Chapter 3

Development of Regional Production and Logistics Networks in East Asia: The Case of Thailand

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Development of Regional Production and Logistics Networks in East Asia: The Case of Thailand

Wanwiwat Ketsawa

Abstract

Globalization leads to free flows of capital, labor, technology and information, which have beneficial impacts to the Thai industry. Under the new economic era and trade liberalization, the Thai economy and industry have dramatically improved in terms of new information and communication technologies, transportation and the fostering of regional economic cooperation, which have enticed and sustained the flows of capital and labor. Accordingly, there have been many attempts from manufacturers to shift their emphasis from the conventional business approach (in which links and cooperation with external firms are perceived to be not too significant) toward a proactive business strategy (in which hub firms or institutions have substantial links to external suppliers, competitors and customers) to remain competitive in an integrated market, especially with regards to the development of industrial technology, information and innovation. Hence, industrial linkages and agglomeration have played a crucial role in achieving industrial maturity and regional economic cooperation.

In this paper, I argue that there is a relationship among industrial clusters, intra and inter cluster, university-industry linkages, agglomeration, generating innovation and

enhancing firm's performance. The Thai industry, which is mostly composed of small and medium enterprises, has demonstrated significant linkages which considerably created innovation and improved the industrial performance. Both industrial linkage/agglomeration and product/process innovation were the most remarkable consequences which not only enhanced the efficiency of production but have also contributed to initiating new products, improving the quality of products, reducing production costs and improving the productivity of the Thai industry as whole.

1. INTRODUCTION

The world of business has changed tremendously from the past. This includes how business is conducted and the level of competition and marketing, which through new technology has enabled entrepreneurs to seek new markets more easily without limitations. These factors have caused competition to become quite fierce in almost every business. However, there is one method that could assist the Thai industry to survive and this is to cooperate among themselves in the form of industrial clusters and linkage in order to boost the potential to create innovation. Cooperation in the form of clusters and linkage both domestically and internationally can affect industry in various ways. Most important is innovation. Linkage can support the flow of information and knowledge which are the sources of innovation. Another is marketing and production. It is also important for firms who are engaged in similar business to band together in

purchasing raw materials to lower production costs and to expand their business in a sustainable way.

The formation of industrial clusters and linkages are an essential step for developing countries to stabilize the industrial structure, foster local firms and entrepreneurs, and nurture the advanced society with the dynamism of innovation. Furthermore, effective links among industrial clusters should be established to narrow development gaps, both domestic and international.

Having said this, the objective of this research is to study Thailand's development of regional production and logistics networks. My aim is to scrutinize the mechanism of industrial clusters in generating innovation and intra and inter-cluster linkages. I will examine the effects of infrastructure development and agglomeration on innovation in Thailand by conducting qualitative and econometric analyses and case studies. I will focus on industrial linkages and networks, intra and inter-clusters, knowledge linkages, and innovation resulting from agglomeration to enhance firms' performance.

1.1. Objectives of the study

1) To study the recent development of regional production and logistics networks in Thailand especially that of industrial clusters, intra and inter-clusters, university-industry linkages, agglomeration, generation of innovation and performance.
2) To support country studies of Japan, Brunei, Indonesia, Philippines, and Vietnam.

1.2. Research methodology

This study was conducted using both quantitative analysis through a mail survey and qualitative analysis through a country study of Thailand.

Scope of mail survey

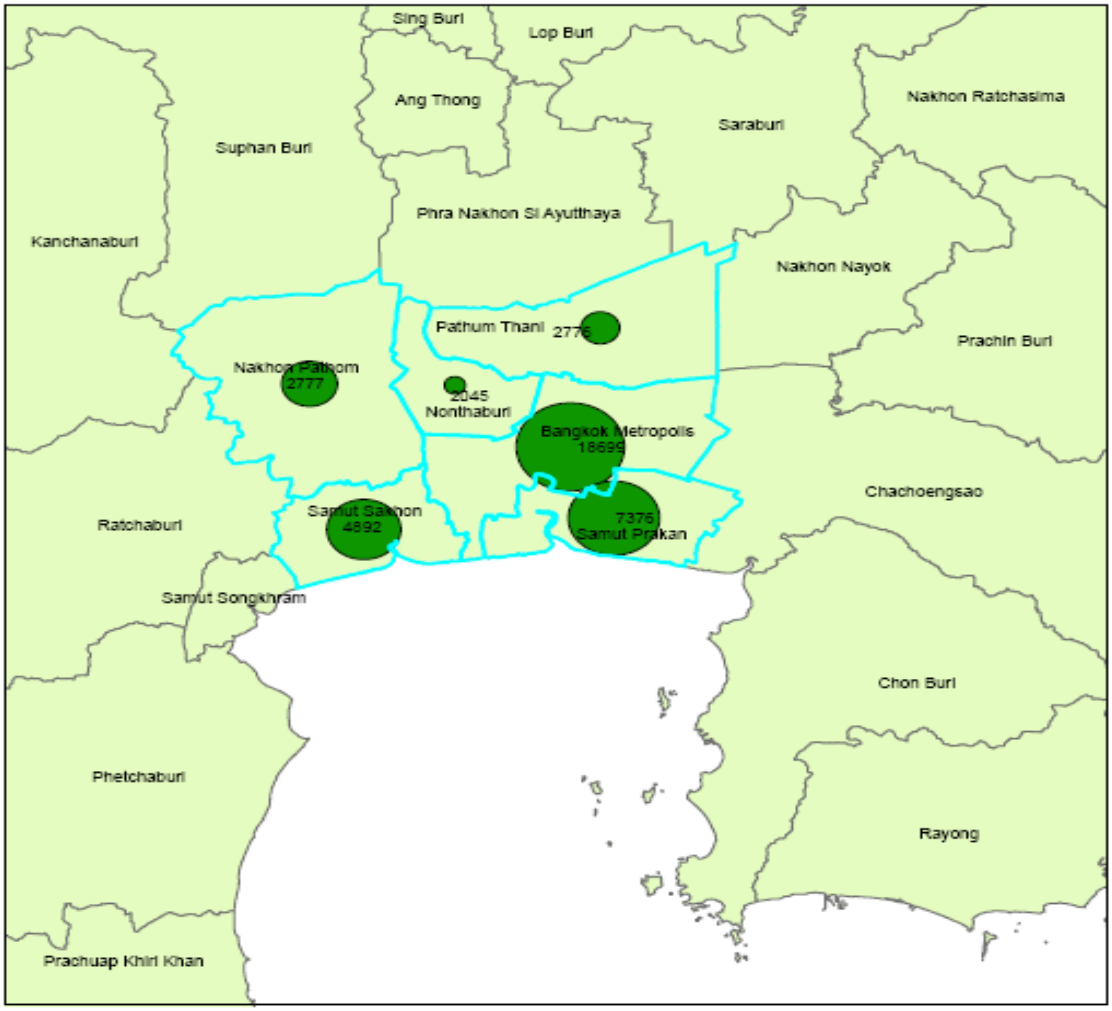
a. Metropolitan Bangkok and the five boundary provinces of Nakornpathom, Nonthaburi, Pathumthani, Samutprakarn and Samutsakhon.
b. Manufacturing industries according to statistics data from the Department of Industrial Works, Ministry of Industry.

Population and sample

Based on statistics from the Department of Industrial Works, Ministry of Industry, the population is the total amount of listed factories by each industrial area (Map 1).

1) Total number of population	**38,565**	factories
Bangkok	18,699	factories
Nakornpathom	2,777	factories
Nonthaburi	2,045	factories
Pathumthani	2,776	factories
Samutprakarn	7,376	factories
Samutsakhon	4,892	factories
2) Total sample	**124**	factories

Map 1. Number of Factory in Bangkok and 5 Boundary Provinces



Source : Author with supported by IDE Bangkok, 2009

Definition of firm size

Following the definition of the Ministry of Industry, firm size for the Thai industry is classified as follows:

- Firms which have 1-49 employees is grouped as Small
- Firms which have 50-199 employees is grouped as Medium
- Firms which have 200-999 employees is grouped as Large
- Firms which have 1,000 or up employees is grouped as Very large

Method of mail survey and case study

1) Mail survey (quantitative analyses) for various selected industries in metropolitan Bangkok and boundary provinces and case studies on agglomeration and related policies (qualitative analyses).
2) For the mail survey (questionnaire)
    (1) Constructed a mailing list of factories located in the selected area
    (2) Translated the questionnaire from English to Thai.
    (3) Requested the Director General, Department of Industrial Promotion, Ministry of Industry, to issue a letter (using the official stationary) by mail and email to the intended participants to ask for their support in the survey
    (4) Conducted a follow-up survey (by phone) to increase valid responses.
    (5) Constructed a dataset in Excel format and delivered it to the WG Coordinator.
    (6) Produced a paper on the results of the survey (based on descriptive statistics).
3) For the case study of the survey area,
    (1) Conducted a historical and quantitative analytical review of the present situation of industrial development in Thailand and the survey area, based on secondary statistics and previous studies
    (2) Produced a report including policy suggestions as conclusions of the case study.
4) Based on the case studies, firm and plant visits, in-depth interviews, and the data collected through the questionnaire survey, the WG members analyzed the levels of progress and the factors that promoted industrial agglomerations in the areas and tested the original hypothesis on the relationship between agglomeration and innovation, and drafted policy suggestions.

Questionnaire & Code of variables

Questionnaire

The questionnaire consisted of 4 parts (7 pages);

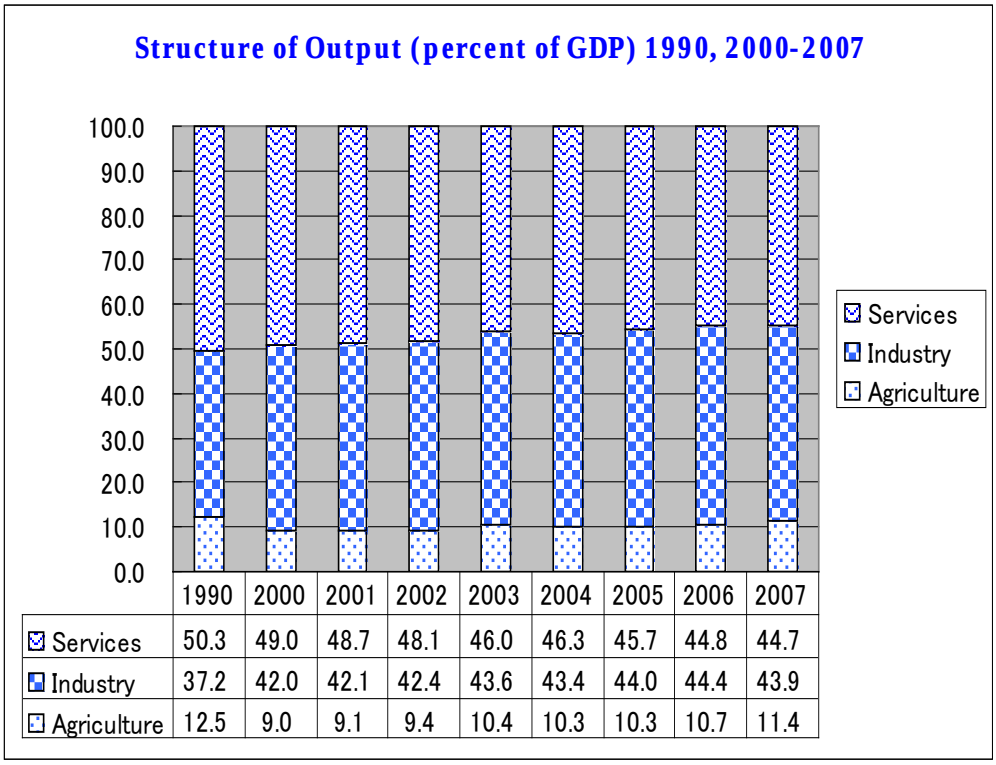
A: Profile of operations	8 questions
B: Innovative activities for businesses upgrading in the past three years	5 questions
C: Business linkages with main customer and supplier at present	2 questions
D: Sources of information and new technologies for innovation and business upgrading	3 questions

2. BACKGROUND

Review of the Thai industry and structural changes during the past decade

The emergence of industrial clusters and agglomeration for sharing of resources (e.g., ICT infrastructure, R&D facilities) and knowledge can help link the country's production processes to the world's production processes. This can cut down the cost of production, management, logistics and production factors and help develop the country to become a hub (e.g., production hub, services hub or innovation hub). This will enhance the country's development by helping it to climb up the global industrial value chain, to leap from being merely a production base to being a production, services and innovation hub. Such leap can increase the share of the country's industrial export products in the global industrial value chain. The production processes of industries are scattered in countries in different regions all over the world, and are linked by ICT infrastructure created by each individual country.

Figure 1. Structure of Output (Percent of GDP) 1990, 2000-2007



	1990	2000	2001	2002	2003	2004	2005	2006	2007
Services	50.3	49.0	48.7	48.1	46.0	46.3	45.7	44.8	44.7
Industry	37.2	42.0	42.1	42.4	43.6	43.4	44.0	44.4	43.9
Agriculture	12.5	9.0	9.1	9.4	10.4	10.3	10.3	10.7	11.4

Source: ADB, 2008

The population is aging. This leads to a declining workforce which will cause stronger competition to acquire younger workers especially in professional fields such as engineering. This trend leads to a demand for foreign workers both skilled and unskilled. Consumption of goods for the senior age group will also become greater, particularly in the areas of health and well-being and traveling.

In Thailand, the change of population structure results in the change of its workforce. This may not be in synch with the trend of the global workforce demand which has changed from being labor intensive to knowledge intensive, technology intensive and R&D intensive.

In 2003, Thailand's key industries can be categorized as follows: (1) food and animal feed, (2) textile and garment, (3) footwear and leather, (4) wood furniture, (5) petrochemical, (6) mold and die, (7) rubber and rubber products, (8) ceramics and glass, (9) iron and steel, (10) electrical and electric supplies, (11) automobile and parts, and (12) gems and jewelries.

Sixty percent of employment comes from the first, second and third industrial categories. Capital-intensive industries (e.g., petrochemicals, automobile and parts, electrical and electronics appliances) do not employ vocational students, science program high school students, engineers, and agriculture, food science and technology graduates.

The labor force survey also indicates that there are only 14.1% of Thai workforce with high school certificate and 11.3% with middle school certificate. In addition, 92% of the Thai workforce are not science and technology graduates.

To maintain and amplify the country's competitive ability, the change in the industrial structure may need to occur sooner than expected. The country should change from producing good and services with low value-added and creativity (sweat and tear industry) to producing goods and services that embody more knowledge (sweat and brain industry) and whose innovation is based on R&D and networks (brain and opportunity industry).

The rapid changes resulting from globalization widely affect not only the economic stream, but also the society, culture, behavior and well-being of the Thai people. Therefore, it is important to empower the people by equipping them with knowledge to decrease any undesired effects. Meanwhile, the knowledge restructuring

for the Thai people in all professions is necessary. This is to increase their capabilities to take advantage of the benefits from globalization and to help the Thai society become a learning society that can lead to a knowledge-based economy and society.

Science and technology competitiveness capability

Thailand's science and technology competitiveness capability released by the IMD World Competitiveness shows that between 1997 and 2006, the level of the country's science and technology competitiveness capability continually declined. It plunged 32nd in 1997 to 53rd in 2006. Thailand's technology capability also fell from 32nd in 1997 to 48th in 2006.

For 2003-2004, the World Economic Forum ranked Thailand at the 36th place in terms of technological sophistication among 102 countries, following Singapore, Malaysia and Vietnam which were ranked 5th, 14th and 15th, respectively.

Research and development investment

In 2004, the R&D expenditures of Thailand totaled 16.571 million baht, a 7% increase equivalent to 0.25% of its GDP. About 36% came from private sector investments. This pales in comparison with the expenditures for R&D of developed countries such as Japan (3.35% of GDP, 70% invested by private sector). For that year, in general, developed countries invested 2.1 to 2.9% of their GDP for R&D activities. For Asia Pacific countries, the magnitude of their R&D investments was as follows: Malaysia, 0.69% of GDP, 65% invested by private sector;, Singapore 2.25% of GDP,

64% invested by private sector; Taiwan, 2.54% of GDP, 82% invested by private sector; and South Korea, 2.64% of GDP, 76% invested by private sector.

The National Sciences and Technology Development Agency (NSTDA) reported that in 2003, Thailand's total full-time R&D workforce totaled 32,011 and 42,379. In 2001 and 2003, the total workforce was 17,710 and 18,114 full-time R&D resources. This is equivalent to 5.14 and 6.7 full-time R&D resources per 10,000 populations, 2.87 being researchers per 10,000 populations. This researcher-to-population ratio from the IMD Science and Technology Indicator Information indicates that Thailand needs to develop more R&D resources given the country's imbalanced researcher-to-population ratio. The ratio turned out to be only 0.33 per 1,000 population, which pales in comparison to other Asia Pacific countries such as Japan, Taiwan and Korea, the key producers of technology and innovation goods, whose research-to-population ratios stood at 7.07, 4.77 and 2.92 per 1,000 population, respectively.

Table 1. R&D Expenditure on Industrial Development of Thailand by Types of Industries, Year 2004

(Unit : THB)

Types of Industries	Process Inprovement	Process Development	Product Improvement	New Product Development	Others	Unidentified	Total	Share %
Food and beverages	86,267,044.08	58,084,402.80	171,235,482.83	474,547,963.77	20,952,953.99	-	811,087,847.47	15.71
Garment	12,409,090.91	9,927,272.73	2,481,818.18	-	-	-	24,818,181.82	0.48
Apparels	2,013,541.67	1,013,541.67	3,040,625.00	5,067,708.33	-	-	11,135,416.67	0.22
Shoes and Leather	583,333.33	334,866.67	947,000.00	4,824,800.00	583,333.33	-	7,273,333.33	0.14
Wood	4,255,058.82	5,415,529.41	7,089,966.39	28,088,493.00	-	-	44,849,047.62	0.87
Paper	24,876,250.00	31,706,666.67	68,904,364.41	57,773,100.28	937,500.00	-	184,197,881.36	3.57
Printing	2,605,333.32	5,210,666.67	4,410,666.67	4,160,000.00	-	-	16,386,666.66	0.32
Petroleum	232,747,761.52	13,680,000.00	141,873,384.19	47,399,006.85	39,399,006.85	-	475,099,159.41	9.20
Chemical	149,193,303.52	34,434,116.29	242,841,019.02	508,698,974.04	4,260,555.55	-	939,427,968.42	18.19
Rubber	92,888,030.03	84,738,617.21	265,971,169.38	305,192,198.05	11,241,125.79	-	760,031,140.46	14.72
Non Metal	7,416,686.57	8,622,925.37	94,468,417.91	142,414,059.70	-	-	252,922,089.55	4.90
Basic Metal	26,700,000.00	11,963,709.62	14,619,726.92	55,790,467.31	-	-	109,073,903.85	2.11
Applied Metal	5,075,555.55	4,690,740.74	3,263,925.93	725,500.00	112,500.00	-	13,868,222.22	0.27
Machinery	20,813,736.29	25,262,155.20	72,319,904.45	78,133,697.24	1,018,305.09	-	197,547,798.27	3.83
Electronics	33,387,578.95	47,417,578.95	53,685,578.95	241,245,052.63	-	-	375,735,789.48	7.28
Radio & TV	43,951,414.95	98,290,454.38	165,135,367.01	258,687,760.55	77,200,000.00	12,500,000.00	655,764,996.89	12.70
Automotive	21,392,878.79	9,372,878.79	19,351,212.12	41,063,588.07	1,440,000.00	-	92,620,557.77	1.79
Manufacturing	**766,576,598.30**	**450,166,123.17**	**1,331,639,629.35**	**2,253,812,369.82**	**157,145,280.60**	**12,500,000.00**	**4,971,840,001.25**	**96.28**
Computer	-	-	9,600,000.00	-	2,400,000.00	-	12,000,000.00	0.23
R&D	13,301,966.67	29,811,366.67	8,791,666.66	103,064,200.00	21,030,800.00	-	176,000,000.00	3.41
Other services	2,875,384.62	1,232,307.69	-	-	-	-	4,107,692.31	0.08
Services	**16,177,351.29**	**31,043,674.36**	**18,391,666.66**	**103,064,200.00**	**23,430,800.00**	**-**	**192,107,692.31**	**3.72**
TOTAL	**782,753,949.59**	**481,209,797.53**	**1,350,031,296.02**	**2,356,876,569.82**	**180,576,080.60**	**12,500,000.00**	**5,163,947,693.56**	**100.00**

Sources: NSTDA, Ministry of Sciences and Technology, 2006, Thailand.

Table 2. R&D Expenditure on Industrial Development of Thailand by Type of R&D, Year 2004

(UNIT : THB)

Types of Industries	Basic Research	Apply Research	Testing & Development	TOTAL
Food and beverages	33,231,923.19	228,839,526.94	549,016,397.34	811,087,847.47
Garment	-	4,963,636.36	19,854,545.46	24,818,181.82
Apparels	5,067,708.33	3,533,854.17	2,533,854.17	11,135,416.67
Shoes and Leather	3,572,000.00	1,047,800.00	2,653,533.33	7,273,333.33
Wood	2,780,470.59	8,567,126.05	33,501,450.98	44,849,047.62
Paper	4,133,333.33	3,700,000.00	176,364,548.03	184,197,881.36
Printing	144,000.00	7,744,000.00	8,498,666.66	16,386,666.66
Petroleum	4,000,000.00	440,190,068.50	30,909,090.91	475,099,159.41
Chemical	47,900,828.29	205,591,562.28	685,935,577.85	939,427,968.42
Rubber	126,163,935.41	413,572,544.26	220,294,660.79	760,031,140.46
Non Metal	31,600,746.27	100,148,656.72	121,172,686.56	252,922,089.55
โลหะขั้นมูลฐาน	248,325.00	13,786,786.54	95,038,792.31	109,073,903.85
โลหะประดิษฐ์	2,711,111.11	3,325,925.93	7,831,185.18	13,868,222.22
Machinery	3,975,416.67	21,617,789.54	171,954,592.06	197,547,798.27
Electronics	43,512,000.00	73,476,631.58	258,747,157.90	375,735,789.48
Radio & TV	19,308,810.94	152,302,865.62	484,153,320.33	655,764,996.89
Automotive	5,893,939.39	20,441,818.18	66,284,800.20	92,620,557.77
Manufacturing	**334,244,548.52**	**1,702,850,592.67**	**2,934,744,860.06**	**4,971,840,001.25**
Computer	1,200,000.00	8,400,000.00	2,400,000.00	12,000,000.00
Research and Development	2,450,000.00	86,789,700.00	86,760,300.00	176,000,000.00
Other services	-	-	4,107,692.31	4,107,692.31
Services	**3,650,000.00**	**95,189,700.00**	**93,267,992.31**	**192,107,692.31**
TOTAL	**337,894,548.52**	**1,798,040,292.67**	**3,028,012,852.37**	**5,163,947,693.56**

Sources: NSTDA, Ministry of Sciences and Technology, 2006, Thailand.

Government R&D Expenditure and Networks

There are some organizations that grant R&D budget to support public and private needs, such as the National Research Council of Thailand (NRCT), the Thailand

Research Fund (TRF), and the National Innovation Agency (NIA). NIA is an autonomous organization operating under the policy guidance of the National Innovation Board, by utilizing the Innovation Development Fund and the Revolving Fund of Research and Technology Development which totaled about 3 billion baht in 2006**.** During the first period, the NIA focused on developing strategic innovation projects in five branches: food and herbs, indigenous rubber and products, software and mechatronics, automotives and parts, and engineering and industrial designs. This organization has integrated government R&D budget and fund, which is allocated to universities, public institutes, non-government organizations and industry.

Patent Acquisition and Registration

The number of patents in Thailand is as low as 65 while countries that invest continually in R&D such as Japan and Korea own as many as 123,978 and 34,052 patents, respectively. Possessing patents especially ones that relate to innovation and technology can increase the country's competitiveness capability and the value of its products.

There seems to be some data inconsistency, however. Based on the research of IMD, there are sources that indicate Thailand's patents totaled 13,991 as of March 2003. Among 2,978 Thai patents, only 375 items are inventions. Most of the patents are inventions that utilize primary level of technology (e.g., fish scale remover, mango fruit collector, juice maker). Such patents cannot create high value as they require only a low level of technology.

Meanwhile, the NSTDA reported that in 2005, there were 10,885 requests for patent acquisition, of which 4,258 were filled by Thai people. Patent registration totaled 1,322 items, of which 505 were made by Thai nationals. In addition, there were 28 requests for patent acquisition by Thai people in the United States and 17 in Japan. There were 3,000 print editions and 27,795 science articles used as reference 1,445 and 1,403 times, respectively, both nationally and internationally.

Table 3. Number of Granted Patent by Type

(Unit : patents)

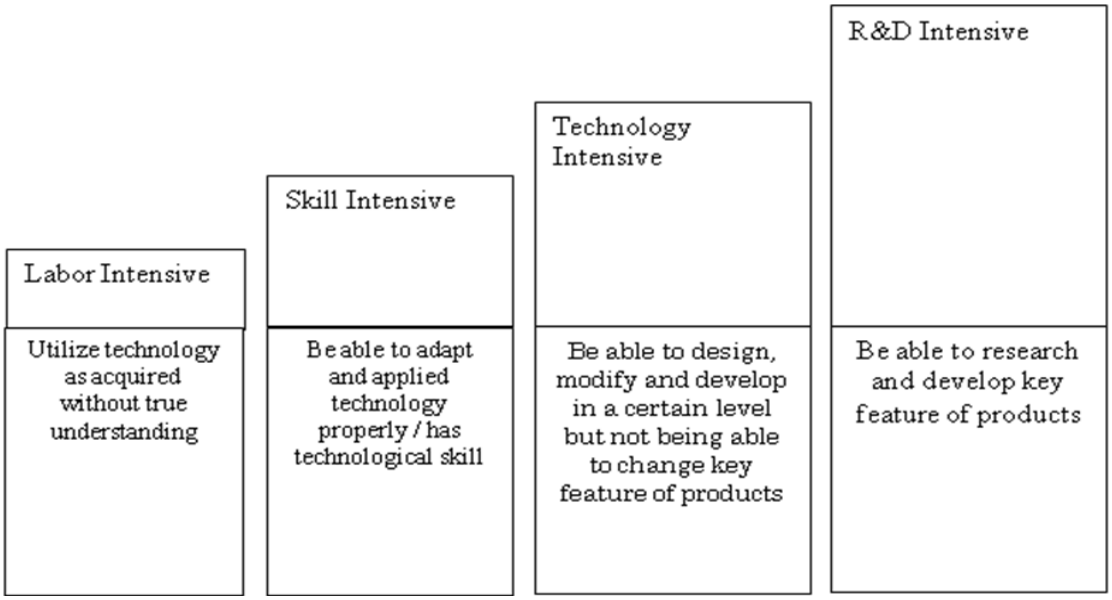
	Number of granted patent		
Year	**Total**	**Design**	**Innovation**
1981	**4**	4	0
1985	**84**	79	5
1990	**86**	79	7
1995	**101**	100	1
2000	**164**	119	45
2004	**867**	810	57

Source: Department of Intellectual Property, Ministry of Commerce, Thailand, 2006.

Level of Production Technology

The private sector of Thailand, most of them being small and medium enterprises (SMEs), utilize the first level of technology which is labor intensive and/or the second level of technology which is skill intensive. Some are only producers of goods that have been designed by others. Few have sufficient capability level to design and develop products utilizing the third level of technology (technology intensive) and the fourth level of technology (R&D intensive).

Diagram 1. Levels of Production Technology



Source: National Strategy of Science and Technology (2004-2013) adapted from World Bank 2000.

ICT Development and Virtual Networks

NSTDA reported that Thailand has 2,609 computer units (unit: 1,000 computers) or a ratio of 4 computers per 100 population. There were 10 internet users per 100 population and 51.3 mobile phone users per 100 population in 2006. It appears there had been significant improvements since 2004 based on the report of the National Statistic Office, Ministry of Sciences and Technology, Thailand.

Table 4.1. ICT Diffusion and Utilization in Thailand, 1979-2004

(Unit : % per household)

ITEMS	1979	1984	1989	1994	1999	2000	2001	2003	2004
Personal Computer	n.a	n.a	n.a	n.a	n.a	**5.0**	**5.1**	**8.2**	**11.1**
Television	**17.0**	**33.0**	**50.0**	**75.0**	n.a	n.a	n.a	**92.0**	n.a
Radio	**79.0**	**75.0**	**73.0**	**74.0**	n.a	n.a	n.a	**51.0**	n.a
Faximile	n.a	n.a	n.a	n.a	n.a	**1.6**	n.a	n.a	n.a
Internet User (% of population)	n.a	n.a	n.a	n.a	**2.4**	**3.7**	**5.6**	**10.4**	**11.9**
Basic Telephone Unit (per 100 household)	n.a	n.a	n.a	n.a	**12.3**	**12.4**	**12.5**	**13.5**	**13.6**
Mobile Phone User (% of population)	n.a	n.a	n.a	n.a	n.a	**5.6**	**11.8**	**34.1**	**36.3**

Source: National Statistic Office, Thailand.

Table 4.2. Internet User by Country Year 2003

Country	Internet User ('000)	Internet User (per 10,000 people)
USA	159,000.0*	5,513.77*
Singapore	2,100.0*	5,043.59*
Hong Kong	3,212.80	4,691.66
Japan	57,200.0*	4,488.56*
Taiwan	8,830.00	3,900.76
Malaysia	8,692.10	3,453.31
Thailand	6,031.30	964.53
China	79,500.00	632.48
India	18,481.00	174.86
Asia	243,405.90	674.25
World	675,677.70	1,107.08

Remark: * Data in Year 2002.
Source: International Telecommunication Union (ITU).

Foreign Direct Investment (FDI) and Market

Within the first 10 months of 2007, Japanese investors had the most number of investments (247), totaling 109,204 million baht. USA was the second biggest source of investment (44), totaling 63,564 million baht. Singapore was third (65) with a total investment value of 14,982 million baht.

During the first 10 months of 2007, the types of businesses that received the highest support are services and utility services (160,700 million baht), chemicals, paper and plastic business (156,500 million baht), electronics and electrical appliances (94,700 million baht), metal products and equipment (59,600 million baht), agriculture and agricultural products (52,800 million baht), mining, ceramics and metal (44,400), and light industry and textile (14,600 million baht).

Table 5. The Investments Received Support from BOI, classified by Types of Industries, 2007

Economy	2007 (Jan. - Oct.)	
	Number of investment plans	Investment value (million baht)
Agriculture and agricultural products	174	52,800
Mining, ceramics and metals	29	44,400
Light industry and textiles	85	14,600
Metal products and equipments	203	59,600
Electronics and electrical appliances	229	94,700
Chemicals, paper and plastics	124	156,500
Services and utility services	282	160,700
Total	1,126	583,300

Source: The Board of Investment of Thailand, 2007.

Table 6. Foreign Investment that Received Support from BOI, Categorized by main East Asian Countries, 2007

(Unit : million baht)

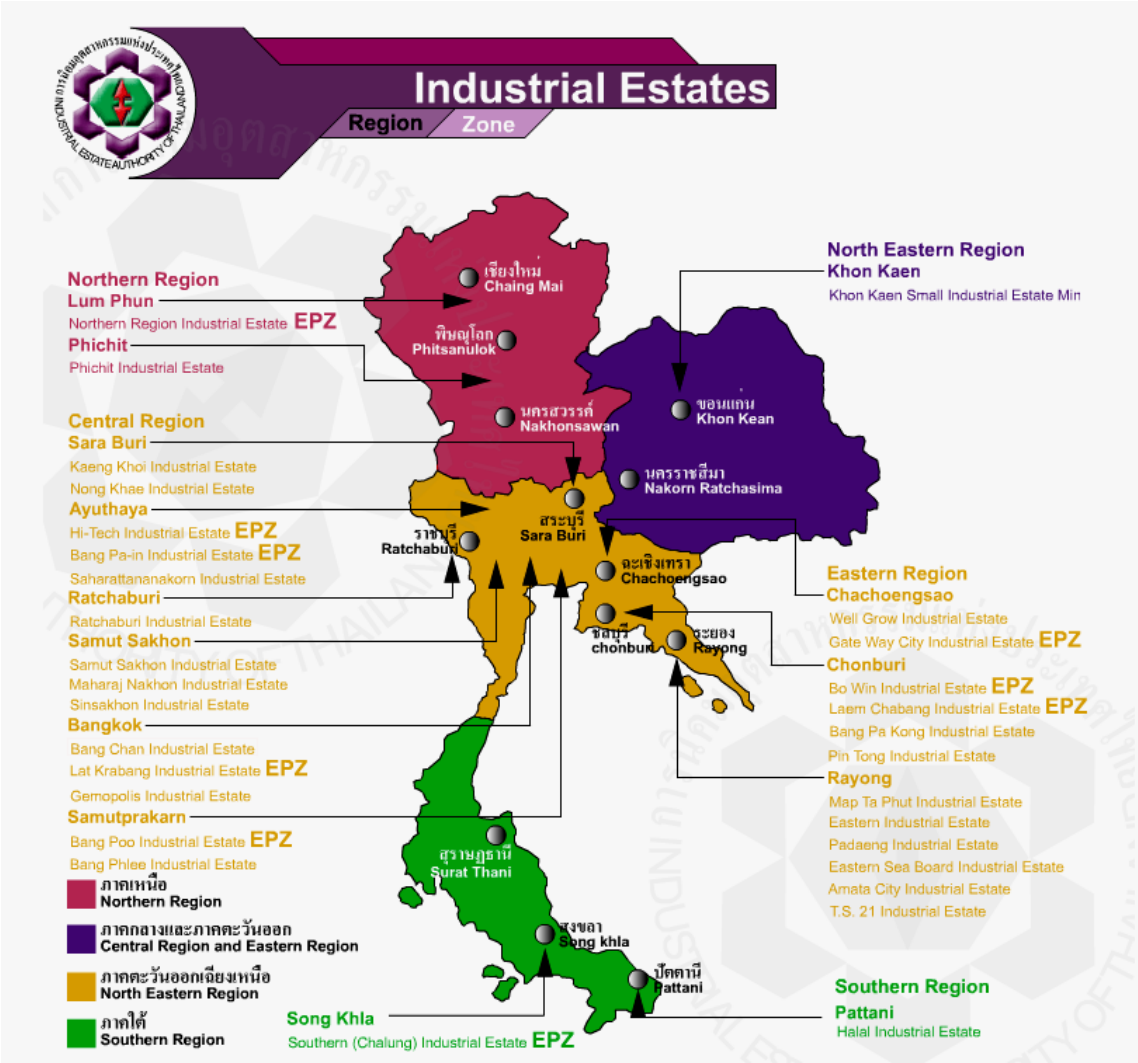
Country	2006		2006 (Jan. - Oct.)		2007 (Jan. - Oct.)	
	Number of investment plan	investment value	Number of investment plan	investment value	Number of investment plan	investment value
Japan	353	115,200	278	66,066	274	109,204
Taiwan	63	10,472	48	9,534	40	7,616
Hong Kong	18	10,031	15	9,767	15	10,103
South Korea	24	4,025	21	3,910	44	5,899
Singapore	62	18,750	50	13,637	65	30,501
Malaysia	35	5,368	29	4,792	25	10,762
Indonesia	5	587	5	587	4	4,031
The Philippines	1	67	1	67	1	90
China	16	2,456	14	2,377	20	5,274

Source: Office of the Board of Investment (BOI), Thailand, 2008.

Industrial Estates in Thailand

The Industrial Estate Authority of Thailand (IEAT) has established 34 industrial estates located in 15 provinces nationwide which consist of two categories: (1) industrial estates developed by IEAT, totaling nine to date, and (2) industrial estates that IEAT jointly developed with the private sector, totaling 25.

Map 2. Industrial Estate in Thailand by Region, 2008



Source : Industrial Estate Authority of Thailand, 2008.

Map 3. Industrial Estate in Thailand by Zone, 2008

Source: Industrial Estate Authority of Thailand, 2008.

The industrial estates were developed and managed by the IEAT. The industrial zones are under the Ministry of Industry (MOI) and aim to support regional development and specific industrial sectors. The industrial parks are established entirely by the private sector. The total land must be at least 500 Rai (or 800,000 M^2), with 60-70 percent allocated to factories. All required facilities are provided in the industrial parks. Most industrial parks are promoted by the Board of Investment.

An industrial estate in Thailand resembles an industrial town or industrial city

providing complete infrastructure necessary for industrial operations such as ample electricity, water supply, flood protection, waste water treatment and solid waste disposal. It is accessible to seaports, airports and other transportation centers. Besides providing communication facilities and security systems, an industrial estate also contains commercial banks and a post office. Some have customs offices, schools, hospitals, shopping centers and other facilities needed by investors and workers. It is just like a self-contained community.

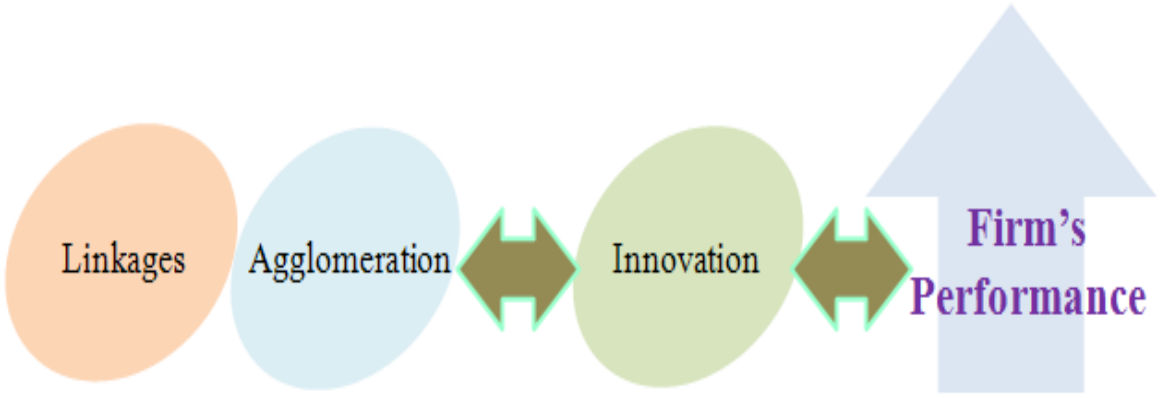
3. HYPOTHESIS

Following globalization, the Thai industry became more open to the global market, making it more susceptible to market fluctuations. Hence, the Thai industry needs to adjust to a knowledge-based economy by enhancing the industrial clusters and linkages to initiate innovation in order to increase its performance while maintaining its comparative advantages and competitiveness. Clustering and public-private linkages are being implemented by various public organizations that act as service providers. Budget and resources, however, remain limited in many developing countries like Thailand.

This study seeks to determine the sources of innovation and explain the relationship among R&D linkages, industrial linkages, innovation, and firm's performance. This is illustrated as follows:

Linkages / Agglomeration → Innovation → Performance

Figure 2. Hypothesis of the Study



Source: Author and team.

The different variables and their definitions are as follows:

- *Linkages* is any linkage or contact between firms and customers or suppliers in terms of local or foreign firm, university and industry R&D linkages, government or public organizations and industry (Q16), receiving or dispatching engineers with customers/suppliers (Q14.12, Q14.13), capital tie-up with customer/suppliers (Q14.9) and duration of the relationship with the customer/supplier (Q14.11).
- *Agglomeration* is any benefit from activities that firms obtain when locating close to each other or in the same industrial estate or as industrial clustering. This study referred to distance (Q14.6) and travel time from firms to customer/supplier (Q14.7) and just-in-time distribution system adopted by the customer/supplier (Q14.8).
- *Innovation* refers to either: (1) product innovation or new products/services introduced in the market (Q9, Q9.1, Q9.2, Q9.3), or (2) process innovation or new production methods adopted by the firm (Q10) such as newly bought machines or facilities with new functions, (Q10.1), improved existing machines, equipment or facilities (Q10.2), or introduced new know-how on production methods (Q10.3). In addition, innovation could also mean securing new suppliers (Q11), seeking new market/customers (Q12) and improving business processes or organization (Q13).
- *Performance* refers to business performance of firm in comparison with the last year (Q6), for instance, increase in sales, (Q6.1), increase in profit (Q6.2), increase in

number of employees (Q6.3), increase in the value of exports (Q6.4), increase in the value of exports to developed countries (Q6.5), increase in the number of export destinations (Q6.6), improvement in productivity of operation (Q6.7), substantial improvement in quality of products (Q6.8), substantial reduction in product defects (Q6.9), substantial decrease of production cost (Q6.10) and substantial reduction in lead time (Q6.11).

4. EMPIRICAL RESULTS

4.1. Descriptive Analysis and Key Findings

The structure of the Thai industry can be summarized as follows:

Capital Type, Year of Establishment, Foreign Investors

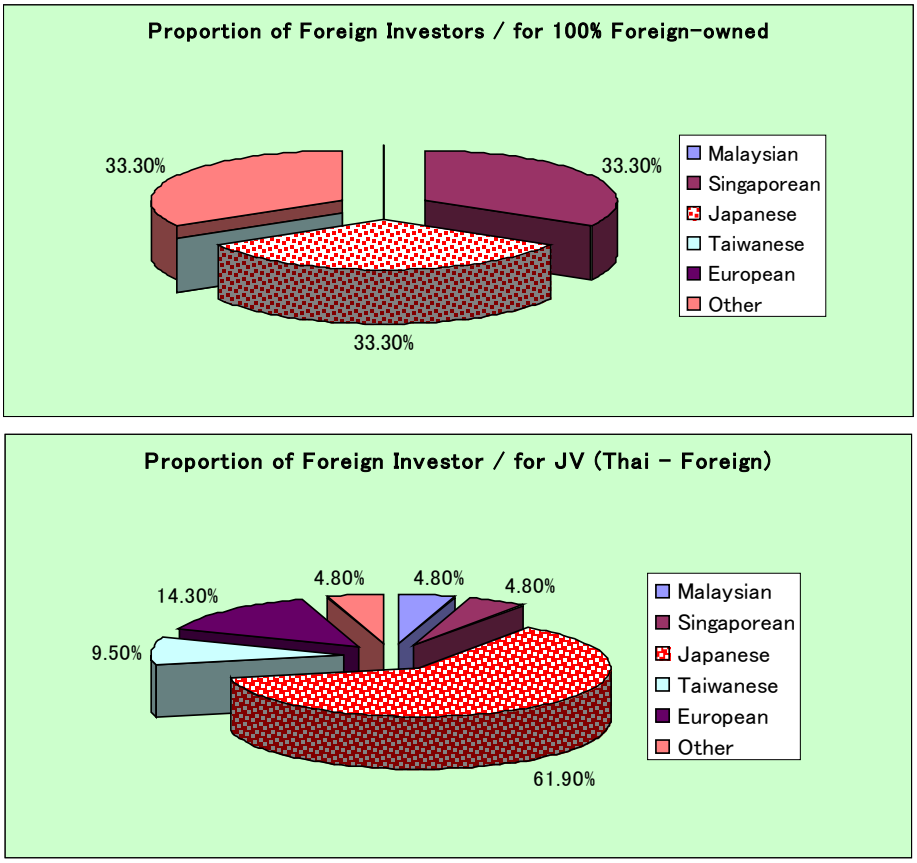
Eighty-one percent of the respondents are wholly owned Thai SMEs by middle-aged entrepreneurs established after the 1990s. On joint venture and foreign firms in Thailand, the most important partners of the Thai industry in the last decade are Japanese and Singaporeans.

Table 7. Characteristics of Respondents

Characteristics	N	Minimum	Maximum	Mean
Age of Firms	115	2	58	16.99
Number of Full-time Employees	122	10	2500	239.59
100% Local-owned Firm	124	0	1	0.81
Joint-ventured Firm	124	0	1	0.17
100% Foreign-owned Firm	124	0	1	0.02
Production (raw material processing)	123	0	1	0.24
Production (components and parts)	123	0	1	0.17
Production (final products)	123	0	1	0.51
Procurement of raw materials, parts or supplies	123	0	1	0.09
Marketing, sales promotion	123	0	1	0.07
Does your establishment carry out R&D at present?	124	0	1	0.39

Source: Survey 2009, Author and team.

Figure 3. Proportion of Foreign Investors

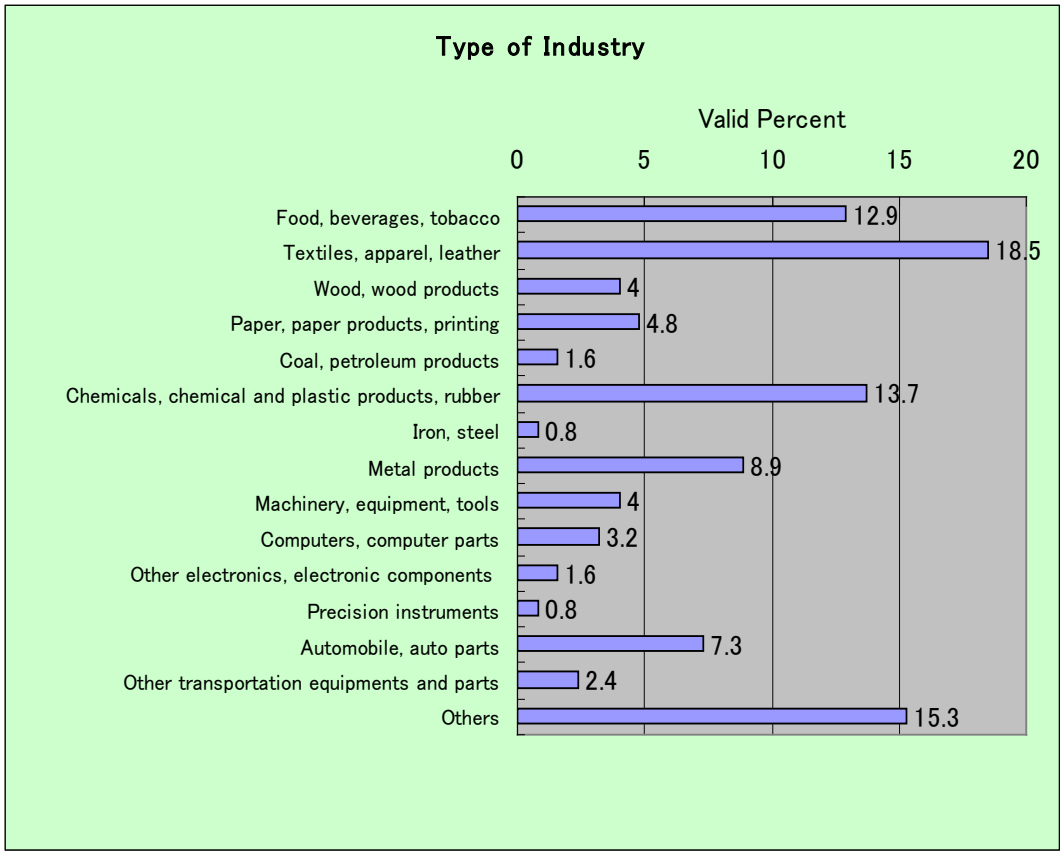


Source: Survey 2009, Author and team.

Proportion and Type of Industry

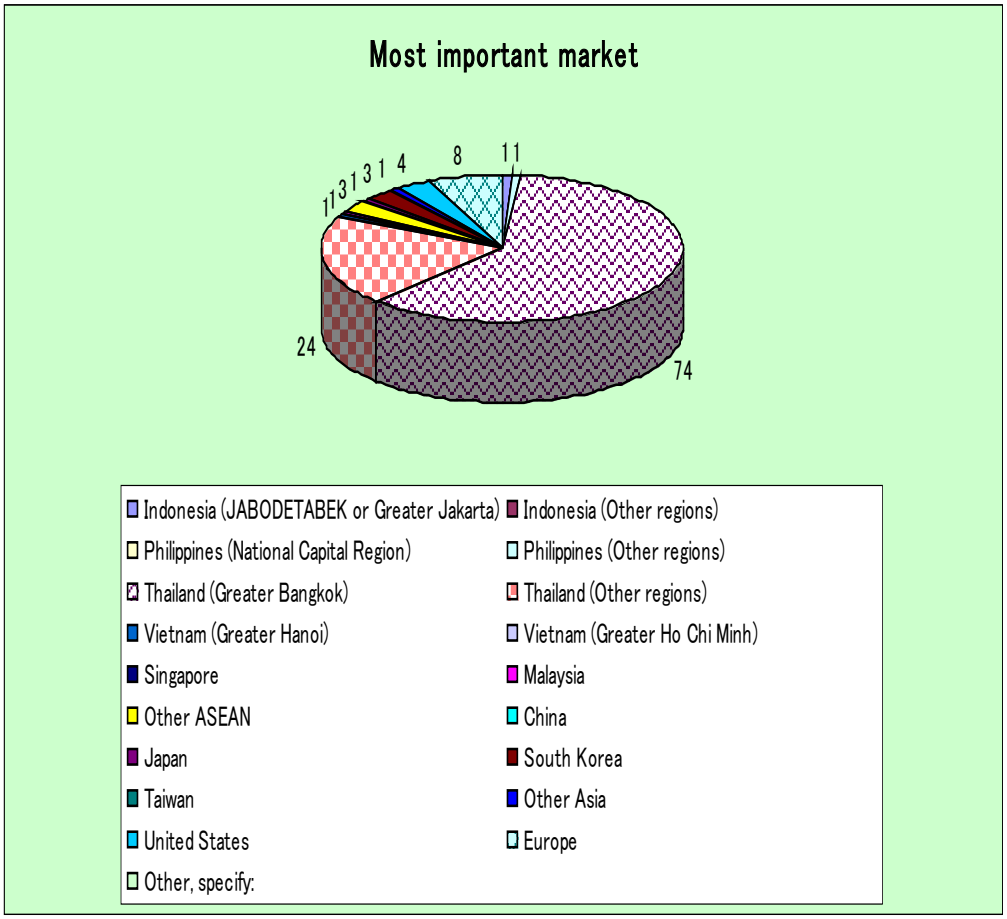
The combined textile, apparel and leather industry was the largest industry (18.5%). This industry is labor intensive and needs to utilize low-wages workers and migrants from neighboring areas. To compete with China, the adoption and utilization of innovations in designing, branding and differentiating new products should be taken into account. The industry of chemical and plastic products, and rubber has also played a significant role (13.7%). The third largest industry is food, beverages, and tobacco (12.9%). For other industries (15.3%), since the Kyoto Protocol was implemented, industries related to recycling, re-conditioning, energy-saving and others that are environmentally related have become more concentrated. Advancements in environmental technology have resulted in newcomers entering this industry. Overall, most of Thai SMEs still rely on domestic suppliers and customers especially in Bangkok area and boundary provinces (60%) and other provinces (20%).

Figure 4.1. Type of Industries



Source: Survey 2009, Author and team.

Figure 4.2. Most Important Market or Customers/Suppliers (Unit Frequency)

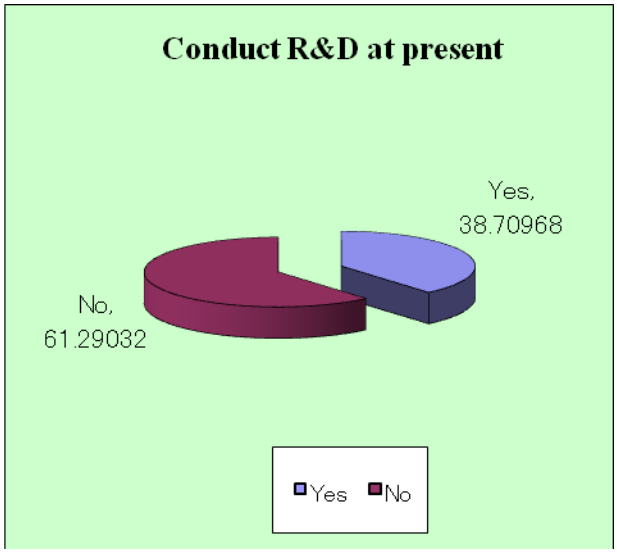


Source: Survey 2009, Author and team.

Carrying Out R&D Activity

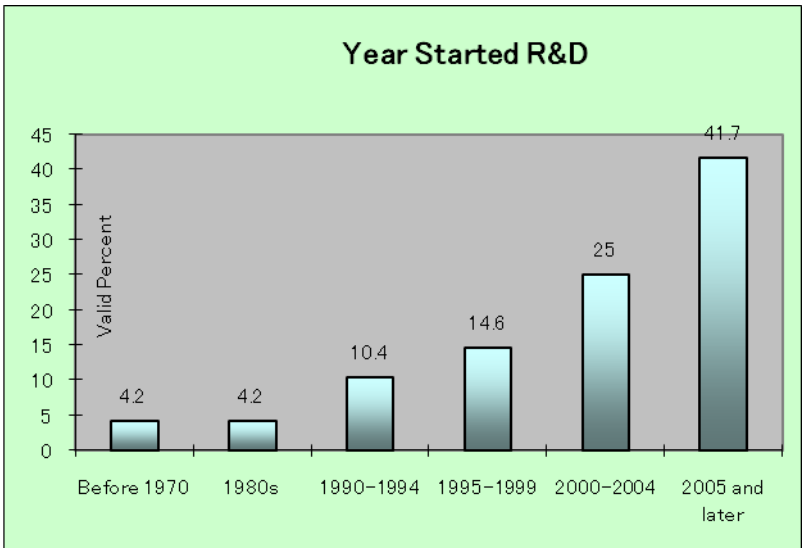
Only around 40 percent of Thai industry has carried out R&D activities. These activities were mostly focused on basic research and applied research which were started after the 2000s. As a result of the 1997 world economic crisis, the Thai currency was depreciated or devalued sharply. Exporters benefited from this depreciation thus exports increased. Firms were forced to improve their production efficiency to maintain their competitiveness and had to put more efforts on implementing R&D activities. In general, however, they rely mostly on their own internal R&D capacity which is usually a small section or department consisting of one to five researchers.

Figure 5.1. Conduct R&D at Present



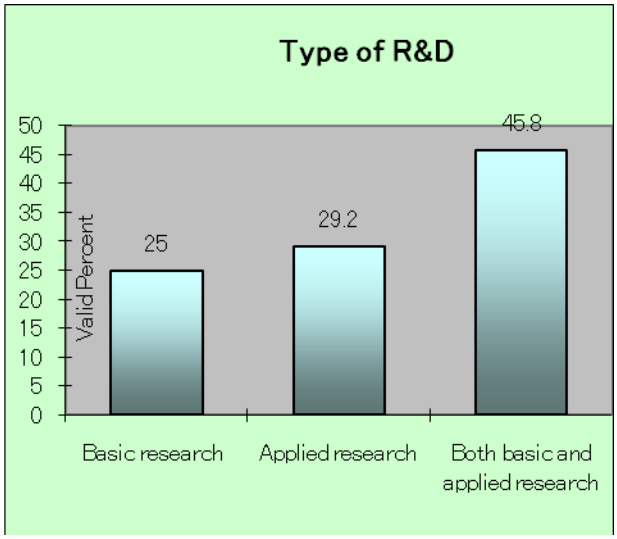
Source: Survey 2009, Author and team.

Figure 5.2. Year Started R&D



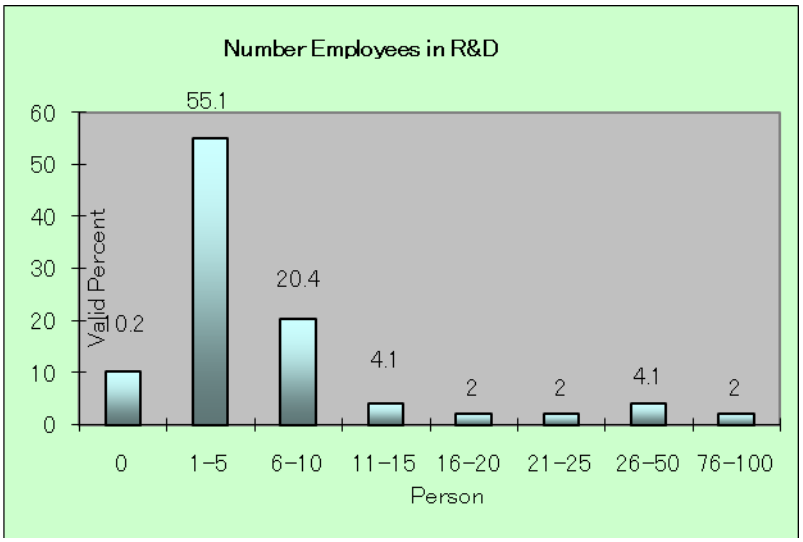
Source: Survey 2009, Author and team.

Figure 5.3. Type of R&D



Source: Survey 2009, Author and team.

Figure 5.4. Number of Employees in R&D



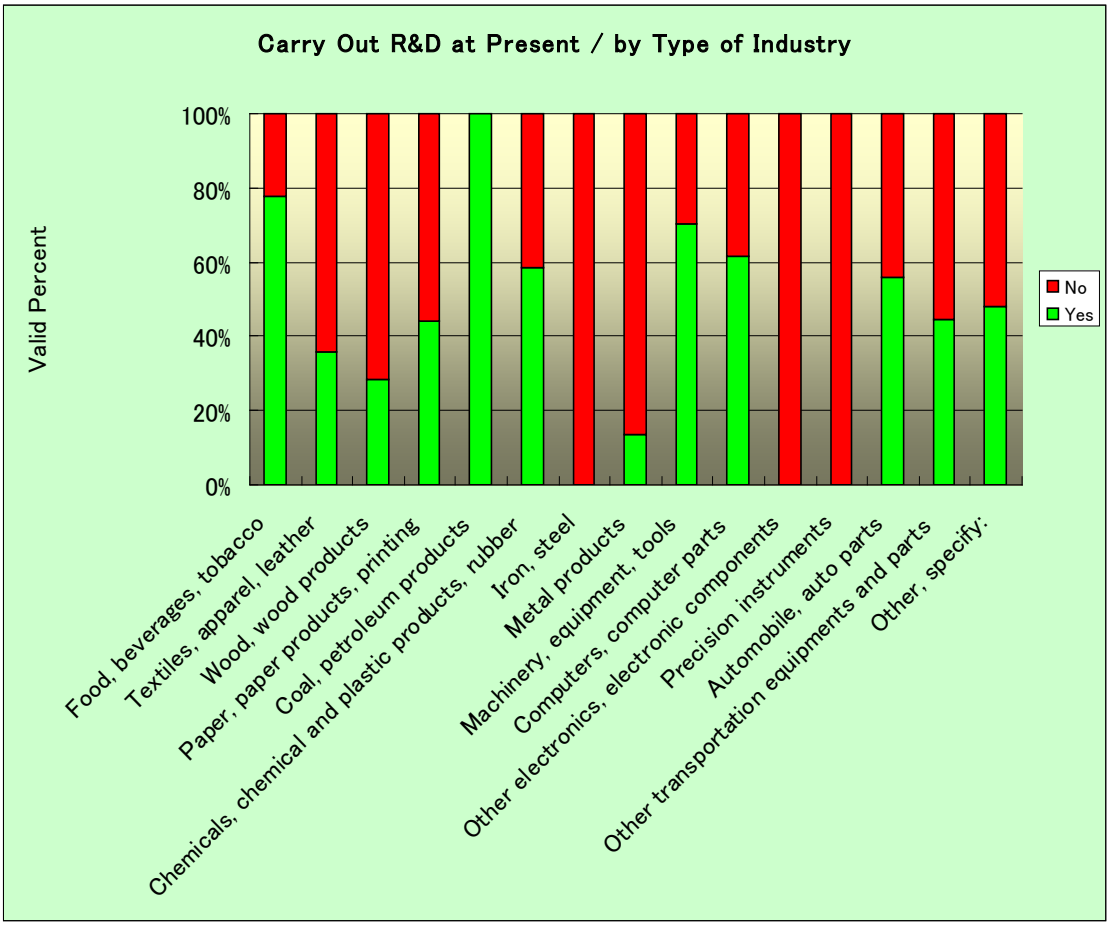
Source: Survey 2009, Author and team.

R&D by Industry

Among the 15 surveyed industries, the top three industries in terms of high rate of conducting R&D and innovation are high-technology-intensive industries or knowledge-based industries such as (1) coal and petroleum products, (2) food,

beverages, and tobacco, and (3) machinery, equipment and tools.

Figure 6. Carry out R&D at Present by Type of Industry



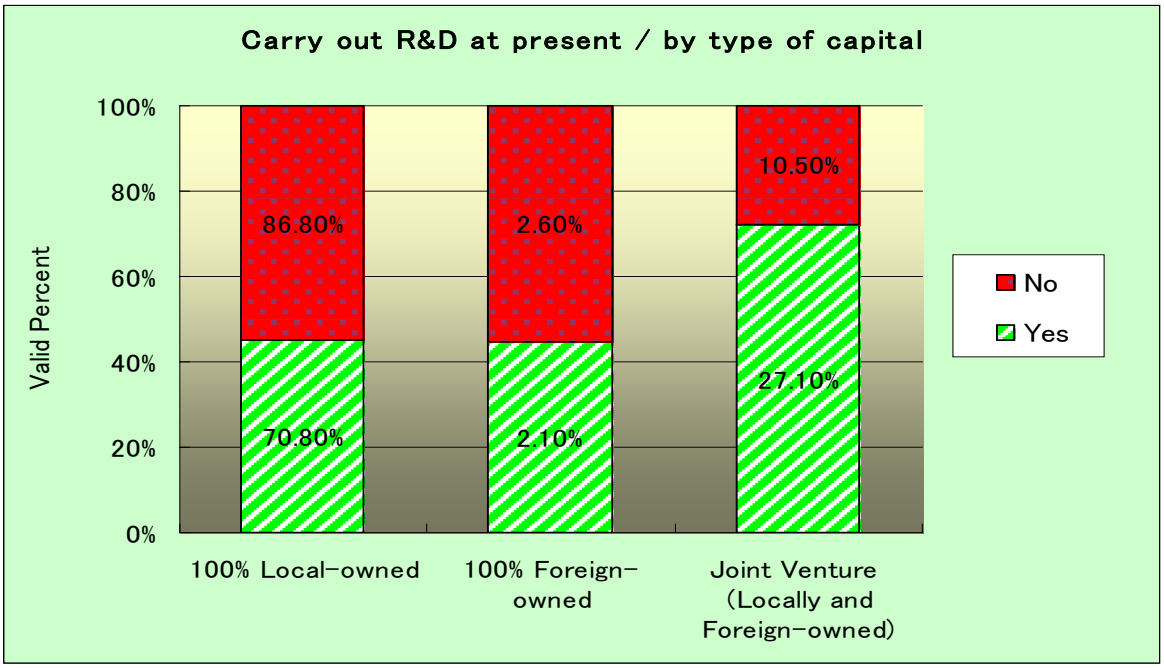
Source: Survey 2009, Author and team.

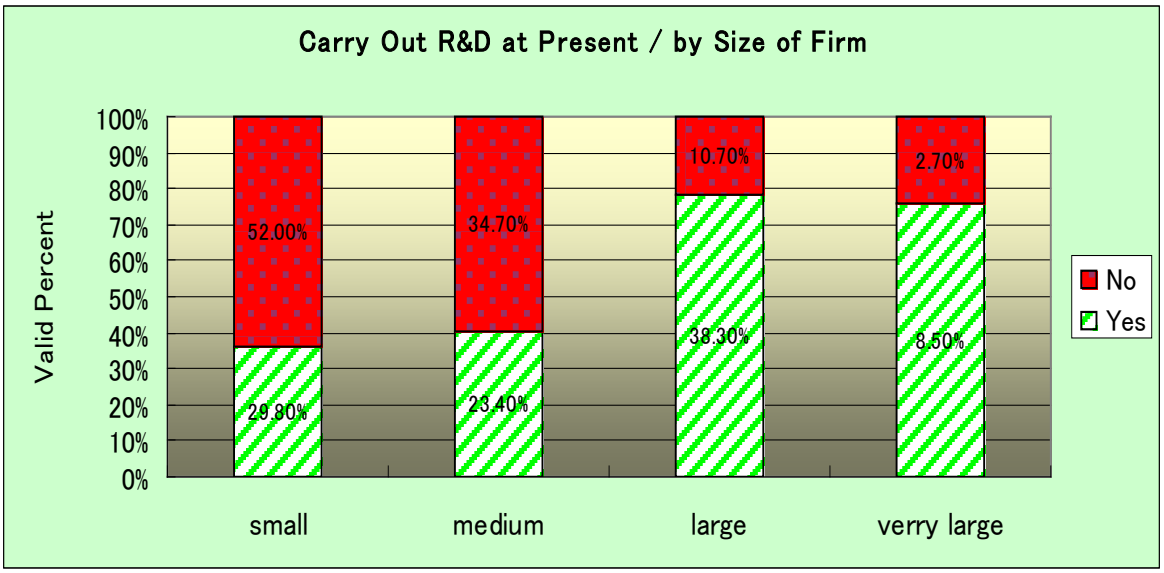
R&D by Size and Capital

Firms realize the importance of R&D in creating innovation and accordingly, the need to invest on resources such as money, time, experienced researchers and linkages. Mostly large and very large or joint-venture firms could afford to do this. Based on the survey, they have had a comparatively high rate of carrying out R&D activities. In contrast, the 100% locally owned Thai enterprises, which are mostly SMEs, have

limited resources especially financial support and knowledge inventory.

Figure 7. Carry out R&D at Present by Type of Capital and Size of Firm



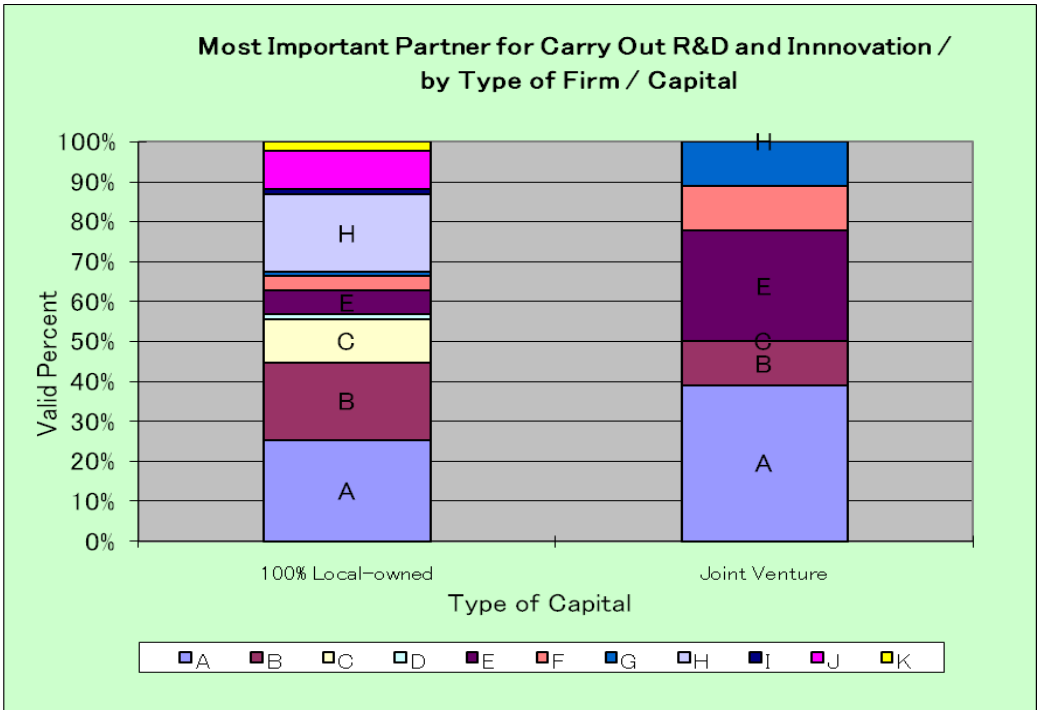


Note: Small (up to 49 employees); Medium (50-199); Large (200-999); Very large (1000 up).
Source: Survey 2009, Author and team.

Most Important Partner for R&D

The government budget on R&D expenditure is always limited unlike in the developed nations. The most important partners for innovation and upgrading—the private sector—would normally rely on their own resources, department, headquarter or affiliated company (25.3%). Some firms dealing with local customers or suppliers are forced to maintain and improve the quality of their products, hence they are also perceived to be another important partner for R&D (19.3%). Only a few of them, however, could access government and public agencies' grants and link to local universities or R&D institutes.

Figure 8. Most Important Partner for Carrying Out R&D and Innovation

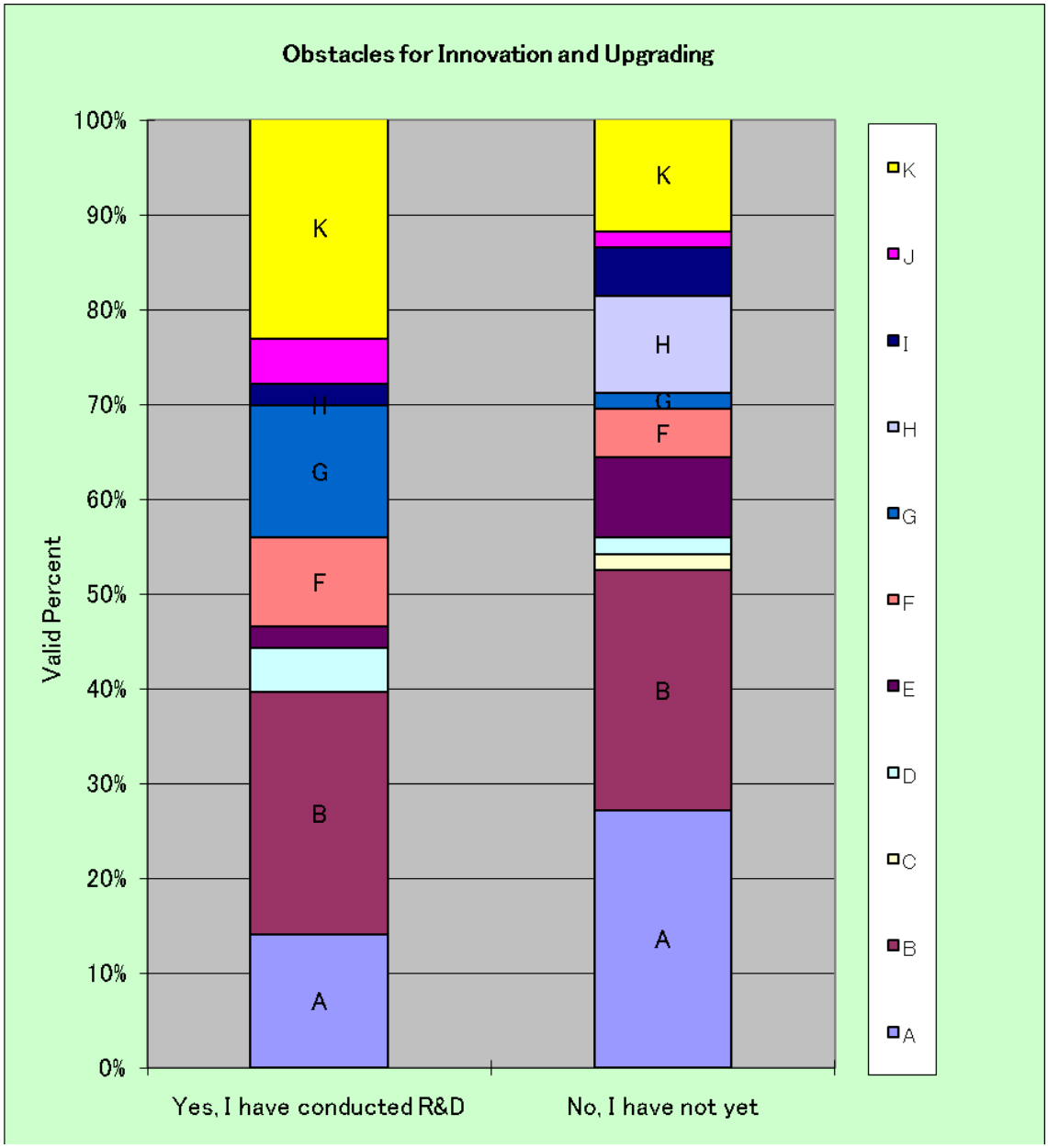


Note 1: A (Own department, headquarters, affiliates); B (Local firm (customers or supplier)); C (Local firm (competitor)); D (Local firm in different business field); E (MNC or JV (competitor or supplier)); F (MNC or JV (competitor)); G (Foreign International Cooperation Agencies); H (Government, Public Agencies); I (Local business organization); J (Local universities, R&D Institutes); K (Consultants, financial institutions)
Note 2: Analysis excluded 100% Foreign-owned because too low respondents
Source: Survey 2009, Author and team.

Most Serious Obstacles for R&D

The most serious obstacles to R&D identified by the firms are the high cost of R&D equipment which is usually highly dependent on imported items (25.6%) and the highly rigid labor mobility which constrains workers to bring the technology they acquired from previous employers or firm (23.3%). Most private firms require their employees to sign a clause in their employment contracts specifying that after they resign, they shall not be able to apply for any jobs within the same industry especially in competitor firms. This is to prevent the flow of technology or utilization of previous know-how and some significantly important business secrets. Other serious obstacles are the lack of R&D supporting infrastructures such as financing and consulting which can provide support services (14%) and high tariffs on equipment and materials necessary for innovation (14%).

Figure 9. Obstacles for Innovation and Upgrading



Note: A(No R&D supporting industry such as consulting, financing.); B (Price of R&D support services is high.); C (No university or public institute in the neighborhood.); D (Technological capabilities of universities or public institutes located in the neighborhood are too weak to collaborate.); E (No business organization or chamber of commerce which can provide training courses, seminar or testing facilities.); F (Protection of intellectual property right (IPR) is not sufficient.); G (High tariffs on equipments and materials necessary for innovation.); H (No tax break or accelerated depreciation system.); I (My establishment is not familiar with public support programs and procedures to apply for support measures.); J (Public support programs are not designed appropriately for innovation); K (Labor mobility is too rigid for workers to bring with them technologies acquired from previous employer or from previous)
Source: Survey 2009, Author and team.

Improvement of ICT and International Standard

During the last three years, more than half of the firms surveyed have utilized better ICT networks and industrial clusters. They developed new products by improving their existing machinery, equipment or factory instead of purchasing new and costly machines. The supply chain of Thai exporter has been under great pressure to follow various international standards such as the ISO. Thus, firms adapted and implemented more complicated and advanced ICT systems while, at the same time, keeping the firm's resilience in check against economic uncertainties and market fluctuations.

Table 10. Adopted a New Production Method in Recent 3 years VS Type of Industries (Process Innovation)

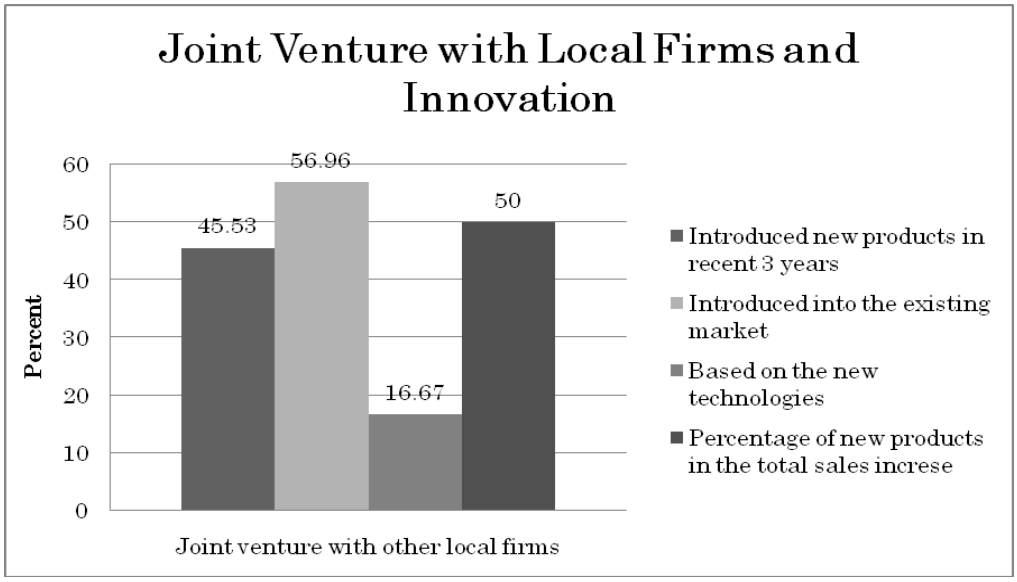
Type of Industries	Bought new machines or facilities with new function to operation			
		Yes	No	Total
Food, beverages, tobacco	Count	11	5	16
	% within Type of Industries	68.80%	31.20%	100.00%
	% within Bought new machines or ….	**14.90%**	10.20%	13.00%
Textiles, apparel, leather	Count	13	10	23
	% within Type of Industries	56.50%	43.50%	100.00%
	% within Bought new machines or ….	**17.60%**	20.40%	18.70%
Wood, wood products	Count	1	4	5
	% within Type of Industries	20.00%	80.00%	100.00%
	% within Bought new machines or ….	1.40%	8.20%	4.10%
Paper, paper products, printing	Count	4	1	5
	% within Type of Industries	80.00%	20.00%	100.00%
	% within Bought new machines or ….	5.40%	2.00%	4.10%
Coal, petroleum products	Count	2	0	2
	% within Type of Industries	100.00%	0.00%	100.00%
	% within Bought new machines or ….	2.70%	0.00%	1.60%
Chemicals, chemical	Count	11	6	17
and plastic products, rubber	% within Type of Industries	64.70%	35.30%	100.00%
	% within Bought new machines or ….	**14.90%**	12.20%	13.80%
Iron, steel	Count	1	0	1
	% within Type of Industries	100.00%	0.00%	100.00%
	% within Bought new machines or ….	1.40%	0.00%	0.80%
Metal products	Count	7	4	11
	% within Type of Industries	63.60%	36.40%	100.00%
	% within Bought new machines or ….	9.50%	8.20%	8.90%
Machinery, equipment, tools	Count	4	1	5
	% within Type of Industries	80.00%	20.00%	100.00%
	% within Bought new machines or ….	5.40%	2.00%	4.10%
Computers, computer parts	Count	1	3	4
	% within Type of Industries	25.00%	75.00%	100.00%
	% within Bought new machines or ….	1.40%	6.10%	3.30%
Other electronics,	Count	1	1	2
electronic components	% within Type of Industries	50.00%	50.00%	100.00%
	% within Bought new machines or ….	1.40%	2.00%	1.60%
Precision instruments	Count	1	0	1
	% within Type of Industries	100.00%	0.00%	100.00%
	% within Bought new machines or ….	1.40%	0.00%	0.80%
Automobile, auto parts	Count	7	2	9
	% within Type of Industries	77.80%	22.20%	100.00%
	% within Bought new machines or ….	9.50%	4.10%	7.30%
Other transportation	Count	2	1	3
equipments and parts	% within Type of Industries	66.70%	33.30%	100.00%
	% within Bought new machines or ….	2.70%	2.00%	2.40%
Other, specify:	Count	8	11	19
	% within Type of Industries	42.10%	57.90%	100.00%
	% within Bought new machines or ….	10.80%	22.40%	15.40%
Total	Count	74	49	123
	% within Type of Industries	60.20%	39.80%	100.00%
	% within Bought new machines or ….	100.00%	100.00%	100.00%

Source: Survey 2009, Author and team.

Linkages with Local Firms

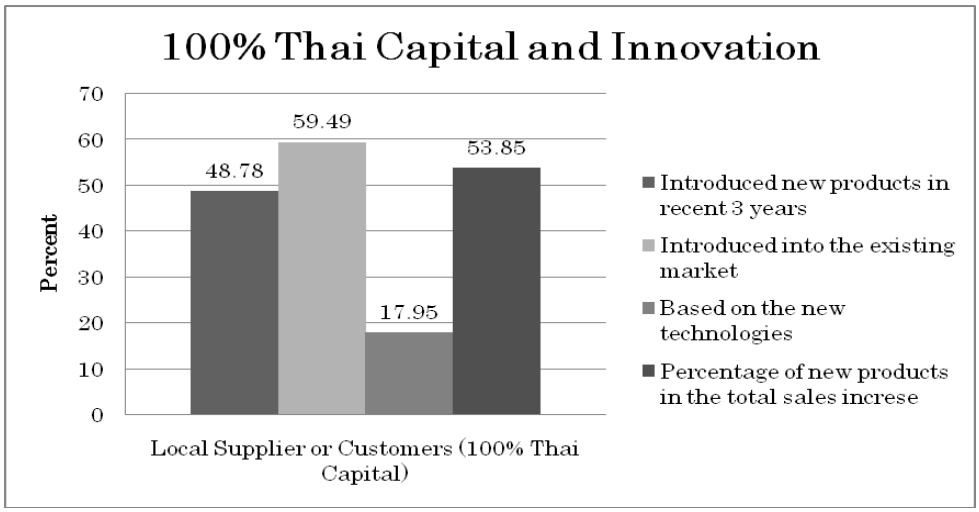
Linkages with local firms have played an important role for the Thai industry. As a result of market liberalization, technologies have developed more rapidly and consumers have become more conscious of product quality and getting value for their money. Therefore, in terms of exchanging information, technology transfer and market expansion, linkages with local firms such as joint venture with other local firms, local suppliers and customers and competitors could facilitate product innovation through the introduction of new products or services in the market.

Figure 11. Linkage with Own Joint Venture with Local Firm (Q16.2.1) vs. Innovation



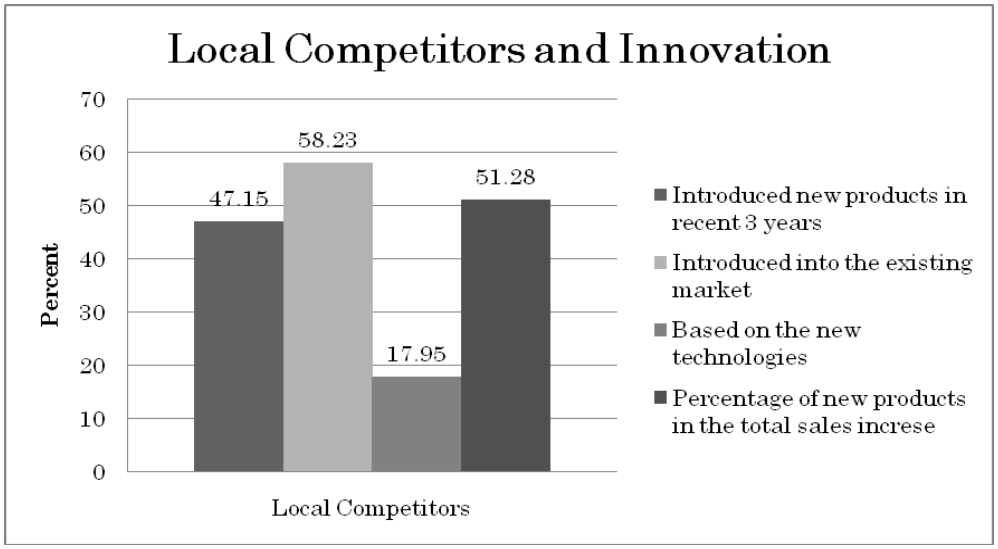
Source: Survey 2009, Author and team.

Figure 12. Linkage with Local Suppliers or Customers (100% Thai) (Q16.2.2) vs Innovation



Source: Survey 2009, Author and team.

Figure 13. Linkage with Local Competitors (Q16.2.3) vs Innovation



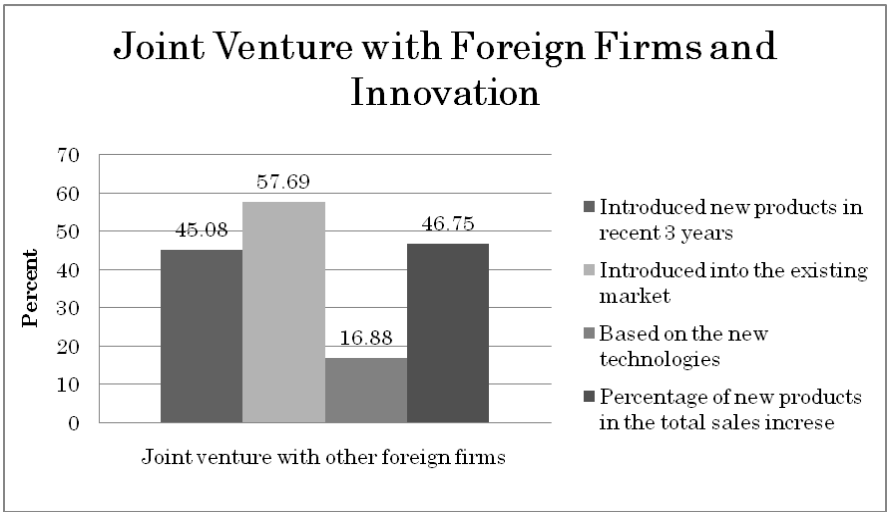
Source: Survey 2009, Author and team.

Linkages with Foreign Firms

Foreign firms and large firms have a high rate of carrying out R&D activities, innovation and upgrading. Therefore, to obtain benefit from them, linkages with these foreign firms such as through joint venture with other foreign firms, foreign suppliers

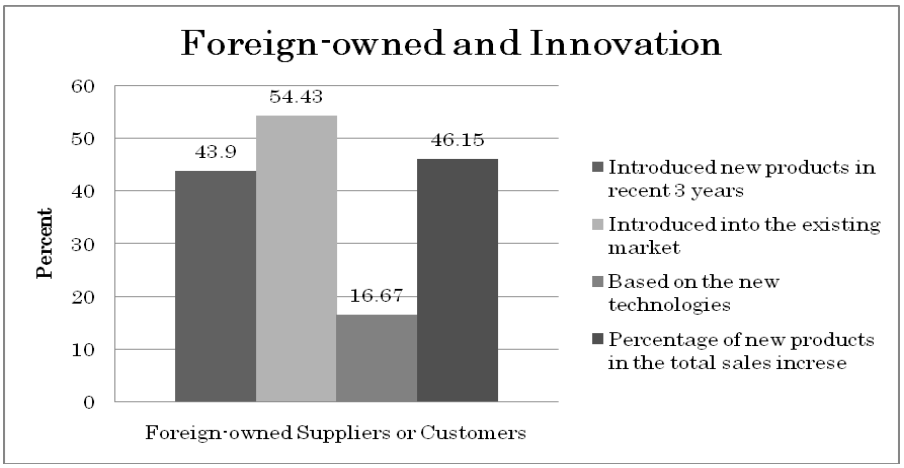
and customers are ideal. These linkages have shown to significantly result in product innovation by way of new products or services being launched into the market.

Figure 14. Linkage with Own Joint Venture with Other Foreign Firms (Q16.3.1) vs Innovation



Source: Survey 2009, Author and team.

Figure 15. Linkages with Foreign Owned Suppliers and Customers (Q16.3.2) vs Innovation

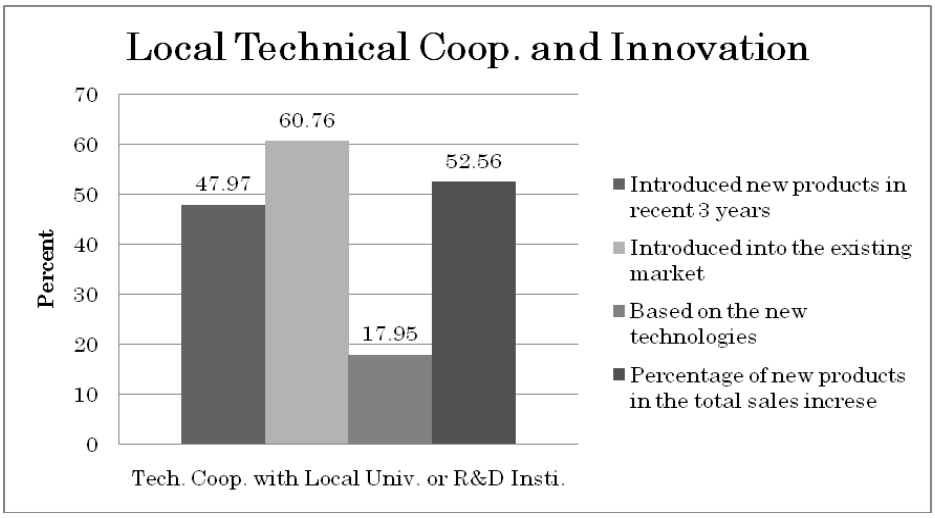


Source: Survey 2009, Author and team.

Linkages with University

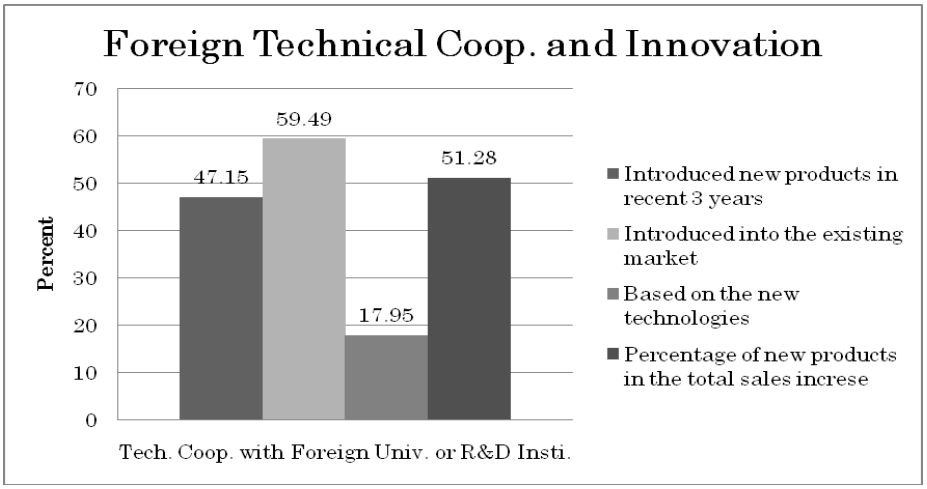
Universities, academic institutes and public agencies play a crucial role in R&D activity, knowledge creation and innovation diffusion. Therefore, linkages with these entities could benefit the industry by bringing about product innovation in the market.

Figure 16. Technical Cooperation with Local University (Q16.5.1) vs Innovation



Source: Survey 2009, Author and team.

Figure 17. Technical Cooperation with Foreign University (Q16.5.2) vs Innovation



Source: Survey 2009, Author and team.

Distance and Travel Time

As related in a study by Masatsugu Tsuji, Shoichi Miyahara, Tomohiro Machikita and Yasushi Ueki (2009) titled “Tentative summary of estimation”, the distance from a partner is negatively significant for the Thai industry. This implies that geographical distance is an obstacle to innovation. Moreover, travel time from the establishment to the customer/supplier is negatively significant.

Product Innovation by Industry and Size

As shown in Figures 6 and 8, the textiles, food and plastics industries, which have a high rate of conducted R&D activities, have had a relatively high rate of product innovation, as shown in the introduction of new products/services in the last three year and the increase in percentage of new products/services in the total sales. However, SMEs have a faster rate of adoption in the short term which implies that they have the ability to introduce new products or services in the market more easily in the short term.

Table 8. Introduced New Products/Services to the Market in Recent 3 years VS Type of Industries (Product Innovation)

Type of Industries	Introduced new products			
		Yes	**No**	**Total**
Food, beverages, tobacco	Count	11	5	16
	% within Type of Industries	68.80%	31.20%	100.00%
	% within Introduced new products	**13.90%**	11.10%	12.90%
Textiles, apparel, leather	Count	17	6	23
	% within Type of Industries	73.90%	26.10%	100.00%
	% within Introduced new products	**21.50%**	13.30%	18.50%
Wood, wood products	Count	2	3	5
	% within Type of Industries	40.00%	60.00%	100.00%
	% within Introduced new products	2.50%	6.70%	4.00%
Paper, paper products, printing	Count	5	1	6
	% within Type of Industries	83.30%	16.70%	100.00%
	% within Introduced new products	6.30%	2.20%	4.80%
Coal, petroleum products	Count	2	0	2
	% within Type of Industries	100.00%	0.00%	100.00%
	% within Introduced new products	2.50%	0.00%	1.60%
Chemicals, chemical	Count	9	8	17
and plastic products, rubber	% within Type of Industries	52.90%	47.10%	100.00%
	% within Introduced new products	**11.40%**	17.80%	13.70%
Iron, steel	Count	1	0	1
	% within Type of Industries	100.00%	0.00%	100.00%
	% within Introduced new products	1.30%	0.00%	0.80%
Metal products	Count	3	8	11
	% within Type of Industries	27.30%	72.70%	100.00%
	% within Introduced new products	3.80%	17.80%	8.90%
Machinery, equipment, tools	Count	3	2	5
	% within Type of Industries	60.00%	40.00%	100.00%
	% within Introduced new products	3.80%	4.40%	4.00%
Computers, computer parts	Count	3	1	4
	% within Type of Industries	75.00%	25.00%	100.00%
	% within Introduced new products	3.80%	2.20%	3.20%
Other electronics,	Count	2	0	2
electronic components	% within Type of Industries	100.00%	0.00%	100.00%
	% within Introduced new products	2.50%	0.00%	1.60%
Precision instruments	Count	0	1	1
	% within Type of Industries	0.00%	100.00%	100.00%
	% within Introduced new products	0.00%	2.20%	0.80%
Automobile, auto parts	Count	6	3	9
	% within Type of Industries	66.70%	33.30%	100.00%
	% within Introduced new products	7.60%	6.70%	7.30%
Other transportation	Count	1	2	3
equipments and parts	% within Type of Industries	33.30%	66.70%	100.00%
	% within Introduced new products	1.30%	4.40%	2.40%
Other, specify:	Count	14	5	19
	% within Type of Industries	73.70%	26.30%	100.00%
	% within Introduced new products	17.70%	11.10%	15.30%
Total	Count	79	45	124
	% within Type of Industries	63.70%	36.30%	100.00%
	% within Introduced new products	100.00%	100.00%	100.00%

Source: Survey 2009, Author and team.

Table 9. Introduced New Products/Services to the Market in Recent 3 Years VS Size of Factory (Product Innovation)

Size	Introduced new products			
		Yes	**No**	**Total**
small	Count	27	26	53
	% within Size of factory	50.90%	49.10%	100.00%
	% within Introduced new products	**35.10%**	57.80%	43.40%
medium	Count	26	11	37
	% within Size of factory	70.30%	29.70%	100.00%
	% within Introduced new products	**33.80%**	24.40%	30.30%
large	Count	20	6	26
	% within Size of factory	76.90%	23.10%	100.00%
	% within Introduced new products	26.00%	13.30%	21.30%
verry large	Count	4	2	6
	% within Size of factory	66.70%	33.30%	100.00%
	% within Introduced new products	5.20%	4.40%	4.90%
Total	Count	77	45	122
	% within Size of factory	63.10%	36.90%	100.00%
	% within Introduced new products	100.00%	100.00%	100.00%

Source: Survey 2009, Author and team.

Process Innovation by Industry and Size

Similar to product innovation, the textiles, food and plastics industries which have a high rate of conducting R&D activities, have had a relatively high rate of process innovation such as buying new machines or facilities or introducing new production methods.

Table 10. Adopted a New Production Method in Recent 3 years VS Type of Industries (Process Innovation)

Type of Industries	Bought new machines or facilities with new function to operation			
		Yes	**No**	**Total**
Food, beverages, tobacco	Count	11	5	16
	% within Type of Industries	68.80%	31.20%	100.00%
	% within Bought new machines or ….	**14.90%**	10.20%	13.00%
Textiles, apparel, leather	Count	13	10	23
	% within Type of Industries	56.50%	43.50%	100.00%
	% within Bought new machines or ….	**17.60%**	20.40%	18.70%
Wood, wood products	Count	1	4	5
	% within Type of Industries	20.00%	80.00%	100.00%
	% within Bought new machines or ….	1.40%	8.20%	4.10%
Paper, paper products, printing	Count	4	1	5
	% within Type of Industries	80.00%	20.00%	100.00%
	% within Bought new machines or ….	5.40%	2.00%	4.10%
Coal, petroleum products	Count	2	0	2
	% within Type of Industries	100.00%	0.00%	100.00%
	% within Bought new machines or ….	2.70%	0.00%	1.60%
Chemicals, chemical	Count	11	6	17
and plastic products, rubber	% within Type of Industries	64.70%	35.30%	100.00%
	% within Bought new machines or ….	**14.90%**	12.20%	13.80%
Iron, steel	Count	1	0	1
	% within Type of Industries	100.00%	0.00%	100.00%
	% within Bought new machines or ….	1.40%	0.00%	0.80%
Metal products	Count	7	4	11
	% within Type of Industries	63.60%	36.40%	100.00%
	% within Bought new machines or ….	9.50%	8.20%	8.90%
Machinery, equipment, tools	Count	4	1	5
	% within Type of Industries	80.00%	20.00%	100.00%
	% within Bought new machines or ….	5.40%	2.00%	4.10%
Computers, computer parts	Count	1	3	4
	% within Type of Industries	25.00%	75.00%	100.00%
	% within Bought new machines or ….	1.40%	6.10%	3.30%
Other electronics,	Count	1	1	2
electronic components	% within Type of Industries	50.00%	50.00%	100.00%
	% within Bought new machines or ….	1.40%	2.00%	1.60%
Precision instruments	Count	1	0	1
	% within Type of Industries	100.00%	0.00%	100.00%
	% within Bought new machines or ….	1.40%	0.00%	0.80%
Automobile, auto parts	Count	7	2	9
	% within Type of Industries	77.80%	22.20%	100.00%
	% within Bought new machines or ….	9.50%	4.10%	7.30%
Other transportation	Count	2	1	3
equipments and parts	% within Type of Industries	66.70%	33.30%	100.00%
	% within Bought new machines or ….	2.70%	2.00%	2.40%
Other, specify:	Count	8	11	19
	% within Type of Industries	42.10%	57.90%	100.00%
	% within Bought new machines or ….	10.80%	22.40%	15.40%
Total	Count	74	49	123
	% within Type of Industries	60.20%	39.80%	100.00%
	% within Bought new machines or ….	100.00%	100.00%	100.00%

Source: Survey 2009, Author and team.

Table 11. Adopted a New Production Method in Recent 3 Years VS Size of Factory (Process Innovention)

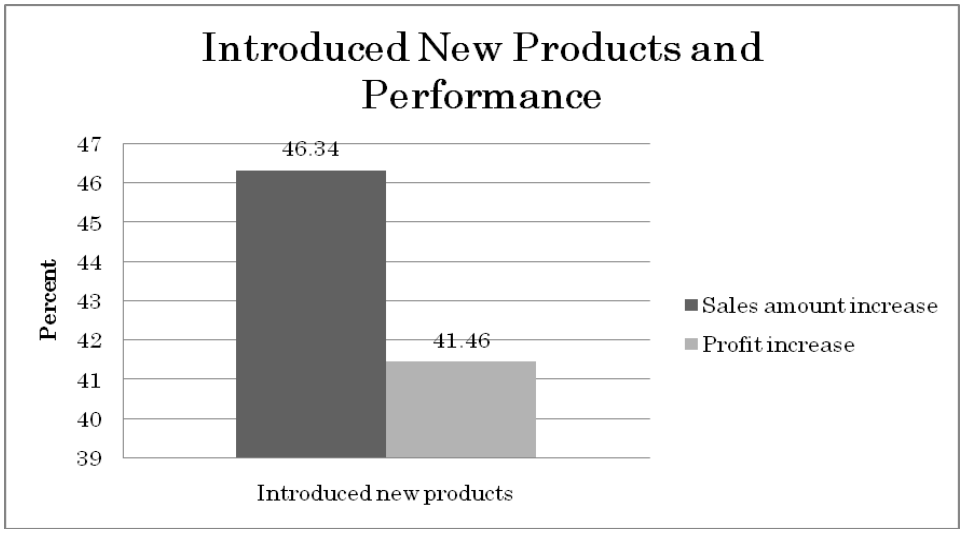
Size	Bought new machines or facilities with new functions to operation			
		Yes	**No**	**Total**
small	Count	25	27	52
	% within Size of factory	48.10%	51.90%	100.00%
	% within Bought new machines or …	34.20%	56.20%	43.00%
medium	Count	21	16	37
	% within Size of factory	56.80%	43.20%	100.00%
	% within Bought new machines or …	28.80%	33.30%	30.60%
large	Count	23	3	26
	% within Size of factory	88.50%	11.50%	100.00%
	% within Bought new machines or …	31.50%	6.20%	21.50%
verry large	Count	4	2	6
	% within Size of factory	66.70%	33.30%	100.00%
	% within Bought new machines or …	5.50%	4.20%	5.00%
Total	Count	73	48	121
	% within Size of factory	60.30%	39.70%	100.00%
	% within Bought new machines or …	100.00%	100.00%	100.00%

Source: Survey 2009, Author and team.

Innovation and Performance

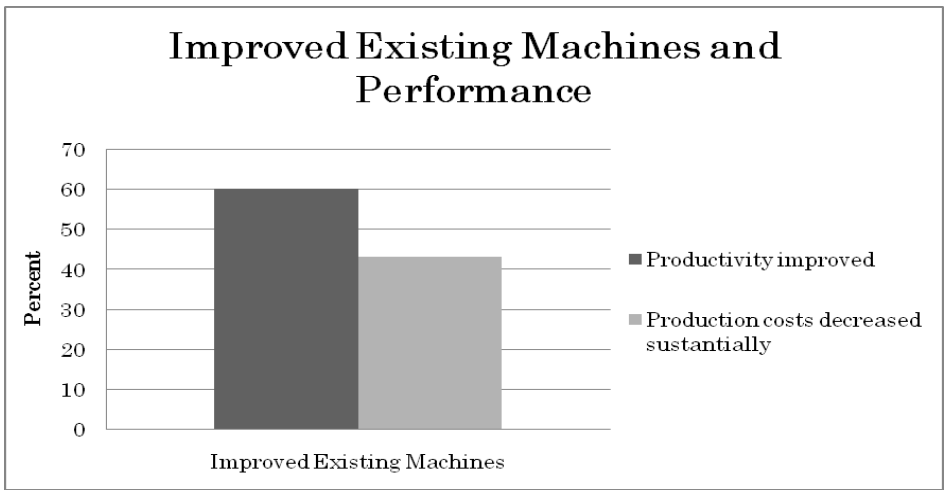
Product innovation or the introduction of new products could lead to performance improvement such as increase in total sales and profit. In contrast, production cost may not be reduced substantially with process innovation (improvement of existing machines). However, process innovation can improve productivity significantly and decrease production cost substantially in the long term.

Figure 18. Product Innovation (Q.9) vs Performance (Q6.1, Q6.2)



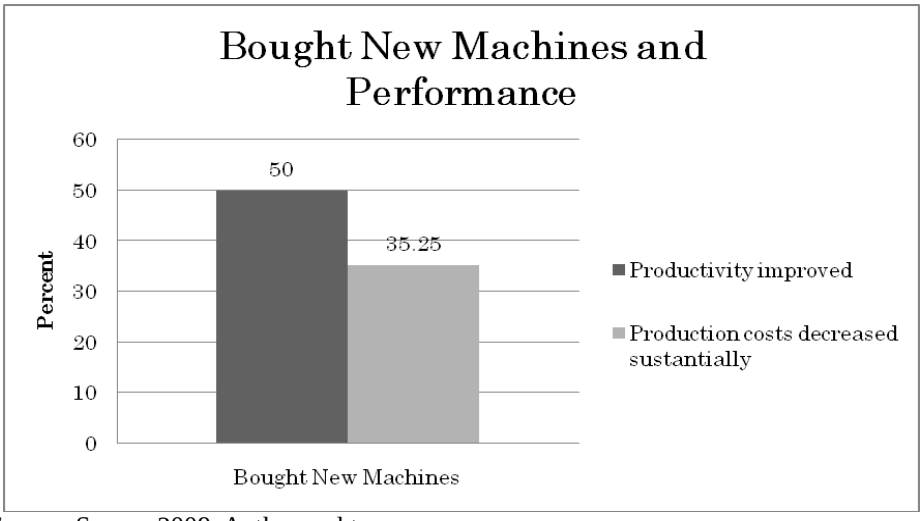
Source: Survey 2009, Author and team.

Figure 19. Process Innovation (Q10.2) vs Performance (Q6.7, Q6.10)



Source: Survey 2009, Author and team.

Figure 20. Process Innovation (Q10.1) vs Performance (Q6.7, Q6.10)

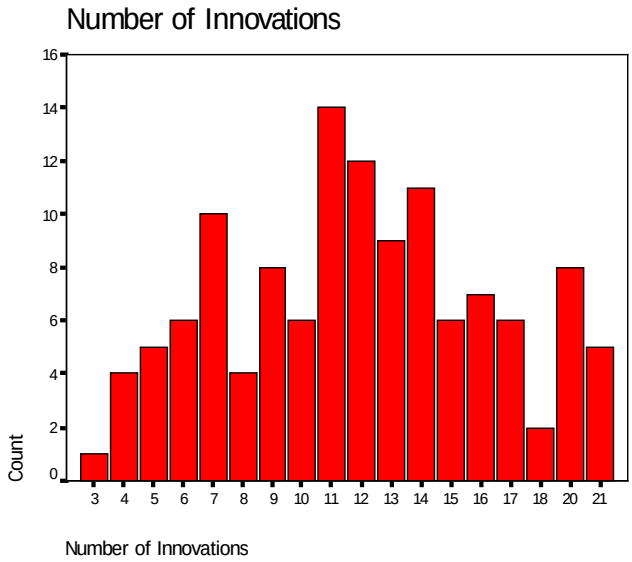


Source: Survey 2009, Author and team.

Number of Innovations

Much of the Thai industry has had some forms of innovation such as introducing new products, adopting new production method, securing new partners, seeking new market, and improving business processes or organizations. From the figure, it can be seen that none of the firms have been operating without any innovation.

Figure 21. Number of Innovation (Q9 - Q13, Excepted Q9.1-Q9.3)

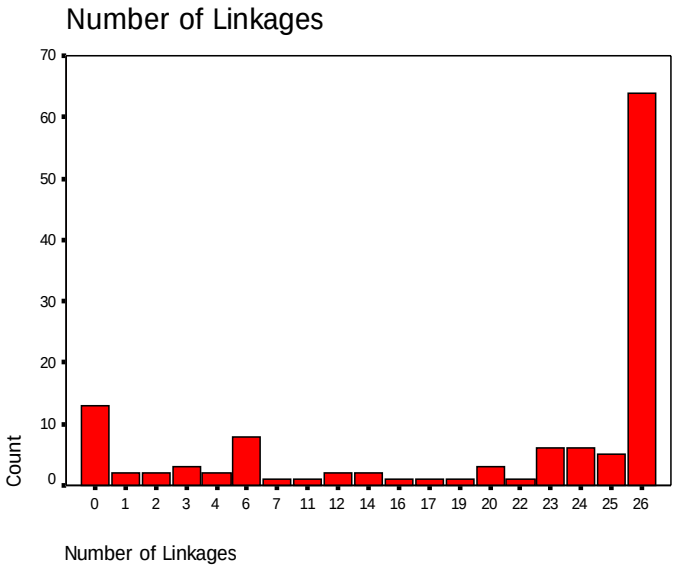


Source: Survey 2009, Author and team.

Number of Linkages

Since the Thai economy has opened up to the global market, much of the Thai industry has come to realize the importance of linkages. In the past decade, the Thai government has actively promoted industrial clustering and agglomeration with local SMEs. It can be seen from the investment promotion policy of the Board of Investment (BOI) that the government has been trying its best to encourage firms to locate their establishments inside the industrial estates or special zones by offering attractive incentives. As can be seen in Figure 22, the number of linkages between industry and local and foreign companies, local support organizations, universities and sources of information and technologies has been quite high.

Figure 22. Number of Linkages (Q16.2-Q16.7)

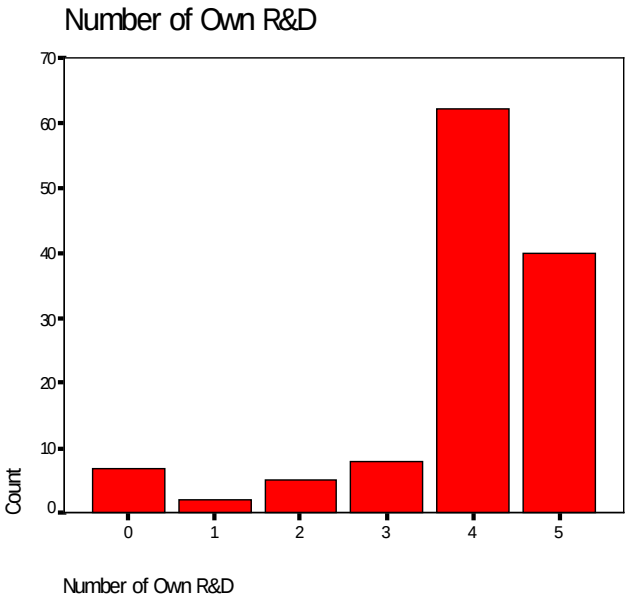


Source: Survey 2009, Author and team.

Importance of Internal Resources

Due to limited resources, the Thai industry relies much on its own resources (R&D departments, headquarters, and affiliates). It perceives internal sources of information and own R&D efforts as the most practical and important sources of information and new technologies for innovation and upgrading.

Figure 23. Important of Internal Resources of Information and own R&D Efforts (Q16.1)



Source: Survey 2009, Author and team.

4.2. Econometric Analysis

4.2.1. Linkages and innovation

Linkages on local firm (Q16.2) and human resource (Q16.6) were positively significantly, while university (Q16.5) and other sources of information (Q16.7) were negatively significant (Table 12.1). Trying to improve the level of confidence, we tried to get rid of insignificant factors such as foreign firms and local organization (Q16.3, Q16.4), and as can be gleaned from Table 12.2, all variables (Q16.2, Q16.5, Q16.6, Q16.7) were significant with the confidence level improved.

Linkages with local customer/supplier, competitor or local firm in the different businesses which is neither supplier/customer, nor even recruitment of mid-class personnel, or personnel retired from MNCs and large firms, could facilitate innovation and upgrading.

Linkages with university (Q16.5) and other sources of information (Q16.7) were negatively significant. This can be because the Thai industry has rarely conducted R&D activities or bought technology or patents from others. In recent years, the Thai government has implemented various support schemes for the Thai industry especially industrial clustering, developing ICT infrastructure and promotion of R&D activities. The government also put much effort on R&D promotion through universities and national research institutes such as the National Research Council and the Thailand Research Fund. The National Research Council stated that the most serious problem for innovation in the Thai industry is not the generation of innovation as the country has a huge stock of innovation created from R&D activities but the lack of proper infrastructure to support knowledge diffusion, utilization, and commercialization of these innovations.

4.2.2. Innovation and performance

Improving business process (Q13) and securing new suppliers (Q11) were positively significant. Therefore, it can be said that the industry's move to secure new suppliers of raw materials, parts or services (Q11), and its efforts to improve business processes or organizations such as ISO standard, and ICT development in the last three years (Q13) have contributed to the firm's performance (Table 13).

Table 12. Result from Econometric Analysis (Linkages vs Innovation)

12.1

Dependent Variable: INNOVATION (Q9-Q13)
Method: Least Squares
Sample: 1 122
Included observations: 122

Variable		Coefficient	Std. Error	t-Statistic	Prob.	
Q16_2	Local firms	0.561793	0.333238	1.685859	0.094534	*
Q16_3	Foreign and MNCs	0.411011	0.29403	1.397851	0.164848	
Q16_4	Local organizations	-0.02694	0.377954	-0.07128	0.943302	
Q16_5	Universities, R&D Institutes	-1.7071	0.981964	-1.73845	0.084807	*
Q16_6	Human resources	3.317454	1.165481	2.846425	0.005237	**
Q16_7	Other sources of information	-1.72683	0.549243	-3.14401	0.002121	**
C	Constant	9.683818	0.925859	10.45928	2.14E-18	

R-squared	0.178066	Mean dependent var	11.37705
Adjusted R-squared	0.135182	S.D. dependent var	4.558758
S.E. of regression	4.239444	Akaike info criterion	5.782406
Sum squared resid	2066.882	Schwarz criterion	5.943293
Log likelihood	-345.727	F-statistic	4.152311
Durbin-Watson stat	1.722938	Prob(F-statistic)	0.000819

Note: ** Significant at 1%, * Significant at 10%.

12.2

Dependent Variable: INNOVATION (Q9-Q13)
Method: Least Squares
Sample: 1 122
Included observations: 122

Variable		Coefficient	Std. Error	t-Statistic	Prob.	
Q16_2	Local firms	0.805125471	0.268165494	3.002345529	0.003276175	**
Q16_5	Universities, R&D Institutes	-1.972163065	0.814008836	-2.422778448	0.016935613	**
Q16_6	Human resources	3.884372984	1.143685012	3.396366084	0.000933552	**
Q16_7	Other sources of information	-1.482545945	0.550978143	-2.690752737	0.008173038	**
C	Constant	10.01844762	0.876555805	11.42933235	9.00E-21	

R-squared	0.158047019	Mean dependent var	12.01639344
Adjusted R-squared	0.129262302	S.D. dependent var	4.613998833
S.E. of regression	4.305475816	Akaike info criterion	5.797772486
Sum squared resid	2168.843274	Schwarz criterion	5.912691381
Log likelihood	-348.6641216	F-statistic	5.490657324
Durbin-Watson stat	1.777223543	Prob(F-statistic)	0.000436398

Note: ** Significant at 1%, * Significant at 10%.

Table 13. Result from Econometric Analysis (Innovation vs Performance)

13.1

Dependent Variable: PERFORMANCE
Method: Least Squares
Sample: 1 122
Included observations: 122

	Variable	Coefficient	Std. Error	t-Statistic	Prob.	
Q10	Process Innocation	0.121152	0.243517	0.497511	0.619771	
Q11	Securing new suppliers	0.219314	0.128762	1.703249	0.091199	*
Q12	Securing new customers	0.185611	0.135766	1.367134	0.174227	
Q13	Improving business process	0.678652	0.236874	2.865028	0.004952	**
Q9	Product Innovation	-0.23653	0.482422	-0.49031	0.624844	
C	Constant	3.328298	0.720124	4.621838	9.94E-06	

R-squared	0.198283	Mean dependent var	6.286885
Adjusted R-squared	0.163726	S.D. dependent var	2.731752
S.E. of regression	2.498133	Akaike info criterion	4.716894
Sum squared resid	723.9177	Schwarz criterion	4.854797
Log likelihood	-281.731	F-statistic	5.737886
Durbin-Watson stat	1.685045	Prob(F-statistic)	9.09E-05

Note: ** Significant at 1%, * Significant at 10%.

13.2

Dependent Variable: PERFORMANCE
Method: Least Squares
Sample: 1 122
Included observations: 122

	Variable	Coefficient	Std. Error	t-Statistic	Prob.	
Q11	Securing new suppliers	0.326329783	0.1038293	3.142945045	0.00211154	**
Q13	Improving business process	0.728405909	0.215642089	3.377846654	0.000987878	**
C	Constant	3.766063424	0.547101977	6.88365896	2.93E-10	

R-squared	0.181940364	Mean dependent var	6.286885246
Adjusted R-squared	0.168191463	S.D. dependent var	2.731752406
S.E. of regression	2.491454848	Akaike info criterion	4.687893475
Sum squared resid	738.6743241	Schwarz criterion	4.756844812
Log likelihood	-282.961502	F-statistic	13.23308375
Durbin-Watson stat	1.647605657	Prob(F-statistic)	6.47E-06

Note: ** Significant at 1%, * Significant at 10%.

4.3. More Findings from Factory Visits and In-depth Interviews

Due to inadequate sample size and the limited resources to collect more questionnaires, we deemed it useful to look for more evidence through factory visits and in-depth interviews with entrepreneurs. We chose the machinery industry, which is a large industry in Thailand especially that which deals with machines and equipment for the automotive market, and the pharmaceutical industry, in which R&D and linkages play an important role for their innovation and upgrading.

4.3.1. NR Group of Companies

The NR Industry Co., Ltd. and Group of Companies were established in 1977 at Samutprakarn province (1 hour east of Bangkok) as a small workshop company with 100%-owned Thai capital. It produces various types of tailor-made machines and services including R&D and design, 5-Axises CNC, metal sheet and painting, and maintenance service, mostly to support the pharmaceutical and packaging industries.

The NR group has a strong internal R&D department integrated with affiliated R&D companies. It is linked with the Thailand Ministry of Sciences and Technology, public universities such as the Engineering Faculty of Kasetsart University and some vocational colleges, and international agencies. Internal R&D and international best practices are the most important partners for their innovation and upgrading of production. Since the NR group believes the importance of a knowledge-based economy though knowledge creation, diffusion and utilization, it has placed huge investments on R&D activities. More than 20% of its annual expenses each year are spent especially on reverse engineering methodology and retrofitting technique to create

new innovations at least once every decade. The group has a motto of “one supplier, one equipment” for traceability purpose. Its owner or CEO has played a very important role in initiating new innovations by forging wide and strong domestic networks, especially with public R&D funders such as the Ministry of Sciences and Technology (NSTDA, M-TECH, BIOTECH, NIA), universities and machinery clusters such as the Thai Machinery Association. The owner and managerial staff are also regularly attending international workshops, exhibitions or trade fairs to seek for relevant new technologies.

This case study shows the importance of having a leader who has an initiative in leading internal R&D activities as well as in linking with external networks or linkages for innovation and upgrading, all of which contribute to enhancement of the firm’s industrial performance.

4.3.2. Thai Central Mechanics Co., Ltd.

The Thai Central Mechanics Company (TCM) was established in 1989 at Samutprakarn province and has 100% owned Thai capital. It produces various made-to-order machines and services such as turnkey solution, automation system, material handling, electrical system, CNC and retrofit, mostly to support the automotive industry.

TCM’s internal R&D teams that are linked with customers are the company’s most important parties for innovation and upgrading. When customers (which are mainly Japanese automotive firms) launch new models, products or parts, the company discusses and produces made-to-order products under technical assistance from customers and university professors. TCM has a close relationship or linkage with the

academe especially the King Mongkut's University of Technology North Bangkok, the Thai-German Institute (TGI) and recently, the National Innovation Agency (NIA). It is also a member of the Thai Machinery Association. TCM has received only a minimal support from government or public grants. It usually utilizes the financial support of private commercial banks in developing new innovations. The management of this company has highly concentrated much on human resource development, especially in-house training, and provision of incentives to engineers and technicians. The company has been cooperating with universities annually in implementing an international student exchange program to capitalize on the information and technique flows from this activity.

Since two years ago, thanks to the deep experience, far vision, nationalism and astute management of its owner/CEO, the company was able to prepare in advance for the impending regional economic downturn. It has invested most of its resources on environmental engineering and bio-technology, which was also made possible through some financial support from the government in the form of interest subsidy.

As this case study has shown, the expertise and experience of a company's leader in coordinating the internal R&D activities and in linking with customers and universities for technical assistance have played a crucial role in realizing innovations to improve the firm's performance.

5. CONCLUSION

The survey results and country studies reveal that the Thai industry is made up mostly of SMEs that have a limited budget with hardly any public financial support for R&D activities for innovation or upgrading. They stand in contrast to large, foreign or joint venture firms that have active R&D activities. For firms with R&D activities, they have relied much on their own R&D and internal resources. Nevertheless, Thai firms who have been linking with customers/suppliers/competitors, universities or public organizations, exchanging engineers with customers/suppliers or accessing public assistance or R&D grants, have gained benefits from these linkages. Furthermore, significant associations among domestic and foreign firms and university-industry linkages were seen particularly in industries such as textiles and apparels, food and beverages, plastics and plastic products. These have led to product/process innovations, agglomeration and upgrading. As witnessed in recent years, firms were able to pioneer in the development of new products/services. The results have also provided evidence that innovation advances a firm's performance. Product innovation or launching new products could lead to better performance by boosting total sales and profit. Meanwhile, process innovation or improvement of existing machines has an effect of increasing productivity but it has hardly any substantial effect on diminishing production cost at least on the short term.

For the Thai industry, the significant sources of innovation and upgrading include cluster/agglomeration, industrial linkages, university-industry linkages and own R&D resources. These resources have, to some extent, led to some improvement in firm performance and the country's industrial development.

Policy Implications and Recommendations

1) Promoting linkages and agglomeration

- Uphold linkages and networks among Thai firms, joint ventures and foreign firms through clustering, business matching, workshops and virtual networks via ICT and web portal, as foundation for information exchange, knowledge generation and technology catching-up.
- Encourage engineer and researcher exchange program (dispatch and accept) among customers/suppliers/competitors.
- Persuade firms to locate in industrial estates or special zones to generate industrial agglomeration.
- Endorse and broaden research/scholastic consortium to enhance linkages among public- university– private researchers.

2) Building up internal resources and R&D function

- Enhance R&D financial support scheme to industry.
- Diminish direct/indirect cost of R&D for the private sector (e.g., tax exemption for preferred industrial R&D activities, refundable import duty/tariff for R&D equipment especially those that are used for joint projects between university and industry)
- Support the broadening of expertise and foreign linkages among researchers

3) Enhancing environment for knowledge-based industry/society

- Initiate East Asian cooperation on intellectual property law to give confidence to the creation of new innovations and to ensure that firms are given sufficient incentives to innovate new products and processes for industry and the services sectors.
- Enhance infrastructure (e.g. science parks, software parks, research funding, incubation center, IT infrastructure, media, etc.) for knowledge diffusion, utilization and commercialization, and continue to promote private sector involvement in developing the knowledge economy.

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APPENDIX

- **List of variables**

Descriptive	Variables
Linkages	Q16.2 Q16.3 Q16.4 Q16.5 Q16.6 Q16.7
Innovation	Q9 Q10 Q11 Q12 Q13
Performance	Q6

Q6. Current business performance of your establishment in comparison with that of 2007

Q9. Introduced new products or services to the market in recent three years

Q10. Adopted a new production method in the recent three years

Q11. Secured new supplier of raw materials, parts, supplies or services in the recent three years

Q12. Secured a new customer in the recent three years

Q13. Made efforts to improve business processes or organizations in the recent three years

Q16.2 Technology transfer from local firms/cooperation with local firms (100% Thai capital)

Q16.3 Technology transfer from multinational companies (MNCs) or cooperation with MNCs

Q16.4 Technical assistances by local support organizations (government and local business organization) such as dispatch of experts, seminar, lecture or training counselor/expert dispatched/hired by them

Q16.5 Linkages with universities, R&D institutes and academic societies

Q16.6 Human resources

Q16.7 Other sources of information and technologies