

Technology Transfer and Technological Capability in the Quality Control Process of Thai Pharmaceutical Manufacturers

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บทคัดย่อ

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บทความนี้เป็นส่วนหนึ่งของการวิจัยเรื่องการถ่ายทอดเทคโนโลยีจากต่างประเทศและการสร้างขีดความสามารถทางเทคโนโลยีของอุตสาหกรรมยาในประเทศไทย โดยศึกษารูปแบบ ช่องทาง ปัญหาและอุปสรรคในการถ่ายทอดเทคโนโลยีและขีดความสามารถทางเทคโนโลยีด้านการควบคุมคุณภาพของอุตสาหกรรมยา **วิธีดำเนินการวิจัย:** รวบรวมข้อมูลจากสถานประกอบการอุตสาหกรรมยาแผนปัจจุบันจำนวน 67 แห่ง โดยการสัมภาษณ์ผู้บริหารโรงงานหรือเภสัชกรโดยวิธีการสุ่มตัวอย่างแบบเจาะจง ใช้ Likert scale ในการให้ลำดับความสำคัญของปัจจัยที่เกี่ยวข้องกับรูปแบบ ช่องทางของการถ่ายทอดเทคโนโลยี และปัจจัยที่มีผลต่อการสร้างขีดความสามารถทางเทคโนโลยี **ผลการวิจัย:** รูปแบบของการถ่ายทอดเทคโนโลยีส่วนใหญ่ ได้แก่ เอกสารสิ่งพิมพ์ อินเทอร์เน็ต และการเข้าร่วมนิทรรศการและงานประชุม ช่องทางของการถ่ายทอดเทคโนโลยีส่วนใหญ่ผ่านทางคู่มือการใช้งาน การฝึกอบรมกับสถาบันวิชาการ และคำแนะนำจากเจ้าของเทคโนโลยี ปัญหาและอุปสรรคของการถ่ายทอดเทคโนโลยี ได้แก่ การขาดข้อมูลในการเลือกเทคโนโลยี ความไม่เต็มใจในการถ่ายทอดเทคโนโลยีของเจ้าของเทคโนโลยี ความไม่สมบูรณ์ในการถ่ายทอดเทคโนโลยี และทักษะที่ไม่เพียงพอของผู้รับเทคโนโลยี สำหรับขีดความสามารถทางเทคโนโลยี อุตสาหกรรมยาพึ่งพาคู่มือจากภายนอกในการแสวงหา การนำเทคโนโลยีมาใช้ การปรับใช้ และการทำวิจัยและพัฒนา โดยปัจจัยทั้งจากภายในและภายนอกมีบทบาทต่างๆ กันในการสร้างขีดความสามารถทางเทคโนโลยีของอุตสาหกรรมยา **สรุปผลการวิจัย:** รูปแบบและช่องทางของการถ่ายทอดเทคโนโลยีด้านการควบคุมคุณภาพส่วนใหญ่เป็นแบบไม่เป็นทางการ ดังนั้นการจัดตั้งหน่วยงานกลางเพื่อให้เกิดการประสานงานอย่างเป็นระบบระหว่างหน่วยงานที่เกี่ยวข้องจะชว่นำมาซึ่งการเพิ่มประสิทธิภาพและประสิทธิผลในการถ่ายทอดเทคโนโลยีและการสร้างขีดความสามารถทางเทคโนโลยีของอุตสาหกรรมยาในประเทศไทย

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Technology Transfer and Technological Capability in the Quality Control Process of Thai Pharmaceutical Manufacturers

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Abstract

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As part of a survey research in technology transfer from foreign countries and technological capability of Thai pharmaceutical industry, forms, channels, difficulties and obstacles of technology transfer as well as technological capability in the quality control process are conducted. **Methods:** Data were collected through an interview from 67 modern pharmaceutical manufacturers. Likert scale was used to determine level of activities concerning forms and channels of technology transfer and level of technological capability. **Results:** Most forms of technology transfer were printed documents, internet, and participating in exhibitions and conferences. Most channels were instruction manuals, training with academic institutions, and guidance from technology donors. Difficulties and obstacles in technology transfer included a lack of information for technology selection, inhospitality of technology donors, incomplete handover of technology, and inadequate skills of the recipients. For technological capability, the industry depended on outside personnel in the search, installation, adaptation of technology, and research and development. Factors from both inside and outside the manufacturers demonstrated different roles in building up their technological capability. **Conclusion:** Forms and channels of technology transfer in the quality control process that Thai pharmaceutical industry received were mainly not official. Consequently, central agency was proposed to systematically coordinate among related organizations in bringing about more effective and efficient technology transfer and technological capability building in Thai pharmaceutical manufacturers.

Keywords: quality control process; technological capability; technology transfer; Thai pharmaceutical industry

Introduction

It is well known that new technology is usually established in developed countries and developing countries import and utilize it through a technology transfer. This type of technology transfer is classified as international technology transfer or horizontal technology transfer (Damijan *et al.*, 2016; Jude, 2013). International technology transfer occurs through various forms and channels, either directly from a technology purchase or indirectly from a purchase of goods (Saggi, 2015). Reverse engineering is considered a non-commercial/ non-formal channel, while technology licensing or subcontracting is considered a commercial/ formal channel of horizontal technology transfer (Posadas, 2015). Agreements between the developers in developed countries and the recipients in developing countries are useful for making technologies available to people in the recipient countries, especially in developing countries where transfer of technology is more efficient, economical and less risk than technology innovation (Janodia *et al.*, 2008). If foreign technologies are easy to be transferred and adopted, the recipient countries will be able to catch up rapidly (Fu *et al.*, 2011). Accordingly, transfer of advanced technology is essential for economic growth and development, which enables the employees in low- and middle-income countries to accelerate the acquisition of knowledge, experience, and equipment (International Federation of Pharmaceutical Manufacturers & Associations, 2013).

According to The United Nations Centre on Transnational Corporation (1983), pharmaceutical industries in developing countries rely on technology transfer from developed countries through foreign direct investment (FDI) under multinational corporations (MNC). In 2004, World Medicines Situation reported that the pharmaceutical production was concentrated in the high-income countries which, in 1999, contributed for 92.9% in value of the world pharmaceutical production (WHO, 2011). This report implied that advanced technology originated from developed countries. Moreover, technology

transfer from MNC to local suppliers in developing countries increases their productivity and lower prices among local firms (Blalock and Gertler, 2008). Import of machinery and equipment is also another form that developing countries acquire advanced technology and enhance competitiveness (Fu *et al.*, 2011).

Pharmaceutical quality control is one of the key processes in manufacturing of a qualified pharmaceutical product. Pharmaceutical products must be consistently produced and controlled to the quality standards, complying with the requirements of the marketing authorization, do not place patients at risk due to inadequate safety, quality or efficacy and will not be released until the quality has been judged satisfactory (Quick *et al.*, 1997; World Health Organization (WHO), 2007). In developing countries, technology transfer lowers cost in drug development. For example, India, China and Brazil, with technological capabilities and enough human capital to contribute to their economic development, benefit from technology transfer. Patent protection hindered technology transfer from developed countries but Indian Patents Act of 1970 initiated Indian pharmaceutical companies in reverse engineering the technology and developing technological capacities to become research driven industry (Janodia *et al.*, 2008).

This study was a part of our survey research which reviewed the characteristics of technology transfer from abroad to Thai pharmaceutical manufacturers. Technology was classified into 3 groups, i.e., Equipment/ Machinery/Device, Manufacturing Process/ Production, and Quality Control. The characteristics of technology transfer in manufacturing process were previously published (Toyama *et al.*, 2014). We present here forms and channels, together with difficulties and obstacles of technology transfer, including technological capability in Thai pharmaceutical quality control process. Data from this study will be employed to improve the efficiency and the effectiveness of technology transfer to Thailand from

foreign countries, and strengthen the technological capability in the quality control process of Thai pharmaceutical industry.

Materials and Methods

Details of questionnaire development, data collection and analysis were in accordance with methods used in the study of technology transfer and technological capability in the manufacturing process of Thai pharmaceutical industry (Toyama *et al.*, 2014).

Questionnaire development

A questionnaire with script and open-ended questions was used as a survey instrument to collect primary data from the pharmaceutical industry.

The questionnaire comprised general information, characteristics of technology transfer, difficulties and obstacles in technology transfer, and technological capability in the quality control process of the manufacturer. Characteristics of technology transfer were evaluated by forms (such as printed documents, contract with donor, training from abroad, etc.) and channels (such as instruction manual, training from donor, technology purchase from abroad, etc.) that Thai pharmaceutical industry received a transfer of technology. Difficulties and obstacles were obtained from open-ended questions. Roles of outside personnel and agencies, and factors from both inside and outside the manufacturer were used to determine technological capability of the manufacturers.

Data collection

A purposive sampling of 67 from 167 modern pharmaceutical manufacturers (data from Bureau of Drug Control, Ministry of Public Health in 2009) was performed for this study. A survey was conducted through a face-to-face interview, by the authors and graduate students in the Pharmaceutical Technology department, with the owners, administrators or pharmacists from these 67 manufacturers. Names of the interviewees and manufacturers were concealed.

Data analysis

The level of activities concerning characteristics of technology transfer and technological capability was determined using five-level ranking scale (Likert scale: highest = 5, high = 4, medium = 3, low = 2, lowest = 1) (Panpinit, 2004). Descriptive statistics, comprising of percentage, mean and standard deviation were used to analyze data.

Technological capability was considered from 1) the reliability of the manufacturer on outside personnel and/or other agencies and 2) roles of factors inside/outside the manufacturer in performing activities that built up the manufacturer's technological capability. Personnel and agencies from outside the manufacturer included academic scholars, consultants and suppliers. Factors inside included executive administrator, middle level personnel, and the manufacturer's policy involving technology and human resource development, and factors outside are government policy, competitors, customers, business groups, and technology donors/ owners/ suppliers. Technological capability was determined from the following activities: *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) (Toyama, 2000).

Results and Discussion

1. Technology transfer in the quality control process

1.1 Forms of technology transfer

Printed documents such as publications in scientific journals and textbooks (mean values, $\bar{X} = 3.25$), articles and information from the internet ($\bar{X} = 3.20$), and participating in trade exhibitions and academic conferences ($\bar{X} = 2.97$), respectively, were the first 3 forms of

technology transfer in the quality control process that Thai pharmaceutical companies received from abroad (Table 1). This ranking was in accordance with forms of technology transfer in the manufacturing process (Toyama *et al.*, 2014), but was not in agreement with data obtained from technology transfer in manufacturers with respect to their sizes (Toyama *et al.*, 2015). These forms indicated unofficial and non-commercialized technology transfer in Thai pharmaceutical industry where market mechanism was not involved. However, the forth rank was a transfer of technology through a contract with technology donor ($\bar{X} = 2.81$), which was official and commercialized.

Unofficial and non-commercialized technology transfer is usually low-cost, less time-consuming and easy to access. The recipient is able to choose appropriate technology. Nevertheless, the disadvantages occur such as the information obtained is incomplete or inadequate, not suitable for existing condition of the recipient manufacturer, may need adaptation prior to application, and the transfer of technology needs adequate technical skills and competency of personnel in the receiving manufacturer. These drawbacks limit the process of technology transfer.

Table 1. Ranking and mean values for forms of technology transfer in the quality control process

Forms of technology transfer	Number of respondents					Mean	SD
	Highest	High	Medium	Low	Lowest		
Contract between donor and recipient	7 (11.9)	12 (20.3)	17 (28.8)	9 (15.3)	14 (23.7)	2.81	1.33
Joint venture agreement	2 (3.8)	1 (1.9)	5 (9.6)	8 (15.4)	36 (69.2)	1.56	1.02
Import of equipment/machine	3 (5.0)	13 (21.7)	17 (28.3)	13 (21.7)	14 (23.3)	2.63	1.21
Training from abroad	1 (1.7)	7 (11.9)	10 (16.9)	8 (13.6)	33 (55.9)	1.90	1.17
Research with local academic	1 (2.0)	6 (12.0)	5 (10.0)	11 (22.0)	27 (54.0)	1.86	1.14
Research with agency from abroad	0 (0.0)	3 (6.1)	3 (6.1)	2 (4.1)	41 (83.7)	1.35	0.86
Printed documents	8 (11.9)	17 (25.4)	31 (46.3)	6 (9.0)	5 (7.5)	3.25	1.04
Internet	10 (15.2)	17 (25.8)	21 (31.8)	12 (18.2)	6 (9.1)	3.20	1.18
Trade exhibition and conferences	3 (4.9)	17 (27.9)	21 (34.4)	15 (24.6)	5 (8.2)	2.97	1.03

Percentage of respondents are shown in parenthesis

1.2. Channels of technology transfer

Channels of technology transfer are shown in Table 2. The first 3 channels were self-study from instruction manuals accompanying the purchase of technology ($\bar{X} = 3.37$), training from local academic institutes such as

universities ($\bar{X} = 3.29$), and training or guidance from technology owner/donor/supplier ($\bar{X} = 3.07$), respectively. Results indicated that a successful technology transfer received through these channels depended mainly on experienced and competent personnel.

Table 2. Ranking and mean values for channels of technology transfer in the quality control process

Channels of technology transfer	Number of respondents					Mean	SD
	Highest	High	Medium	Low	Lowest		
Foreign direct investment	3 (5.6)	3 (5.6)	3 (5.6)	8 (14.8)	37 (68.5)	1.65	1.17
Technology purchase from abroad	7 (12.3)	11 (19.3)	3 (14.0)	11 (19.3)	20 (35.1)	2.54	1.45
Technology purchase from local	4 (7.0)	12 (12.1)	8 (14.0)	13 (22.8)	20 (35.1)	2.42	1.35
Reverse engineering	1 (1.9)	6 (11.1)	11 (20.4)	15 (27.8)	21 (38.9)	2.09	1.10
Training among business group	1 (2.0)	4 (8.0)	12 (24.0)	7 (14.0)	26 (52.0)	1.94	1.13
Training from local academic	7 (11.3)	24 (38.7)	17 (27.4)	8 (12.9)	6 (9.7)	3.29	1.14
Training from abroad	3 (6.1)	4 (8.2)	3 (6.1)	8 (16.3)	31 (63.3)	1.78	1.25
Training from technology donor	9 (15.3)	16 (27.1)	14 (23.7)	10 (16.9)	10 (16.9)	3.07	1.32
Through instruction manual	8 (12.3)	24 (36.9)	20 (30.8)	10 (15.4)	3 (4.6)	3.37	1.04

Percentage of respondents are shown in parenthesis

1.3. Difficulties and obstacles in technology transfer

The difficulties and obstacles in receiving technology transfer of the quality control process included the acquisition of technology (lack of information for technology selection) , the inhospitality of the owner/ donor/ supplier in providing applicable technology, the incomplete handover of technology, and the incapable or unskillful recipients. The pharmacists had insufficient knowledge in industrial management, analytical method development and validation, and quality assurance system which limited their proficiency in obtaining technology transfer. However, the quality control process in any pharmaceutical production must conform to the requirements in the official pharmacopeias and the regulations by Thai FDA (Food and Drug Administration),

and advanced technology may not be official in the pharmacopeia and/ or authorized by Thai FDA. Consequently, transfer of newer technology in the quality control process was limited, in comparison with machinery technology or manufacturing process technology.

2. Technological capability in the quality control process

2.1 Roles of outside personnel and agencies in performing activities that built up technological capability of the manufacturers

For *technology acquisition*, the manufacturers required assistance in the search for sources of technology in the quality control process ($\bar{X} = 3.08$), assessment for cost effectiveness ($\bar{X} = 2.92$), decision in technology acquisition ($\bar{X} = 2.79$) and negotiation for technology

acquisition ($\bar{X} = 2.70$), respectively; for *technology operation*, the installation of the instruments used in quality control technology ($\bar{X} = 3.64$), maintenance ($\bar{X} = 3.60$), operation ($\bar{X} = 3.21$), method validation ($\bar{X} = 2.98$), and process control ($\bar{X} = 2.79$), respectively; for *technology adaptation*, the adaptation of quality control technology to existing condition ($\bar{X} = 2.84$), minor modification ($\bar{X} = 2.62$), productivity increase ($\bar{X} = 2.59$), and technology imitation ($\bar{X} = 2.50$), respectively; and for *technology innovation*, research and development ($\bar{X} = 2.76$), product development ($\bar{X} = 2.71$), major modification of quality control technology ($\bar{X} = 2.63$), new technology

development ($\bar{X} = 2.59$), and commercialization of new technology in the quality control process ($\bar{X} = 2.57$), respectively (Table 3). In comparison with the manufacturing technology, the quality control technology required guidance from personnel/agencies outside the manufacturers in technology acquisition and technology operation at the similar ranking (Toyama *et al.*, 2014). Results showed that both technologies needed advice from outside personnel or other agencies most in the operation of technology, particularly in the installation or introduction of instruments.

Table 3. Reliability on personnel/agencies outside manufacturers in performing activities that built up technological capability

Activities in building up technological capability	Number of respondents					Mean	SD
	Highest	High	Medium	Low	Lowest		
Acquisition							
- source	3 (5.0)	21 (35.0)	20 (33.3)	10 (16.7)	6 (10.0)	3.08	1.06
- cost effectiveness	3 (5.0)	17 (28.3)	19 (31.7)	14 (23.3)	7 (11.7)	2.92	1.06
- negotiation	2 (3.5)	15 (26.3)	15 (26.3)	14 (24.6)	11 (19.3)	2.70	1.16
- decision	1 (1.7)	16 (27.6)	19 (32.8)	14 (24.1)	8 (13.8)	2.79	1.06
Operation							
- installation	12 (20.7)	22 (37.9)	18 (31.0)	3 (5.2)	3 (5.2)	3.64	1.04
- operation	6 (10.5)	15 (26.3)	25 (43.9)	7 (12.3)	4 (7.0)	3.21	1.03
- maintenance	13 (21.7)	22 (36.7)	17 (28.3)	4 (6.7)	4 (6.7)	3.60	1.11
- method validation	6 (9.8)	15 (26.4)	19 (31.1)	14 (23.0)	7 (11.5)	2.98	1.16
- process control	3 (5.4)	12 (21.4)	20 (35.7)	12 (21.4)	9 (16.1)	2.79	1.12
Adaptation							
- imitation	2 (3.7)	10 (18.5)	12 (22.2)	19 (35.2)	11 (20.4)	2.50	1.13
- adaptation	3 (5.3)	11 (19.3)	21 (36.8)	18 (31.6)	4 (7.0)	2.84	1.00

- minor modification	2 (3.3)	9 (15.0)	20 (33.3)	22 (36.7)	7 (11.7)	2.62	0.99
- productivity increase	2 (3.6)	11 (19.6)	13 (23.2)	22 (39.3)	8 (14.3)	2.59	1.08
Innovation							
- major modification	3 (5.6)	9 (16.7)	16 (29.6)	17 (31.5)	9 (16.7)	2.63	1.12
- R & D	4 (6.9)	11 (19.0)	21 (36.2)	11 (19.0)	11 (19.0)	2.76	1.17
- new process development	2 (3.6)	14 (25.0)	17 (30.4)	12 (21.4)	11 (19.6)	2.71	1.16
- commercialization	5 (9.3)	6 (11.1)	15 (27.8)	17 (31.5)	11 (20.4)	2.57	1.21
- new tech development	6 (11.1)	3 (5.6)	19 (35.2)	15 (27.8)	11 (20.4)	2.59	1.21

Percentage of respondents are shown in parenthesis

Table 4. Mean values (\bar{X}) and (SD) of roles of factors inside and outside the manufacturers in building up technological capability of the manufacturers

Factors	\bar{X} (SD)			
	Acquisition	Operation	Adaptation	Innovation
Inside the manufacturers				
Executive administrator	3.47 (1.23)	2.52 (1.41)	2.49 (1.37)	2.45 (1.42)
Mid-level personnel	3.51 (1.06)	4.11 (0.93)	3.52 (0.97)	2.60 (1.35)
Technology and HR policy	3.35 (1.23)	3.14 (1.23)	3.00 (1.26)	2.64 (1.32)
Outside the manufacturers				
Government policy	2.69 (1.40)	2.52 (1.39)	2.29 (1.24)	2.40 (1.35)
Competitor	2.84 (1.27)	2.91 (1.30)	2.67 (1.28)	2.63 (1.36)
Customer	2.57 (1.34)	2.49 (1.33)	2.41 (1.21)	2.19 (1.22)
Business group	2.29 (1.44)	2.41 (1.45)	2.28 (1.28)	2.26 (1.35)
Technology donor	3.35 (1.19)	3.15 (1.25)	3.00 (1.26)	3.08 (1.30)

2.2 Roles of factors inside and outside the manufacturers in performing activities that built up technological capability of the manufacturers

From Table 4, mid-level personnel and technology donors/ owners/ suppliers played important role in *technology acquisition* (\bar{X} = 3.51 and 3.35, respectively), *technology operation* (\bar{X} = 4.11 and 3.15, respectively), *technology adaptation* (\bar{X} = 3.52 and 3.00, respectively), while in *technology innovation*, manufacturers' policy (\bar{X} = 2.64), mid-level personnel (\bar{X} = 2.60) and technology donors/owners/suppliers (\bar{X} = 3.08) played important role. Results indicated that mid-level personnel showed important roles in several aspects of building up technological capability of the manufacturers. Furthermore, technology donors/owners/suppliers exhibited important role in all 4 activities that promoted technological capability.

For factors inside the manufacturers, executive administrator and the manufacturers' policy and strategy for technology and human resource development presented influence on the acquisition for technology (\bar{X} = 3.47 and 3.35, respectively), and mid-level personnel on the operation, adaptation, and acquisition of technology (\bar{X} = 4.11, 3.52 and 3.51, respectively), but they all demonstrated lesser influence on the innovation of technology (\bar{X} = 2.45, 2.60, 2.64, respectively). In the search for new technology, all factors inside the manufacturers played critical roles, while mid-level personnel and the policy and strategy of the manufacturers were essential in the operation, adaptation and innovation of technology. For factors outside, the policy of the government, customers and technology donors/ owners/ suppliers displayed influence on the acquisition for new technology of the manufacturers (\bar{X} = 2.69, 2.57, 3.35, respectively), whereas competitors and business groups expressed more influence on the operation of technology (\bar{X} = 2.91 and 2.41). Results showed that technology donors/owners/suppliers, as the outsiders, exhibited crucial

parts in strengthening technological capability of the manufacturers in the quality control process, while business groups did not demonstrated significant role in building up technological capability of the manufacturers.

Several conditions influence effective technology transfer to developing countries. Benefits from technology transfer arise from the ability of the recipient to identify, assimilate and exploit knowledge from its surrounding environment (Fu *et al.*, 2011). In this case technological capability of Thai personnel in the quality control processes play vital roles in successful technology transfer.

From this study, the central agency (CA) was proposed to initiate systematic collaborations among related organizations to enhance effective technology transfer as well as technological capability in Thai pharmaceutical industry (Figure 1) (Toyama *et al.*, 2012). Internal factors includes executive administrators (EX), their policies (P), strategies (S), human resource development (HRD) efforts, and mid or lower-level personnel of pharmaceutical manufacturers. External factors are such as government (G), government organizations (GO), academic institutes (Uni), technology suppliers (Sup), business groups (NF), industrial associations (AS) The environments, for example, market structure and the economic context are also needed to be considered. According to Figure 1, function of each organization is proposed as follows:

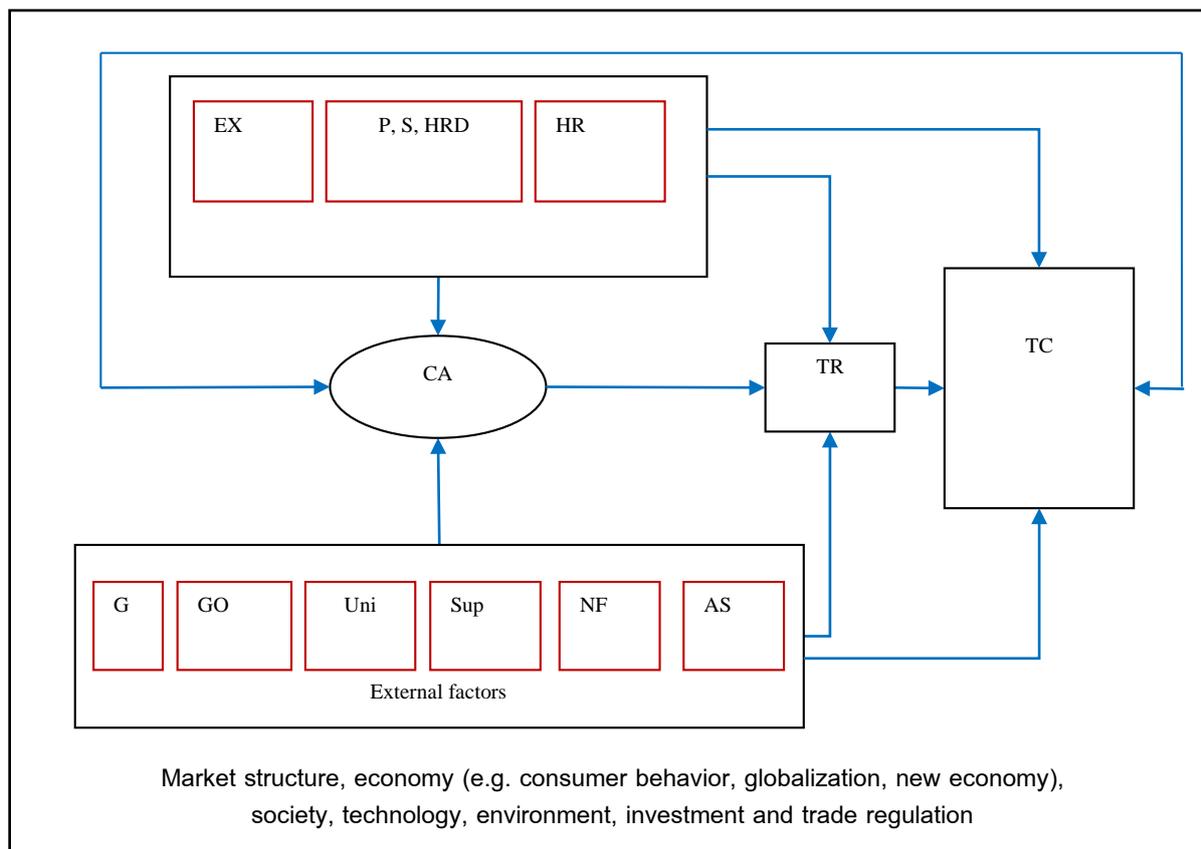


Figure 1. Proposed diagram of central agency and related organizations in promoting efficiency and technological capability of Thai pharmaceutical industry (CA = central agency, TR = technology transfer, TC = technological capability, EX = executive administrators, P, S, HRD = policy, strategy, and human resource development, HR = mid/lower-level personnel, G = government, GO = government organizations, Uni = academic institutes, Sup = technology suppliers, NF = business groups, AS = industrial associations)

The government: Create a constructive environment and facilities for technological development, set up a close linkage among government organizations, universities, R&D institutions, and the pharmaceutical industry (Pavitt and Walker, 1976; Sharif and Ramanatha, 1994) and propose the pharmaceutical industry as one of the main industries to upgrade its technological capability.

The executive administrators: Manage and supervise, initiate cooperation among personnel in the manufacturers, and strengthen business connections with external agencies, i.e. technology suppliers, laboratories, universities, industrial associations, and in-house training programs (Toyama, 2000). Within the manufacturers, executive administrators create a climate of innovation and facilitating technology information transfer across different departments (Brown and Karagozoglou, 1989).

Policies and strategies: Policies and strategies committed by executive administrators are crucial for long-term competitiveness. Administration within the manufacturer needs effective internal information flow to assimilate and improve imported technology and increase technical abilities.

Human resource and human resource development: Goals of the manufacturers are projected by executive administrators and shared by their employees. Beside technical skills, personnel in all levels need to be active, possess managerial competence, technical knowledge, imagination and ambition (Penrose, 1959). Allocation of human resource for better quality manpower should be implemented (Cusumano and Elenkov, 1994; Porter, 1998).

Research and development: R&D is the key to success for business. Activities leading to development of new quality control processes should be initiated (Mowery and Rosenberg, 1989).

University: At present, collaboration between faculties of pharmacy and pharmaceutical manufacturers are established but closer connection in terms of technological activity supporting, R&D, training in new quality control process, etc. are needed.

Industrial associations: Pharmaceutical associations play an indirect role through gathering information from trade shows, technical symposia, industry association meetings, trade or laboratory newsletters, publicity through news and education media, and professional and trade/ industry association contracts (Piper and Naghshpour, 1996).

Business groups: For interactions within the same business groups, the administration should put emphasis on knowledge bonds and technological bonds relating to technologies employed by each manufacturer, more than legal bonds and social bonds (Cusumano and Elenkov, 1994).

Technology suppliers: Provide programs aiming at new technology from abroad in quality control processes and staff training (Bidault *et al.*, 1998; Nishigushi, 1994).

Conclusions

Results showed that forms and channels of technology transfer in the quality control process that Thai pharmaceutical industry received were non-commercialized and mainly not official, primarily through publications and instruction manuals, information from the internet, trade exhibitions and academic conferences, and training from academic institutes and technology donors. Difficulties and obstacles in technology transfer in the quality control process included lack of information about new technology, problems in acquisition and handover of technology, and the capability of Thai personnel. Thai manufacturers needed consultation from outside personnel and organizations in building up their capability in the quality control process. Factors from both inside and outside the

manufacturers exhibited critical roles in all activities concerning technological capability, i. e. , acquisition, operation, adaptation and innovation.

The characteristics of technology transfer, as well as, difficulties and obstacles indicated that Thai pharmaceutical industry required experienced personnel in seeking for appropriate source of technology for their manufacturers. Moreover, as technology recipients, Thai personnel needed to expand their proficiency in technology adsorption and adoption. This included tacit skills, language comprehension and capability in adaptation of acquired technology to current condition. Therefore, to increase the effectiveness of technology transfer and technological capability of Thai pharmaceutical industry, the manufacturers should strongly enhance the competency of their personnel, especially in informal technology acquisition activities. Foresight for administration and management of the administrators is necessary for long term development and competitiveness of Thai manufacturers. The hospitality of technology donors in providing essential information is also vital for successful technology transfer. Several organizations such as Government agencies, industrial associations, academic institutes and suppliers involve in the efficiency of technology transfer and building up technological capability. In the meanwhile, government agencies and related institutions should play a critical role in providing a climate facility that promotes the capability of the manufacturers in acquisition and assimilation of technology in this industry.

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