Research Article

Technology Transfer and Technological Capability: A Case Study in Manufacturing Process in Thai Pharmaceutical Industry

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Abstract

Forms, channels, difficulties and obstacles of technology transfer in manufacturing process and pharmaceutical production, including technological capability were obtained from modern Thai pharmaceutical companies through a survey research. Results showed that Thai pharmaceutical industry received a transfer of technology mostly in the form of printed documents, articles on the internet, and attending trade exhibitions and academic conferences. The first three channels for technology transfer were training received from local academic institutions, self-study from product manuals, and instruction and guidance from technology donors. Difficulties and obstacles in technology transfer were technology performing by the recipient, the hospitality of technology donor, the handover of technology, and the capability of the recipient. In building up technological capability, Thai pharmaceutical manufacturers depended on outside personnel in the acquisition for sources of technology, installation and adaptation of technology with local condition, and product innovation. Findings from this study indicated the status and the efficiency of technology transfer as well as the technological capability of Thai pharmaceutical companies. Results will support the strategy in technological development and build up the competitiveness of Thai pharmaceutical industry, especially among the ASEAN countries.

***Key Words*:** Thai pharmaceutical industry; Technology transfer; Technological capability; Manufacturing process; Pharmaceutical production

Introduction

Technology transfer can be defined as "process by which a developer of technology makes its technology available to a commercial partner that will exploit the technology" (Mendes, 2013), or the dissemination of technical knowledge, skills, and products from a point of origin into a broader sphere of use (Carayannis and Alexander, 2013), and involves specialized technical skills which are transferred to a target group that do not possess those specialized technical skills (Feifei and Yingming, 2010). A technology transfer can be acquired through

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various forms, such as information from printed document and internet, a contract between donor and recipient and a research with academic institute, and through various channels, such as training from local academic institute, technology owner and instruction manual. The effective technology transfer will lead to a successful absorption of technology by the recipient or local company and strengthens the technological capability of the country. Technological capability concerns about the ability of the recipient in the acquisition, operation and adaptation of required technology, and development of new technology or technology innovation (Toyama, 2000). Factors from both inside the manufacturer, such as the administrator, personnel and company policy and from outside the manufacturer such as, technology donor, competitor, customer and government policy, play an important role in the building up of technological capability of the manufacturers.

In the developing countries, the pharmaceutical industry depends mostly on the importation of pharmaceutical products and imitation of technology from developed countries. The United Nations Centre on Transnational Corporations (1983) reported that the pharmaceutical companies in the developing countries relied on technology introduced from abroad through multinational corporations (MNC) operating business in their countries. The manufacturing process and pharmaceutical production was under a transnational company or under the licensing of a multinational company by a local firm. Accordingly, advanced technology in Thai pharmaceutical industry, similar to other developing countries, was imported from developed countries through foreign direct investment (FDI) under the multinational corporations through a wholly owned subsidiary, a joint-venture or a licensing. The manufacturing process supervised by a MNC is, therefore, one channel for a Thai company to receive a technology transfer from developed countries. The reduction in imported technology, the increase in the efficiency of technology employment, technological competence and technological competitiveness of Thai pharmaceutical industry, especially among the ASEAN countries depend on a proficient Thai pharmaceutical industry and qualified personnel. They should be able to adsorb, learn, apply and develop or capable of obtaining technology and increasing their technological capability. This research aimed to study the forms, channels, difficulties and obstacles of technology transfer from foreign countries, including technological capability in the pharmaceutical manufacturing process and production of modern Thai pharmaceutical companies. Results from this study would reveal the existing status of forms and channels, difficulties and obstacles of technology transfer, as well as the technological capability of Thai manufacturing process, and support the strategy in pharmaceutical technology development and build up the competitiveness of Thai pharmaceutical industry, especially among the ASEAN countries.

Materials and Method

Development of a questionnaire

Questionnaires were designed using both open and closed end questions, corresponding to the objectives of the study.

The structure of the questionnaires composed of general information of the respondents, means of technology transfer (forms, channels, difficulties and obstacles), and technological capability building up (roles of outside personnel and agencies, and roles of various factors from inside and outside of the manufacturers).

Pre-test was performed with experts who were consultants of the pharmaceutical manufacturers.

Data collection

According to Bureau of Drug Control,

Ministry of Public Health, there were 167 modern pharmaceutical manufacturers in Thailand in 2009. A purposive sampling of 67 manufacturers locating in Bangkok, and surroundings, i.e, Chachoengsao, Nakhon Pathom, Nonthaburi, Pathum Thani, Phra Nakhon Si Ayutthaya, Samut Prakan and Samut Sakhon was performed for this study. A survey research was conducted, during October 2009 to July 2010, through a face to face interview of the owners, administrators or pharmacists from these 67 manufacturers. Additional information was obtained from telephone interview. Names of the interviewees and manufacturers were undisclosed.

Data analysis

Five-level ranking scale (Likert scale), i.e., 5 – highest, 4 - high, 3 – medium, 2 – low, 1 – lowest, was employed to investigate the level of related activities concerning technology transfer and technological capability (Panpinit, 2004).

Data were analysed using descriptive statistics, comprising of percentage, mean and standard deviation.

The technological capability was evaluated by 2 aspects: 1) the dependability on personnel and/or agencies outside the companies in performing activities that built up technological capability; and 2) roles of factors inside and outside the manufacturers in building up technology competence. The activities concerned were *acquisition of technology* (source of technology, technology worthiness assessment, negotiation, decision in acquiring technology); *operation* (machine installation, operation, maintenance, process control, quality control); *adaptation* (imitation, adaptation to existed condition, minor modification, increased productivity); and *innovation* (major modification, research & development, new product development, commercialization, new technology development). Factors inside the manufacturers were executive administrator, middle level personnel, and manufacturers' policy involving technology and human resource development. Factors outside the manufacturers included the government policy, competitors, customers, business groups, and technology donors/owners/suppliers.

Result and Discussions

Forms of technology transfer

Forms of technology transfer from foreign countries in the manufacturing process and pharmaceutical production in Thai pharmaceutical industry are shown in Table 1. Ranking were divided into 5 levels; highest for the form that the manufacturers used most in receiving technology transfer and lowest for the form that was least used in technology transfer. The first 3 forms that Thai pharmaceutical companies received a transfer of technology from were printed documents such as journal publications and textbooks ($\bar{x}$ = 3.03), articles and information from the internet ($\bar{x}$ = 2.94), and attending trade exhibitions and academic conferences ($\bar{x}$ = 2.79), respectively.

The first 3 forms of technology transfer indicated that technology transfer in Thai pharmaceutical industry was not official, non-commercialized and did not involve market mechanism, while the forth rank was a transfer through a contract between a donor and a recipient ($\bar{x}$ = 2.29), which was official and commercialized. The non-official and non-commercialized technology transfer has various advantages such as it has low costs, the recipient is able to choose appropriate technology and adapt to suitable environment, and the recipient can request for information from several sources or consultants. However, the disadvantages exist and limit technology transfer, for example, this type of technology transfer requires adequate information (i.e., from databases or consultants), sufficient knowledge and competency of personnel in the companies (i.e., technical skills or ability to

Table 1 Ranking and mean values for forms of technology transfer

Forms of technology transfer	Highest	High	Medium	Low	Lowest	Mean	SD
Contract between donor and recipient	3 (5.1)	6 (10.2)	17 (28.8)	12 (20.3)	21 (35.6)	2.29	1.20
Joint venture agreement	1 (1.9)	4 (7.5)	1 (1.9)	10 (18.9)	37 (69.8)	1.53	0.99
Through import of equipment/machine	2 (3.5)	8 (14.0)	10 (17.5)	18 (31.6)	19 (33.3)	2.23	1.17
Training from abroad	2 (3.4)	4 (6.8)	8 (13.6)	12 (20.3)	33 (55.9)	1.81	1.12
Research with local academic	0 (0.0)	5 (9.4)	4 (7.5)	11 (20.8)	33 (62.3)	1.67	0.98
Research with agency from abroad	0 (0.0)	2 (4.0)	4 (8.0)	3 (6.0)	41 (82.0)	1.34	0.80
Printed documents	3 (4.7)	19 (29.7)	24 (37.5)	13 (20.3)	5 (7.8)	3.03	1.01
Internet	7 (10.9)	13 (20.3)	21 (32.8)	15 (23.4)	8 (12.5)	2.94	1.18
Trade exhibition and conference	3 (4.9)	13 (21.3)	23 (37.7)	12 (19.7)	10 (16.4)	2.79	1.11
Others	2 (40.0)	1 (20.0)	2 (40.0)	0 (0.0)	0 (0.0)	4.00	1.00

Percentage of respondents are shown in parenthesis

understand foreign languages), and most of the time needs adaptation before application can take place in each manufacturer.

Channels of technology transfer

Channels of technology transfer from foreign countries ranked by the manufacturers are shown in Table 2. The first 3 channels of technology transfer were training from local educational institutes such as universities ($\bar{x}$ = 3.10), instruction manuals accompanying with the purchase of technology ($\bar{x}$ = 3.00), and training or guidance from technology owner, donor, or supplier ($\bar{x}$ = 2.73), respectively.

Personnel training from either academic institute or technology donor, and direction from instruction manuals were important channels for technology transfer, which were not commercialized and corresponded with the forms of technology transfer. A successful technology transfer through these channels also depended mainly on skilled personnel.

Difficulties and obstacles in technology transfer

Results from the interview showed that difficulties and obstacles in technology transfer involved not only difficulties in performing technology by the recipient, but also the hospitality of the owner/donor/supplier in providing appropriate technology, the handover of technology, and the capability or skill of the recipient. For the recipient, most of the time, technology obtained could not be utilized instantaneously but needed modification before use, because of the difference in the production environment, the lack of special equipment, and the incomplete transfer of technology, including drug producing process and formula. The manufacturing process and production technique usually were undisclosed and might not be transferred to the recipient thoroughly, especially

Table 2 Ranking and mean values for channels of technology transfer

Channels of technology transfer	Highest	High	Medium	Low	Lowest	Mean	SD
Foreign direct investment	4 (7.3)	5 (9.1)	3 (5.5)	7 (12.7)	36 (65.5)	1.80	1.31
Technology purchase from abroad	3 (5.4)	10 (17.9)	8 (14.3)	13 (23.2)	22 (39.3)	2.27	1.30
Technology purchase from local	3 (5.2)	10 (17.2)	12 (20.7)	11 (19.0)	22 (37.9)	2.33	1.29
Reverse engineering	2 (3.6)	8 (14.5)	19 (34.5)	9 (16.4)	17 (30.9)	2.44	1.18
Training among business group	3 (6.4)	3 (6.4)	10 (21.3)	2 (15.4)	24 (51.1)	2.02	1.26
Training from local academic	6 (10.0)	20 (33.3)	15 (25.0)	12 (20.0)	7 (11.7)	3.10	1.19
Training from abroad	0 (0.0)	5 (10.4)	3 (6.2)	9 (18.8)	31 (64.6)	1.62	1.00
Training from technology donor	6 (10.7)	13 (23.2)	9 (16.1)	16 (28.6)	12 (21.4)	2.73	1.33
Through instruction manual	7 (11.1)	16 (25.4)	19 (30.2)	12 (19.0)	9 (14.3)	3.00	1.22
Others	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)	2 (66.7)	1.33	0.58

Percentage of respondents are shown in parenthesis

the details or advanced technique, depending on the voluntariness of technology donor. Problems in the handover of technology included English usage and ability to pay for accessibility to the available information. Most importantly, experience and skilled personnel was significant for a successful beneficiary from the transfer of technology.

Technological capability building up of Thai pharmaceutical industry

Roles of outside personnel and agencies

The manufacturers depended on outside personnel and/or agencies such as university professors, suppliers or consultants in performing activities that built up technological capability of their personnel. For *technology acquisition*, the manufacturers required most advice in the search for sources of technology ($\bar{x}$ = 2.92) and least in the negotiation for purchasing technology ($\bar{x}$ = 2.45); for *technology operation*, most in the installation of the technology ($\bar{x}$ = 3.05) and least in the quality control of the manufacturing process ($\bar{x}$ = 2.57); for *technology adaptation*, most in the adaptation of technology to available condition ($\bar{x}$ = 2.93) and least in minor modification of product ($\bar{x}$ = 2.70); and for *technology innovation*, most in new product development ($\bar{x}$ = 2.69) and least in new technology development ($\bar{x}$ = 2.44) (Table 3). Generally, the companies required outside personnel or other agencies most in the operation of technology, particularly in the installation or introduction of technology.

From the above, the pharmaceutical firms depended on outside personnel least for negotiation because the decision in acquiring technology would rather be done by inside personnel such as the executive administrator. However, the negotiator must have knowledge about the desired technology and understand the contracts,

Table 3 Dependability on personnel/agencies outside the companies in performing activities that built up technological capability of the manufacturers

Activities in building up technological capability	Highest	High	Medium	Low	Lowest	Mean	SD
Acquisition							
- source	3 (5.1)	15 (25.4)	23 (39.0)	10 (16.9)	8 (13.6)	2.92	1.09
- worthiness	3 (5.0)	13 (21.7)	20 (33.3)	14 (23.3)	10 (16.7)	2.75	1.13
- negotiation	2 (3.4)	12 (20.7)	11 (19.0)	18 (31.0)	15 (25.9)	2.45	1.19
- decision	1 (1.7)	10 (16.9)	23 (39.0)	17 (28.8)	8 (13.6)	2.64	0.98
Operation							
- installation	7 (12.3)	14 (24.6)	19 (33.3)	9 (15.8)	8 (14.0)	3.05	1.22
- operation	1 (1.8)	16 (28.1)	20 (35.1)	12 (21.1)	8 (14.0)	2.82	1.05
- maintenance	2 (3.6)	8 (14.5)	24 (43.6)	13 (23.6)	8 (14.5)	2.69	1.02
- process control	2 (3.4)	12 (20.3)	16 (27.1)	18 (30.5)	11 (18.6)	2.59	1.12
- quality control	2 (3.7)	12 (22.2)	13 (24.1)	15 (27.8)	12 (22.2)	2.57	1.18
Adaptation							
- imitation	2 (3.6)	15 (27.3)	19 (34.5)	13 (23.6)	6 (10.9)	2.89	1.05
- adaptation	2 (3.4)	18 (31.0)	15 (25.9)	20 (34.5)	3 (5.2)	2.93	1.01
- minor modification	1 (1.7)	15 (25.0)	16 (26.7)	21 (35.0)	7 (11.7)	2.70	1.03
- increased productivity	1 (1.7)	20 (33.3)	14 (23.3)	17 (28.3)	8 (13.3)	2.82	1.10
Innovation							
- major modification	2 (3.6)	10 (17.9)	16 (28.6)	22 (39.3)	6 (10.7)	2.64	1.02
- R & D	3 (4.8)	12 (19.0)	18 (28.6)	19 (30.2)	11 (17.5)	2.63	1.13
- product development	3 (4.8)	11 (17.7)	22 (35.5)	16 (25.8)	10 (16.1)	2.69	1.10
- commercialization	5 (8.2)	7 (11.5)	20 (32.8)	18 (29.5)	11 (18.0)	2.62	1.16
- new technology development	4 (6.8)	4 (6.8)	18 (30.5)	21 (35.6)	12 (20.3)	2.44	1.10

Percentage of respondents are shown in parenthesis

including costs, after-sale service, licensing, and concerns about law and agreement. For the use of technology, the manufacturers needed advice from technology donors, owners or suppliers for the installation of technology, including after-sale services, while the control of manufacturing process was done by its personnel. In the adaptation of technology, the manufacturers required outside personnel least in minor modification of product because this could be done by inside personnel and might be confidential. For technology innovation, the manufacturers depended on outside personnel most in the development of new product but least in the development of new technology, because there were usually a few modifications in pharmaceutical technology.

Roles of various factors from inside and outside of the manufacturers

In addition to dependability on outside personnel for accomplishment of technology capability, factors from both inside and outside of the manufacturers were also considered for their roles in initiating technological capability of the pharmaceutical industry. Table 4 shows the influences from various factors both inside and outside of the firms in building up their technological competency. In *technology acquisition*, roles of factors inside the manufacturers were comparable, i.e. $\bar{x}$ of 3.33, 3.32, and 3.31 for the manufacturers' policy and strategy in technology and human resource, executive administrator, and mid-level personnel, respectively, while outside factors were technology donors, competitors, customers, and government policy with $\bar{x}$ of 3.33, 3.09, 2.73, and 2.51, respectively. In *technology operation*, mid-level personnel exhibited most influence ($\bar{x}$ = 4.14), for inside factor, while outside factors were competitors, technology donors, and customers ($\bar{x}$ = 3.12, 3.10, and 2.64, respectively). In *technology adaptation*, inside factors were mid-level personnel ($\bar{x}$ = 3.46), and manufacturers' policy ($\bar{x}$ = 3.04), while outside factors were technology donors ($\bar{x}$ = 3.00), competitors ($\bar{x}$ = 2.89), and customers ($\bar{x}$ = 2.61). In *technology innovation*, inside factors were manufacturers' policy ($\bar{x}$ = 2.72), and mid-level personnel ($\bar{x}$ = 2.61), while outside factors

Table 4 Mean values and SD of roles of factors inside and outside the manufacturers in building up technological capability

Factors	Acquisition		Operation		Adaptation		Innovation	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Inside the manufacturers								
Executive administrator	3.32	1.34	2.31	1.29	2.47	1.26	2.50	1.41
Mid-level personnel	3.31	1.26	4.14	0.98	3.46	1.13	2.61	1.19
Technology and HR policy	3.33	1.16	3.13	1.19	3.04	1.20	2.72	1.31
Outside the manufacturers								
Government policy	2.51	1.39	2.30	1.30	2.19	1.14	2.44	1.37
Competitor	3.09	1.25	3.12	1.32	2.89	1.19	2.81	1.30
Customer	2.73	1.35	2.64	1.33	2.61	1.26	2.51	1.33
Business group	2.24	1.33	2.33	1.42	2.20	1.24	2.21	1.34
Technology donor	3.33	1.23	3.10	1.28	3.00	1.32	3.03	1.27

were technology donors ($\bar{x}$ = 3.03), competitors ($\bar{x}$ = 2.81), and customers ($\bar{x}$ = 2.51).

From Table 4, with inside factors, executive administrator presented most influence on the acquisition for technology ($\bar{x}$ = 3.32) and least influence on the operation of technology ($\bar{x}$ = 2.31). Mid-level personnel showed most influence on the operation of technology ($\bar{x}$ = 4.14) and least influence on the innovation of technology ($\bar{x}$ = 2.61). The policy of the manufacturers demonstrated most influence on the search for technology ($\bar{x}$ = 3.33) and least influence on the innovation of technology ($\bar{x}$ = 2.72). For outside factors, the policy of the government displayed most influence on the search for technology ($\bar{x}$ = 2.51) and least influence on the adaptation of technology ($\bar{x}$ = 2.19). Competitors exhibited most influence on the search for technology ($\bar{x}$ = 3.09) and least influence on the innovation of technology ($\bar{x}$ = 2.81). Customers expressed most influence on the search for technology ($\bar{x}$ = 2.73) and least influence on the innovation of technology ($\bar{x}$ = 2.51). Business groups demonstrated most influence on the operation of technology ($\bar{x}$ = 2.33) and least influence on the adaptation of technology ($\bar{x}$ = 2.20). Technology donors displayed most influence on the search for technology ($\bar{x}$ = 3.33) and least influence on the adaptation of technology ($\bar{x}$ = 3.00). Consequently, the government exhibited medium role in the search for new technology and lower roles in other activities, while competitors, customers, and technology donors exhibited medium role in all 4 activities that promoted technological capability. However, role of business groups in all 4 activities were low.

The roles of executive administrators, and the manufacturers' policy and strategy for technology and human resource development were in medium level for the search of new technology; while the role of mid-level personnel was high for the operation of technology. This result was in accordance with Lall (1990) who indicated that a success in building up technological capability not only depended on the potential of the company, but also the ability of the owner or the manager, the collaboration among personnel, the administration and management, and the relationship with outside agencies, which implied that role of executive administrator was important. The policy and strategy of the firms guided their business directions. Technological strategies of the manufacturers in developing countries, such as technology extender, technology exploiter, technology follower, and technology leader, reflected their approach for seeking and adapting for desired technology, including their research and development (Sharif, 1993). These strategies also implied whether the companies put effort on building up their capability or simply reproduced basic technology. The differences in technological strategies exhibited the maneuver of technology for strengthening the competitiveness of the manufacturers (Porter, 1980; Sharif, 1994; Malecki, 1997). Porter (1998) suggested that the manufacturers should modify and develop new products, improve product performance, and reduce production of incompetent products. These technological strategies involved the modification and development of products and manufacturing processes, resulting from the exploration for required technology, and the employment of the companies' resources in product development, R&D, and human resource training.

Mid-level personnel exhibited the highest role in the application and adaptation of technology, which was their sole responsibility and depended on their knowledge, expertise, and skills. Furthermore, technology donors/owners/suppliers could provide information about the installation, operation and maintenance of technology which usually accompanied with technology purchasing and after-sale services. Roles of executive administrators

and government were lowest in these activities.

Technology donors played important roles in technology innovation because they could assist in administration, management and new product development, which improved the performance in technology innovation of the manufacturers (Nishigushi, 1994; Bidault et al., 1998). Competitors also created pressure and indirectly initiated the firms to achieve innovation, increase productivity and production efficiency, leading to the buildup of the competitiveness (Schumpeter, 1934; Penrose, 1959; Porter, 1980; Fagerberg, 1987).

Thailand Development Research Institute (TDRI) (1994) revealed that administration, management, and personnel's skill were crucial for technological capability and differentiated production techniques and quality control of the firms. In addition to the roles of administrators, knowledge, expertise, and skills of personnel indicated the transformation of technology and technological capability of the companies (Penrose, 1959; Tiralap, 1990). Further training for personnel, either official or unofficial, were necessary for technological competency and capability of the manufacturers (Dahiman et al., 1987; Enos, 1991; Lall, 1992).

Conclusions

Most forms and channels of technology transfer in Thai pharmaceutical industry were not official and non-commercialized, mostly through printed documents, instruction manuals and training from local academics. The manufacturers depended on outside personnel in building up their capability in manufacturing process and pharmaceutical technology. Factors both inside and outside the companies exhibited critical roles in the acquisition, operation, adaptation and innovation of technology.

Difficulties and obstacles in technology transfer rose from both the donor and the recipient, involving problems in performing technology, the handover of technology, and the capability of the recipient.

Results from this study suggested that there were many factors involving benefits from technology transfer in the development and elevation of competitiveness of Thai pharmaceutical industry. Those factors were as follows:

Human resource: Capabilities of personnel in technology search, operation, adaptation, and innovation were important, as well as adsorption capacity.

Hospitality of technology donors: A technology transfer would be successful if technology donors handover essential information to recipients.

Foresight in administration and management of the executive administrators: Vision of the owners or executive administrators was important for long term development of the manufacturers, including the competitiveness.

Support from related agencies: Government, government agencies, academic institutes, suppliers, business groups, industrial associations, etc. played significant roles in technology transfer and building up technological capability. The government should have explicit policy in supporting research and development in the pharmaceutical industry, including promotion in human resources, and in foreign investment and technology transfer to Thai personnel from abroad,

Establishment of a central agent: A central agent was proposed to initiate collaborations among government, private sectors, academics and industrial associations for the promotion of technological capability in Thai pharmaceutical industry.

In order to maintain Thailand's position and competitiveness with other ASEAN countries in

the long run, Thai pharmaceutical manufacturers have to develop technology in the manufacturing process. They need to enhance technology absorption transferred from technology donors, and build up their technological capability. This study found that the most forms and channels of technology transfer were from printed documents, internet and trade exhibitions, and training from local educational institutions, manuals and training from technology owners, respectively, while the ability of technology adoption mainly depended on comprehension of the manufacturers' personnel, the willingness of technology donors, and the absorptive ability of the personnel. Therefore, the increase in the effectiveness of technology transfer from those available forms and channels, and in the adoption ability of the pharmaceutical companies will support the competitiveness of Thai pharmaceutical industry.

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