toyota could shorten time to market by 33 percent, avoid the engineering changes after releasing the first drawing by 33 percent, and lower development cost by 50 percent. DELMIA Press release (2004), available at http://catiaworld.com/cwnews/view.asp?msgID=67, accessed in July 2005.
[16] Interview with TTCAP-TH engineer, at Toyota Technical Center, Japan, on February 21, 2006.

assigned to do job as other TMC engineers. Toyota uses a mentor system; an experienced engineer was assigned to be his supervisor. Interestingly, the training of engineer in product development (PD) team is based upon 'on-the-job training' (OJT). The contents of work and technical levels are significantly higher than other operations, such as assembling or repairing. Mr. M needed to understand how to use Toyota software, such as CATIA, and other testing equipment. Moreover, he needed to collaborate with other members in PD teams and in product engineering (PE) teams; thus, Japanese language competency was crucial for the correct communication and exchange information.[17] He evaluated that, after working in Japan for more than 2 years, he can improve his engineering capabilities and becomes more understandable in the TDS. After coming back to Thailand, he needs to be able to provide instruction to newly recruited engineers at TTCAP-TH.

Nonetheless, the main function of R&D activity will be performed in Japan. The centers in Thailand and in Australia would play supportive roles, as indicated in a company's document (An introduction to Toyota factory in Thailand), that TTCAP-TH's functions included "survey and research about consumer preference about style, technology, color, and material for parts. Then this information will feed to the R&D center in Japan to develop and design new automobiles." Therefore, it can be said that TTCAP will be the first 'engineering window' that links between overseas operations and PD team of TMC in Japan. Maintaining product development activity in Japan may provide considerable benefits to TMC, as well as other manufacturers, because of high investment in R&D facilities and the need to have close collaboration among TMC engineers as well as with other first-tier suppliers in Japan.

[17] This may be an explanation for the necessity of Japanese language training before an employee dispatched to Japan.

However, since it is Toyota's strategy to launch many new models of automobiles simultaneously in many locations worldwide (Toyota Annual Report 2006), engineering changes in function and design for local condition are important. The process of engineering changes needs to take into account suppliers' engineering capabilities, especially under the case that suppliers need to develop new parts, of which their official drawings (*Seishiki-zu*) need to have approval by TMC. Since an automobile consists of thousand interrelated parts, having all parts approved must be time and resource consuming.[18] Thus, setting up a technical center in Thailand clearly reflects Toyota's goal to establish a 'self-sufficient' production operations in order to increase localized ratio and shorten lead times to bring a new product to market (Takayasu and Mori 2004, p. 240). In the near future, TTCAP-TH should be able to approve some engineering changes by themselves.

4.4 Technology Transfer in Process Engineering Capability

The steps and procedures of technology transfer in process engineering are similar to the transfer of product and design capabilities explained earlier. The differences are about the content of technology and the location. Because Toyota has long operating experience in Thailand, this preparation process usually takes place at both in Japan and at the plant in Thailand (as also indicated in Table 5). Due to the advancement in design technology, Toyota can perform product engineering and process engineering simultaneously at the early stage of design and development. Toyota uses "digital mock-ups" software to do experiment on virtual assembly and simulate the working environment in 3 dimensions. Also, this software can analyze the ergonomics and the working condition between workers and machines digitally,

[18] Some parts had taken longer than 2 years from the first design until the official drawing was issued. Interview with TTCAP engineer at TMC, February 21, 2006.

so that Toyota can design safe and efficient assembly lines before the construction of the 'real' production lines at the factory.[19]

Even though the design of production line could be done in Japan, dispatching experts to perform the preparation in Thailand was essential because the installation of machines and equipment had to be done in Thailand. At the same time, some Thai engineers were sent to Japan for training at the production site, so that they could learn how to perform and manage the production line (tacit skills) from Japanese experts. Then, these trainees had to codify and transform their accumulated tacit knowledge into a more 'explicit' form of knowledge, which is easier to share with other staff, such as working manual or standard for operation. These documents were then studied and improved by Thai and Japanese engineers. A set of new explicit knowledge such as working manual for the operation in Thailand would be developed (combination). Finally, all of these documents will be used to train and to embed the skill into all employees (internalization). Because the transfer of this technology usually requires 'time' and 'space' for workers to 'socialize', the presence of Japanese experts in Thailand is one crucial factor in determining the success of technology transfer.

The SECI process explained above is the task that Toyota has to accomplish. The process is similar to the observation of a previous study by Techakanont (2002) in a sense that Japanese assemblers aim to develop the skill of "trainers," which will be crucial in passing on the skill to their peers and/or subordinates. Usually, the preparation stage requires enormous supports from headquarter in forms of man-hour of experts and training program for local staff, for instance. With this projection and the intense competition in the global market, Toyota responded by establishing

[19] This is a part of the V-Comm project, in which engineers of Toyota can perform the simulation from V-Comm rooms in different locations simultaneously.

"Toyota Global Production Center" (GPC) in July 2003. The mission of GPC is to rapidly instruct large numbers of mid-level plant managers from overseas and Japan in best practices. A reason behind this establishment is because of globalization strategy of Toyota; as can be seen in the following statement;

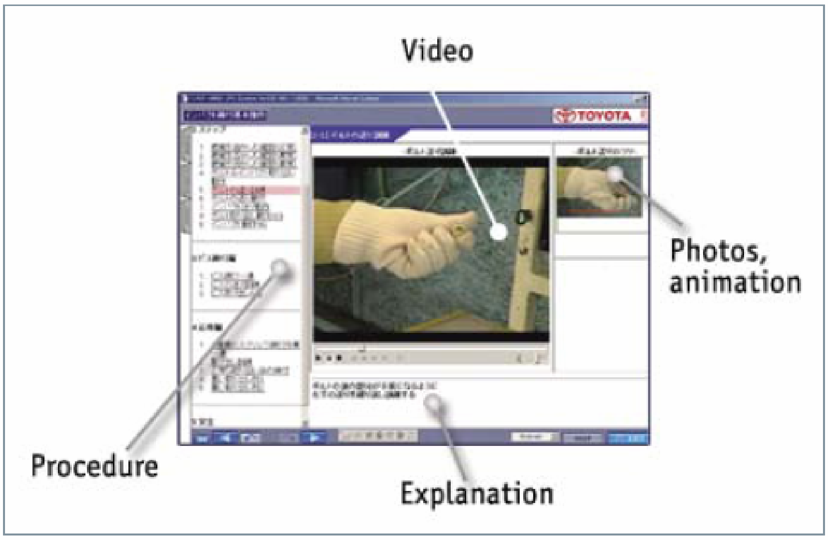
> Toyota sees increased self-reliance for overseas affiliates as essential to successful worldwide expansion. With over 50 manufacturing sites in 26 countries and locations worldwide, Toyota's traditional "mother plant" system of support has been stretched. Toyota's overseas vehicle production posted a year-on-year increase of 18.7% in CY2003 and is on course to rise another 20% in CY2004. "We must advance our competitiveness by developing more efficient training to support overseas manufacturing efficiency and quality," explains Toyota Executive Vice President Kosuke Shiramizu. [20]

The GPC has an objective to reduce resources and costs that the headquarter has to support their overseas facility, at the same time, it aims to provide 'best practice' operation skill to middle class managers. Toyota emphasizes the importance of tacit knowledge of its employees, as it is the key element of the Toyota Production System. One of the main achievements to promote this is the development of "visual manuals." Visual manuals are created because Toyota sought a "common base" for manufacturing at Toyota plants worldwide. Also, this means that Toyota has to find and organize the best practices and eliminating individual methods that rarely written down. In doing so, Toyota "selected and organized the best practices for each skill and applied digital technology to compile these methods into 'visual manuals,' keeping text to a minimum, while using photos along with short animation and video clips to facilitate rapid comprehension." The manuals also have slow-motion videos clips which enable trainees to grasp skills of experts who tend to demonstrate too

[20] Toyota Special Report, compiled October 8, 2004, http://www.toyota.co.jp/en/special/gpc/gpc.html, accessed July 2005.

rapidly. The use of animation with necessary explanation can be regarded as an attempt to 'decode' the 'tacit' skills of experts into a new form of 'explicit' knowledge that can be efficiently shared and learned by other staff. As a result, Toyota can reduce the time and resources spent on support its overseas plants and on training their staff globally. In 2003, it was reported that GPC had about 2,000 visual manuals in stock, covering a vast repertoire of automotive assembly processes.

Figure 6 An Example of Visual Manual



Source: http://www.toyota.co.jp/ accessed in July 2005.

For efficient and effective skills training, trainees will be trained through four stages at GPC (see also Figure 7):

(1) Trainees acquire basic knowledge using visual manuals.

(2) They practice fundamental skills — such as how to tighten screws so they are not too loose or too tight — at specially designed work tables.

(3) They progress to "element work" training, such as joining a door lock rod and door handle.

(4) They learn the basics of standardized work, including how to start and end an operation, the *kanban* system of just-in-time parts ordering and how to use the *andon* system to halt the line if there is a problem.[21]

Figure 7 Training Steps at GPC

Source: http://www.toyota.co.jp/ accessed in July 2005.

Carefully considered, the training practice of GPC is consistent with the SECI process of Nonaka and Takeuchi (1995). It begins with the assembly of experts in manufacturing skill (socialization) in order to create best practice manual (externalization). Then, each manual will be developed into a new form of explicit knowledge (combination), i.e., the 'visual manual.' This manual is then used in training. Trainees can learn from the visual manuals and then assimilate such skill into their skill (internalization).[22]

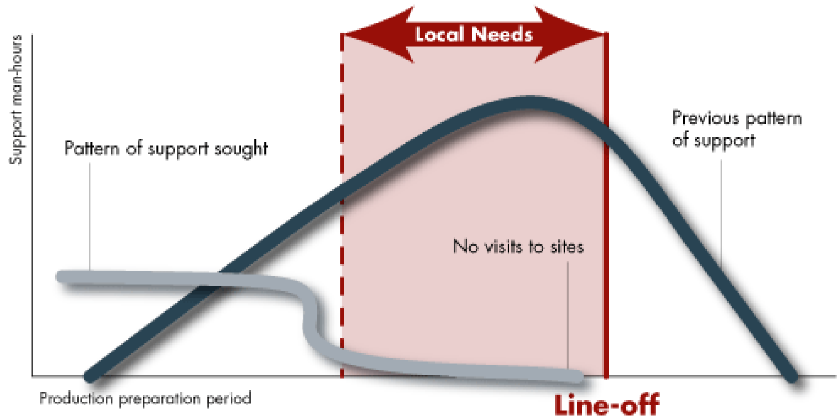
Because of this efficient method of training, GPC is augmenting this capability to reduce preparation time and minimize the need to send personnel to overseas sites to supervise training for new-model assembly. It is reported that Toyota can reduce training costs by 50 percent, while improving the training effectiveness by 6-7 times.[23] The aim of GPC to reduce support resource can be seen in Figure 8. Although the GPC was established after the announcement of the IMV project, it is believed that the GPC was not fully utilized for this project. Hence, sending Thai

[21] Kanban, Just-in-time, andon are some basic skills of the Toyota Production System (TPS).
[22] However, the participation with Japanese experts, or trainers, during the training is important for the transfer such skills.
[23] It should be noted that advancement in digital information systems is one crucial factor behind the Toyota's GPN success. Engineers across the world can now share and exchange information in order to solve some technical or engineering problems effectively and at much less cost. This involves video conferencing and real-time data exchange, as well as skill transfer and training (Ernst 2004, p. 108).

trainees to train in Japan and dispatching Japanese expert to train staff in Thailand was necessary.

Two years after it's opening, GPC trained more than 4,600 employees of Toyota worldwide, and it plan to maintain the training level of 2,000 employees a year. Moreover, Toyota also established three GPC branches in the U.S., Europe (in UK), and Asia (Thailand) in order to promote global scope of training for professional production site managers (Toyota Annual Report 2005). As a part of its GPN, Toyota established a GPC branch in Thailand in August 2006. This center, called Asia-Pacific GPC or AP-GPC, will provide training for Toyota network in Asia-Pacific region. There are currently 16 Japanese and 8 Thai trainers (who had complete training courses and obtained a certification from GPC), but in the future, the number of Japanese trainers will be reduced and more trainers from Asia will take this responsibility. Thus, this confirms the status of Thailand as one important part of Toyota GPN in this region.

Figure 8 Aim in Reduction in Support during the Preparation Stage



Source: http://www.toyota.co.jp/ accessed in July 2005.

4.5 Technology Transfer in Production Management: the Toyota Production System

As GPN usually covers both intra-firm and inter-firm transactions, i.e., production of final products and in-house parts versus procuring parts from local independent suppliers, the lead firm of the network, in this case Toyota, needs to create an effective mode of coordination to link together its affiliates, joint venture suppliers, as well as independent suppliers in Thailand. As Toyota Motor Thailand expanded their annual production capacity from 200,000 units in 2003 to 350,000 units in 2005. This calls for a more systematic production management system of its operation and of its suppliers. Therefore, it is essential for Toyota Motor Japan to transfer and spread its strength in production management system, called "Toyota Production System" (TPS). For the Thai plant, TPS has been initiated since 1987. It was a part of activities that TMT had with their supplier network, called Toyota Cooperation Club or TCC), that tried to promote cost reduction activities.[24]

Since 1998, during the economic crisis, TMT began to promote TPS aggressively for TMT staff as well as supplier network. This is known as "Toyota Way." At first, Toyota tried to implement only in its factories. Since 2001, this activity has been promoted to suppliers, as will be explained later in this section. In essence, TPS consists of three main activities;[25]

1. Just-in-Time: produce right parts, right amount, at the right time.
2. Jidoka: in-station quality control – making problem visible and never letting a defect pass into the next station.

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[24] However, TPS has been developed and become a main activity among TCC members since 1994. There were only 4 firms participating at that time, however. Interview with a Japanese advisor, Purchasing department of Toyota Motor Thailand, on August 17, 2005.

[25] TPS was developed by Taiichi Ohno and was applied not only to the shop floor of Toyota plants but also spread to suppliers (Liker 2004, p. 32). In fact, TPS consists of many sub-activities under these three main activities. For reference about the TPS, see Ohno (1988), Fujimoto (1999), Liker (2004).

3. Kaizen: continuous improvement that encourage employees to suggest new ideas to reduce waste and improve productivity.

It should note that the "Toyota Way" is not merely a tool that anyone can adopt and utilize efficiently without effort. There are other issues, such as corporate culture, organizational routine, and vision. The gist of the system is the 'kaizen' mind and the core factor is the company's human resource. The TPS can be prevailed in organization that had well-trained staff with kaizen mind. Without that, JIT and Jidoka will be meaningless. For instance, if an operator found a defect in the line and did not hold the 'andon,' the line will not stop, the problem will not be corrected, hence, the utmost quality of product cannot be achieved. Therefore, the human resource department of Toyota is important to provide training to their employees and to develop evaluation scheme in order to ensure the effectiveness of training. TMT also promotes the TPS at the management level. For this purpose, in 2004, "Toyota Academy" was established as the training center for promoting TPS. It offers several courses for senior executives and executives of its affiliates, suppliers and dealers. In 2004, it offered 6 courses. In 2005, the number of courses increases to 15 courses. The number of courses and attendees are expected to increase in the future, indicating the long term commitment of Toyota to diffuse its technology to all parties involved in its supply chain in Thailand.

4.6 Transfer of Production Management Technology to Supplier Network in Thailand

As discussed earlier, the expansion of production in recent years has forced Toyota to put more effort in develop technical and managerial skills of Thai staff. Introduction of new model of vehicles for export, assemblers and part suppliers are under pressure to meet the international quality standard and competitive price. Thus, car manufacturers are demanding tougher requirements on their suppliers. Recent studies have reported that there is no longer time for local part suppliers to adjust themselves (Takayasu and Mori 2004). To participate in the network, suppliers should have certain level of engineering capabilities, especially design and product development capabilities (Techakanont and Terdudomtham 2004b). Thus, suppliers have needed to be aware that there were also other ways to respond to the heightened technical requirements from automobile assemblers in order to retain their customers' business. This will allow them to benefit from network participation, such as to upgrade their technological and managerial capabilities (Ernst and Kim 2002).

For TMT, to maintain and improve its competitiveness, it needs to spread the application of TPS to cover not only its own staff, but also the manufacturing of parts (i.e., its suppliers). Based on several interviews with Toyota staff and suppliers in Thailand, this author found that Toyota has put considerable effort to create a high-interconnected network that will facilitate knowledge sharing among members in the cooperation club, which was initiated in early 1980s, with small number of members. The number of suppliers in this club steadily increases and in 2007, there are about 150 members.[26]

The company initiated an action to promote the TPS at the manufacturing level at the production site of suppliers. This activity is conducted by a team of specialists in the purchasing department. They will rove from time to time to instruct and assist suppliers to implement a TPS model line in their operation. This program is run on a voluntary basis. TPS activity is a voluntary activity and suppliers in the "Toyota Cooperation Club" can apply for this program. However, in 2000, there were 8 suppliers joined this activity, and the number of member grew continuously to 78

[26] However, the detailed discussion of TCC will not given here. Rather, discussion will be on the role of knowledge sharing among Toyota and suppliers.

members in 2006 (see Table 6). In 2004, Toyota established a team called TPS Promotion within the purchasing department. There is one Japanese advisor and a group of Thai engineers working in this team.[27] The recent increasing number of suppliers participating in this activity may be an evidence of progressive effort of TMT to spread TPS philosophy to its supplier network in Thailand.

Table 6 Number of Firms Participated in TPS Activities

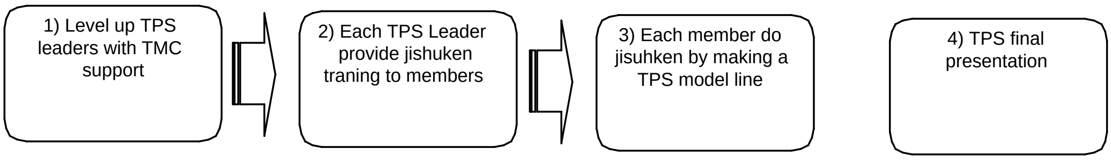
Year	Firms participated	Leader
2000	8	2
2001	12	2
2002	22	3
2003	40	6
2004	44	8
2005	60	8
2006	78	n.a.

Source: Information obtained from interview with Toyota staff

The concept of TPS activity is 'voluntary study groups' (*Jishukenkyu-kai or jishuken*). Suppliers were divided into small groups, according to geographic proximity, competition (direct competitors will not in the same group), and experience with Toyota. Each group has six to eight members with a TPS leader, usually first-tier supplies (such as Denso and NHK) that are capable and familiar in TPS activity. TPS promotion activity in Thailand has 4 major steps. Firstly, TPS members will set the theme, such as productivity or quality improvement by implementing TPS, and TMC will support by sending some experts to work together with the TPS leaders. Secondly, each leader will establish a schedule to for *jishuken* training for members in the group. After each member understood the topic, they will try to implement in their operation line. Lastly, each team will present their result at the TCC annual meeting. The process can be summarized in Figure 9.

[27] Interview with a staff of Toyota's purchasing division, March 7, 2004.

Figure 9 TPS Promotion Activity Concept



Source: By the author, based on interview with TPS promotion staff members

However, TPS promotion team does not only convene the TPS activity explained above. This team also plays a role as 'consulting teams/problem-solving teams' for TMT's suppliers. This is similar to the observation of Dyer and Nobeoka (2000). This assistance is 'free' to suppliers, and one supplier disclosed that by participating TPS promotion, it could lower inventory significantly. Although this firm did not have clear statistics, but the managing director gave a clear example, "we can transform a warehouse, which previously used to keep inventory, into production facility." Clearly, productivity and utilization of the facility of this supplier has been very much improved after implementing TPS concept to its production lines.

Regarding supplier evaluation, TPS promotion team also follows up the TPS activities of suppliers. They visit every supplier and evaluate several aspects related to TPS, such as quality, cost, delivery, just-in-time system, the use of *kanban*, for instance. Evaluation results show that local suppliers are still in the learning process to realize the benefit from their own 'TPS'. Some concerns on this limitation of suppliers to successfully adopt TPS successfully are the lack of skilled labor or responsible organization within the company, no designated team to follow up and maintain the system, lack of knowledge sharing within organization. Although TPS is relatively new to Thailand, this preliminary finding clearly shows the willingness of Toyota to transfer management technology, such as TPS or lean manufacturing, and to encourage knowledge sharing among supplier network in Thailand.

5. Concluding Remarks

The Thai automobile industry has become an export base and integrated into production networks of many Japanese car manufacturers. Progressive global competition has led Japanese firms to consolidate their dispersed operations as a network. This research investigates the Thai automobile industry's relatively recent integration into the global production network and examines how this situation has affected the pattern of knowledge transfer to production network of a Japanese firm.

In examining the roles of foreign automobile manufacturers to transfer technology, this research selects the case of Toyota's IMV project as a case study. In response to intense competition, Toyota has integrated Thailand into a part of the global production network of its multi-purpose vehicles. Research findings on IMV project and recent Toyota's activities confirm that higher technological capabilities, such as product engineering and design activity, have been transferred to their affiliates in Thailand. Analysis on these activities is based on an analytical framework that integrates the essence of technology transfer with that of knowledge-conversion processes and knowledge sharing at the network level.

It has been found that assemblers are demanding a higher level of engineering and operation management capabilities from local suppliers. The development of human resources becomes an urgent priority. Because time is limited, assemblers need to work with existing suppliers to help them develop production capabilities, through supplier network relationship, i.e., Toyota Cooperation Club activities. Overall, the suppliers' own efforts in human-resource development seem to have been the most crucial factor in maintaining and continuously developing their technological capabilities; that, in turn, provides them an opportunity to participate in the network of assemblers and opens them to the benefits of technology transfer. Future studies should pay attention to this evolution of knowledge sharing, roles of Japanese assemblers, and the benefit to suppliers that participate in the network.

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