

## **Firms, Universities, and Governmental Agencies in the Context of the Innovation System of the Thai Food Processing Industry**

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### **Abstract**

This article discusses the roles and functioning of firms, universities, and governmental agencies in the context of the innovation system in the Thai food processing industry. It also analyses the effects on innovation of knowledge interactions between firms and universities and between firms and governmental agencies. It is held that there are still some weaknesses in firms, universities, and governmental agencies that can potentially limit the upgrading of the food innovation system. Notably, interaction and exchange of knowledge among these organisations is relatively low and not sufficiently effective to enhance the innovativeness of food processing firms. It is argued that the current Thai food processing innovation system is not adequately conducive to interactive learning that leads to the enhancement of innovation.

**Keywords:** *Knowledge interaction, Thai food processing industry, product innovation, process innovation*

### **Introduction**

The innovation system in the food-processing industry has been poorly studied compared to that of the high-tech industries, even though food innovation is crucial to sustaining the competitiveness of the sector. The Thai government has emphasised the need to enhance the innovation system of the food-processing industry because the industry contributes significantly to the economic development of the country. For instance, the industrial census carried out by the National Statistical Office of Thailand in 2017 showed that there were 111,616 firms in the food processing industry, accounting for 25.2 percent of manufacturing firms in Thailand. The sector employed 772,943 workers, accounting for 18.4 percent of the manufacturing employment in the same year ([www.nso.go.th](http://www.nso.go.th)). Data from the National Food Institute showed that the value of food exports in 2014 was 915.32 billion baht, accounting for 12.5 percent of the country's total exports (National Food Institute, 2017). Unfortunately, a large part of the sector is still uncompetitive, consisting mainly of small enterprises with limited technological capabilities (Saigosoom, 2012).

The aims of this paper are: (1) to discuss the roles and functioning of firms, universities, and governmental agencies in the context of an innovation system in the Thai food processing industry, and (2) to analyse how the knowledge interaction among these organisations leads to firms' innovation. Thailand is chosen due to both academic and policy relevance. First, as a developing country, Thailand has particular characteristics that differ fundamentally from developed countries. Taking Thailand as a case study facilitates comparison with most existing studies that focus on developed countries. Secondly, although manufacturing industries in Thailand have undergone structural shifts toward capital-intensive and high-tech sectors (e.g., electronics and electrical products, automobiles, ICT), the food-processing industry has nevertheless shown a significant contribution both in terms of export and employment. Therefore, it is still necessary to upgrade the food-processing sector to strengthen its innovation and competitiveness.

### **Theoretical Background**

The analysis in this paper follows the triple-helix model of university-industry-government relationships (Etzkowitz, 2002; Etzkowitz & Leydesdorff, 2000). In this model, universities, firms, and government agencies are placed at the centre of the national innovation system. Their roles and functions, as well as relationships among them, are seen as key to the development of the system. Based on this model, universities have three essential missions including education, research, and commercialisation of knowledge. Commercialising knowledge is increasingly essential for the knowledge economy, as the major component of

competitiveness is knowledge. Hence, the universities' role can overlap that of the private sector (Etzkowitz & Leydesdorff, 2000). Firms in the triple helix model are both users and producers of knowledge. They take a vital role in converting basic knowledge produced by universities into innovation to increase the market value of knowledge. Firms can also produce knowledge by investing in research and development (R&D). It is argued by Cohen and Levinthal (1990) that R&D is not only necessary for knowledge production, but it is also critical for the enhancement of firms' absorptive capacity. Accordingly, firms need to invest in R&D to have sufficient absorptive capacity to identify, assimilate, and utilise external knowledge, particularly knowledge that is generated by other firms and universities. The government plays a supporting role regarding providing technological infrastructure and a suitable institutional environment for the functioning of the innovation system as a whole. In some cases, governments can set out an incentive structure that facilitates the collaboration between firms and universities (Etzkowitz & Leydesdorff, 1995). What is critical to the success of the innovation system is "interactive learning", defined as the interaction and exchange of knowledge between universities, firms, and government agencies (Lundvall, 2007).

The triple-helix model is widely used to guide the technology and innovation policies (Etzkowitz, 2002). In Thailand, the current government's innovation policy is also geared toward promoting interaction among universities, firms, and government agencies based on the triple-helix model. Consequently, several programmes, such as research funding, research services, and consultation have been designed to encourage the interactions among these organisations (Klomklieng, Ratanapanee, Tanchareon, & Meesap, 2012). In the food and agri-business sector, the government's strategy is to upgrade this sector by using science, technology, and innovation, acknowledging the importance of building a platform that facilitates collaboration between academics, firms, and government agencies (National Science, Technology, and Innovation Policy Office, 2015a).

## The Functioning of Firms, Universities, and Government

### *Food-processing Firms*

Generally, research and development (R&D) activities in the food industry are relatively low, particularly when compared to the high-tech sectors (National Science, Technology, and Innovation Policy Office, 2015b). One of the reasons for such a low R&D investment is because the food-processing industry is dominated by a group of small enterprises ( $\leq 50$  workers) with little capacity to carry out R&D (Saigosoom, 2012). In Thailand, small enterprises account for 97.5 percent of companies in the food sector (National Statistical Office, 2012; Office of Small and Medium Enterprise Promotion, 2016). These enterprises are less involved in R&D activities and have limited capability for technological upgrading (Saigosoom, 2012).

**Table 1.** Business Research and Development (R&D) in Thailand's Food Processing Industry, 2014

Innovation-related indicators	Level
Food processing business R&D expenditure (Total, in million baht)	4,097
Food processing business R&D expenditure (per firm, in million baht)	4.83
Share of food processing R&D in total business R&D expenditure (%)	16.08
Firm's R&D intensity (R&D expenditure as a percentage of sales (%))	0.23
Total R&D personnel in food industry (Full-time equivalent: FTE) (persons)	4,648
Share of R&D personnel in the food industry in the total manufacturing R&D personnel (persons)	11.90
Average R&D personnel per firm (FTE)	5.48

Source: National Science, Technology, and Innovation Policy Office (2015b)

As shown in Table 1, the Thai food-processing business expenditure on R&D (BERD) in 2014 was 4,097 million baht (increased from 3,558 million baht in the previous year—National Science Technology and Innovation Policy Office, 2015b). Food-processing firms' R&D expenditure accounts for 16.08 percent of total

business R&D in Thailand (25,471 million baht). On average, each Thai food firm invests about 4.83 million baht annually on R&D. This investment is rather small compared to the high R&D industries such as office machinery (243.52 million baht), petroleum (137.57 million baht), and electrical appliances (7.77 million baht), and even smaller than the low-tech industries such as papers (15.17 million baht) and apparel (7.30 million baht) (National Science Technology and Innovation Policy Office, 2015b). The food sector employs about 11.9 percent of total manufacturing R&D personnel. The average R&D personnel per firm in the food sector are only 5.48. However, it is important to note that some food firms tend to outsource R&D rather than setting up an in-house R&D operation (Tippakoon, 2017b).

The intensity of the Thai food business R&D (i.e., firm's R&D expenditure as a percentage of sales) is relatively low (Table 1), accounting for only 0.23 percent of firm revenue. This is far below the intensity of business R&D in office machinery (0.83%), non-metallic (0.44%), and chemical (0.39%) industries, indicating that weak efforts have been made by Thai food firms to strengthen their innovative capabilities by using formal R&D processes (National Science Technology and Innovation Policy Office, 2015b). Thai food firms, particularly Small and Medium Enterprises (SMEs), are more likely to base their innovation strategy on adopting knowledge developed elsewhere than generating knowledge in-house using internal R&D operation (Saigosoom, 2012). Therefore, it is not surprising that the R&D intensity in the food industry is relatively low.

From the author's in-depth interviews with the owners/managers of 13 marine food firms (Tippakoon, 2017b), R&D investment only recently has been viewed as a necessary step to sustain their competitiveness. The establishment of R&D operations is mainly to respond to competitive pressure in both domestic and global markets, including a rapid change in customer demands/tastes, health and hygienic requirements from importing countries, and increasing competition from low-cost countries (e.g., India, Indonesia, Vietnam, the Philippines). The R&D division in most sample firms was still small, consisting of three to 10 researchers. The R&D team in most firms consists of researchers from various educational backgrounds (e.g. food science, biology, chemistry, animal science, home economics, food services, and marketing). The interviewees mentioned that the combination of knowledge from various fields is necessary to respond to the fast-changing demand conditions in the food market (Tippakoon, 2017b). This finding is consistent with previous research (Intarakumnerd, Chiratana, & Kamondetdecha, 2015), which finds that innovations are the results of an integration of various areas of knowledge (e.g., sciences, social sciences, and arts) acquired from external sources.

Tippakoon (2017b) showed that the primary function of the R&D division in the sample food firms was twofold. First, it develops new products and improves existing products. For most firms, product development is made to respond to demands from their clients and changes in consumers' tastes. Very often, new product development is just an extension of existing line products. In other words, these firms tend to acquire standardised knowledge on products and production techniques developed elsewhere and adopt it as their own. There are only a few large multilateral companies with a sizable R&D operation that can develop "new-to-market" products. Secondly, an R&D division plays a critical role in absorbing knowledge from external sources. For all firms interviewed, R&D personnel are assigned to collaborate with clients and other knowledge sources (e.g., suppliers, universities, and research institutes) in the process of product development. Without R&D personnel, it is difficult for firms to communicate with their clients and other external knowledge sources, especially when it comes to the scientific and technical details about products and production techniques. In this instance, an R&D operation is relevant for innovation because it increases firms' absorptive capability, which includes the ability to identify, assimilate, and utilise relevant knowledge for their innovative activities (Cohen & Levinthal, 1990).

In sum, Thai food-processing firms are more active in R&D activities in recent years. Investment in R&D is expected to help them upgrade their products and production processes to sustain competitiveness. However, the majority of food-processing firms, particularly SMEs, still lack capabilities to carry out R&D (Saigosoom, 2012). Even in firms that indicate investing in R&D, their R&D operations are still small, *ad hoc*, and informal. The budget that they allocate to R&D activities is somewhat limited. In many cases, R&D activities

involve just simple product testing and the minor extension of existing product lines. Overall, Thai food-processing firms tend to follow and acquire standardised knowledge on products and production techniques generated elsewhere, focusing on knowledge adoption rather than a knowledge creation strategy. As a result, they tend to be innovation followers rather than innovation leaders.

### **Universities**

The primary roles of universities in the context of innovation system are to produce a skilled labour force in response to the labour market's demands, to generate new knowledge through research, and to transfer knowledge and technologies for commercial use (Etzkowitz & Leydesdorff, 2000). Regarding the production of the labour force, Table 2 shows that the number of graduates in food-related fields had increased during 2006-2015, indicating the vital role of Thai universities in producing skilled labour for the food industry. Notably, the number of graduates in food science and engineering and biology and biotechnology had increased significantly. It is important to note that such an increase in the number of graduates goes in the same direction as changes in labour demand in the food-processing industry, where the number of workers in this industry increased 9.9 percent from 802,552 to 882,179 between 2007 and 2012 ([www.nso.go.th](http://www.nso.go.th)).

**Table 2.** Number of Graduates in Food-related Fields in Thailand, 2006-2015 (Persons)

<b>Field of Knowledge</b>	<b>2006</b>	<b>2015</b>	<b>Change (%)</b>
1. Food science & engineering, and related fields	2,110	2,260	7.11
2. Agricultural sciences, agro-industry, and fisheries	8,957	8,561	-4.42
3. Biology, bio-tech, and related fields	3,016	4,061	34.65
4. Home economics, kitchen & restaurant management	2,321	1,788	-22.96
<b>Total</b>	<b>16,404</b>	<b>16,670</b>	<b>1.62</b>
<b>Grand Total (all fields in Thailand)</b>	<b>306,225</b>	<b>315,305</b>	<b>2.97</b>

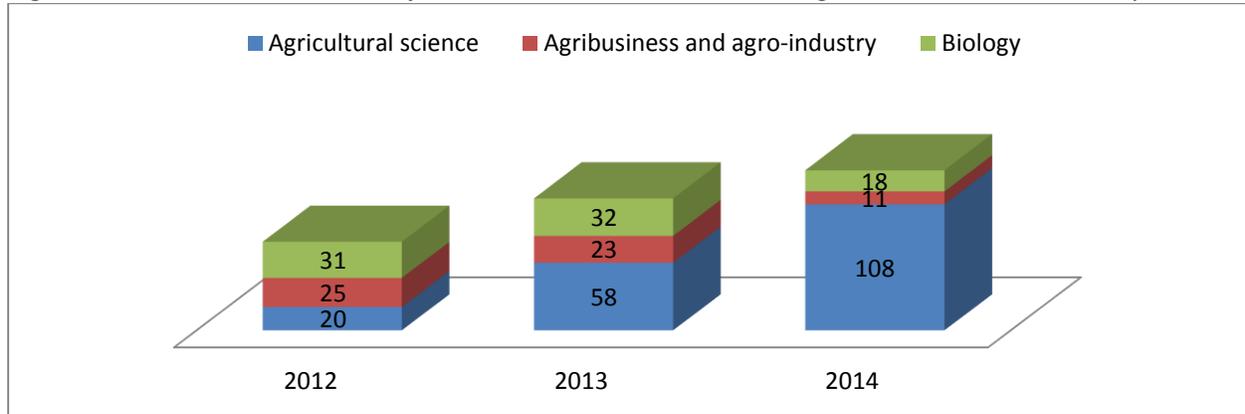
*Source:* Author's compilation from data provided by the Office of Higher Education Commission, Thailand ([www.info.mua.go.th/information/show\\_all\\_statdata\\_table.php?data\\_show=3](http://www.info.mua.go.th/information/show_all_statdata_table.php?data_show=3))

Figure 1 and Figure 2 show that Thai universities have been more active in recent years in carrying out research related to the food industry. For instance, the number of research projects financed by Ministry of Science & Technology (MOST) in the areas of agricultural science, agribusiness and agro-industry, and biology had increased considerably by 2014 (Figure 1). Also, the number of scientific articles published in international journals (Scopus database) in the fields of food science, biotech, and agricultural science tended to increase substantially in 2015 (Figure 2). Of 1,686 articles published in these fields during 2010-2015, about two-thirds (1,305 articles) were published in food science and related fields, indicating the increasing importance of food science research in the Thai research community.

Even though Thai universities have been more active in producing skilled labour and knowledge relevant to the food industry, they are found to have several weaknesses. Often-mentioned weaknesses include: (1) limited resources and funding; (2) production of knowledge that is irrelevant to industry's needs; (3) lack of interest of university professors and research staff to work with the industry; (4) rigid bureaucratic structure and poor incentive system prohibiting the involvement of university staffs in knowledge transfer activities; and (5) lack of experience and human resource capabilities in knowledge transfer and commercialization of technology (Brimble & Doner, 2007; Schiller & Diez, 2007; Doner, Intarakumnerd, & Ritchie, 2013; Intarakumnerd et al., 2015). Based on the author's interviews with 13 managers/owners of food-processing firms (Tippakoon, 2017b), the interviewees agreed with the points raised above. The interest of universities is often to produce papers rather than create useful innovations. Therefore, although Thai universities seem to perform well in producing a skilled workforce, they are still not functioning well in

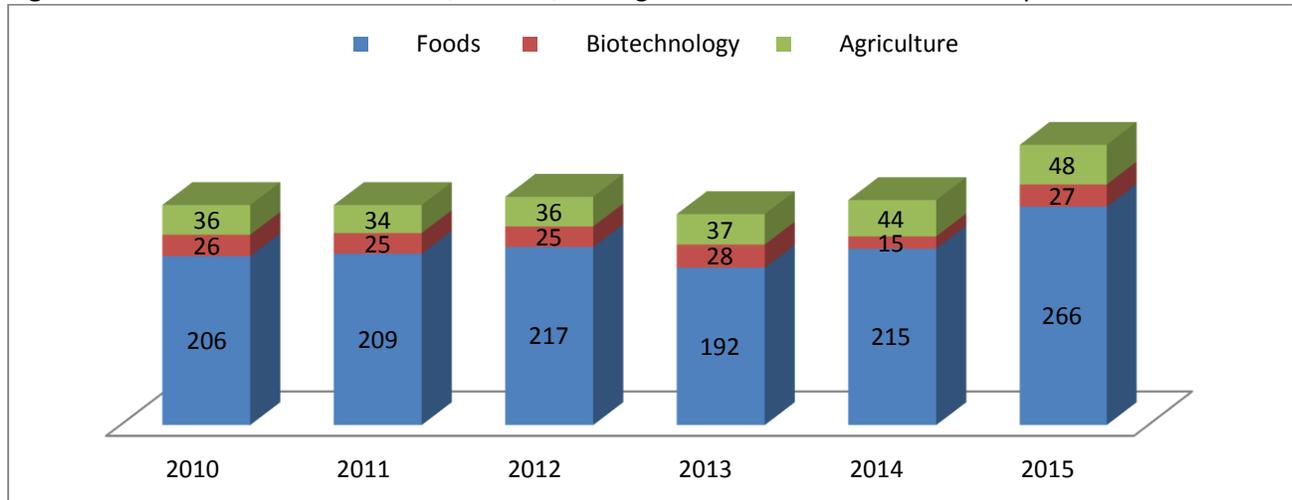
generating knowledge to meet industry demands and in transferring their knowledge and technologies to industrial users.

**Figure 1.** Number of Research Projects in Selected Areas of Knowledge Related to Food Industry, 2012-14



Source: Author's Compilation from Science & Technology Databank, Ministry of Science & Technology, Thailand ([www.stdb.most.go.th/research](http://www.stdb.most.go.th/research))

**Figure 2.** Number of Articles in Foods, Biotech, and Agriculture Fields Published in Scopus Journal Database



Source: Author's Compilation from Scopus Database

### Government

This section will discuss governmental policies and measures to promote innovation in the Thai food-processing industry and the role of relevant public agencies that support the industry. In the context of the innovation system, government plays a crucial role in creating an environment that is conducive to the creation, dissemination, and application of knowledge, which is an environment that supports interactive learning between core components of the system (Lundvall, 2007). For the system to function efficiently, it is important to have institutional settings (e.g., policy, regulations) that facilitate the production and transfer of knowledge, and to have effective public institutions that can serve as intermediaries to support the learning and development of firms (Chunhavuthiyanon & Intarakumnerd, 2014).

Dramatic progress in the government's policies and initiatives to promote innovations in the food industry has occurred in the past three years. New policies and initiatives can be observed: the first set targets increases in business R&D activities and the science and technology (S&T) workforce, the second set focuses

on networking and knowledge interaction among firms, universities, and governmental agencies, and the third set on commercialisation of scientific knowledge. To increase business R&D, the government has tried to reduce the firm's cost of R&D by increasing the proportion of corporate income tax reduction from 100 percent to 300 percent for investment related to R&D and innovation activities (National Science Technology and Innovation Policy Office, 2015b). To facilitate networking and knowledge transfer, incentives have been given to increase the mobility of university staff to the industry and to encourage the commercialisation of university knowledge and technologies. Finally, to increase the commercialisation of universities' scientific knowledge and technologies, the government has adopted a demand-driven approach to its funding policy. For instance, the so-called targeted research programme supervised by the National Research Council (NRC) and The Thailand Research Fund (TRF) means that research funds will only be given to collaborative and co-funded projects between universities and the private sector (National Science Technology and Innovation Policy Office, 2015b). This condition is set to ensure that firms will utilise the output of research.

**Table 3.** Organization of Key Agencies in the Thai Food-processing Innovation System

Activities	Key Agencies	Main Roles
<b>Upstream:</b>		
<ul style="list-style-type: none"> <li>• Generation of basic scientific knowledge related to foods and agriculture</li> </ul>	<ul style="list-style-type: none"> <li>• The National Research Council (NRC)</li> <li>• The Thailand Research Fund (TRF)</li> </ul>	<ul style="list-style-type: none"> <li>• Research funding (broad)</li> <li>• Research funding (broad)</li> </ul>
<b>Midstream:</b>		
<ul style="list-style-type: none"> <li>• Production of applied knowledge</li> <li>• Development of new technologies (prototyping)</li> <li>• Testing</li> </ul>	<ul style="list-style-type: none"> <li>• National Center for Genetic Engineering and Biotechnology, under the National Science and Technology Development Agency (NSTDA)</li> <li>• National Innovation Agency (NIA)</li> </ul>	<ul style="list-style-type: none"> <li>• Conducting applied research</li> <li>• Prototyping</li> <li>• Testing</li> <li>• Funding of innovation projects</li> </ul>
<b>Downstream:</b>		
<ul style="list-style-type: none"> <li>• Knowledge transfer activities (e.g., training, proving consultancy and problem-solving services)</li> <li>• Incubation</li> <li>• Start-up activities</li> </ul>	<ul style="list-style-type: none"> <li>• National Food Institute (NFI)</li> <li>• NSTDA's Innovation and Technology Assistance Programme (ITAP)</li> <li>• NIA's Industrial Park</li> </ul>	<ul style="list-style-type: none"> <li>• Training, consultation services, and product testing</li> <li>• Supporting incubation and start-up activities</li> <li>• Supporting incubation and start-up activities</li> </ul>
	<ul style="list-style-type: none"> <li>• Department of Industrial Promotion</li> <li>• Office of Small and Medium Enterprise Promotion (OSMEP)</li> </ul>	<ul style="list-style-type: none"> <li>• Training</li> <li>• Incubation</li> <li>• Training, incubation and financial supports (focusing on SMEs)</li> </ul>
<b>Other activities:</b>		
<ul style="list-style-type: none"> <li>• Regulation, Standardization, and Monitoring</li> </ul>	<ul style="list-style-type: none"> <li>• The National Bureau of Agricultural Commodity and Food Standards</li> <li>• Food &amp; Drug Agency (FDA)</li> <li>• Thai Industrial Standard Institute</li> </ul>	<ul style="list-style-type: none"> <li>• Monitoring, controlling, and supervising firms to ensure that they meet relevant standards, regulations, and codes of conduct</li> </ul>

Source: Author's Compilation from Various Sources

Another significant change in government policy toward upgrading the Thai food innovation system is a clear division of tasks between the major governmental and public agencies in the system. The roles of those agencies are now organized along the technology supply chain: from the creation of basic knowledge to commercialisation of technologies (Table 3). Financial and other supports are provided based on this. The

National Research and Innovation Policy Council (NRIC) is expected to serve as a supervising body for monitoring and coordinating research activities carried out by relevant government agencies (National Research and Innovation Policy Council, 2016).

Despite several changes in government's policies and institutional settings, success in terms of upgrading the Thai food innovation system is yet to be seen. Thailand's innovation system has often been documented as fragmented, uncoordinated, and inefficient. Governmental agencies are criticised for doing their own business in isolation and not being able to coordinate their activities (Intarakumnerd & Chaminade, 2007, 2011). Thus, positive outcomes must await the removal of a long-lasting tradition of lack of coordination and inefficiency.

## **Statistical Analysis**

### ***Data and Variables***

The analysis in this section is based on the author's research project "clusters, knowledge interaction, and innovation in Thai food-processing establishments" (Tippakoon, 2017a). A questionnaire-based mail survey was used as a data collection method. The sample of 3,200 firms was randomly drawn from the list of 8,985 food-processing firms registered with the Department of Industrial Works. This list consists of food-processing firms of all sizes (small, medium, and large) in six subsectors including (1) processing and preserving of meat (ISIC101); (2) processing and preserving of fish (ISIC102); (3) processing and preserving of fruit and vegetables (ISIC103); (4) manufacture of vegetable and animal oils and fats (ISIC104); (5) dairy products (ISIC105); and (6) other food products (ISIC107).

The survey was carried out during January – April 2016; 299 firms returned questionnaires, accounting for a 9.3 percent return rate. The sub-sectoral distribution of 299 sample establishments was arranged from highest to lowest percentages as follows: ISIC107=113 (37.8%); ISIC104=62 (20.7%); ISIC101=47 (15.7%); ISIC103=31 (10.4%); ISIC102=27 (9.0%); ISIC105=19 (6.4%). This pattern roughly reflects the distribution in the establishment population, which also can be arranged from highest to lowest percentages as follows: ISIC107=4,338 (48.3%); ISIC104=1531(17%); ISIC102=1,146 (12.8%); ISIC101=812 (9%); ISIC103=755 (8.4%); ISIC105=403 (4.5%). The breakdown of the sample by firm size shows that most sample firms are small firms (69.9%; ≤50 workers). Medium (51-250 workers) and large firms (>200 workers) account for 20.1 and 10 percent, respectively.

In the questionnaire, the owner/manager of the firm was asked to give the number of new products (new to the firm, but not necessarily to the market) developed over the past three years. A dependent variable – *product innovation* – was then derived by counting the number of a firm's new products. Also, the owner/manager was asked to indicate whether their firm had (1) used new machines, tools, or production facilities, (2) improved production methods/techniques, and (3) improved the organisation of work or managerial practices to improve the efficiency of the firm. A firm was assessed as having introduced a process innovation if they have done all these three things over the past three years. This was used as another dependent variable – *process innovation*. Key independent variables were *competitor*, *supplier*, *client*, *business service provider*, *university*, and *governmental agency*. These variables were derived from the question that asked how often, over the past three years, a firm had interacted with each knowledge source. The firm owner/manager was asked to answer, using a 10-point Likert scale (0 = no interaction, 10 = most often). Variables *Age* (in natural log), *Size* (natural log of firm's employees), *Export* (0 = no export, 1= export), *R&D* (0 = not invest in R&D, 1 = invest in R&D), and subsector dummies were used as control variables.

### ***Analytical Method***

The analysis based on the data received from the survey can be divided into two parts. First, descriptive statistics (i.e., frequency and percentage) were used to depict an overall picture about knowledge interactions between firms and various knowledge sources, including universities and governmental agencies. Secondly,

regression analysis was used to examine the relationship between independent variables (especially, firm knowledge interaction with each organisation) and each dependent variable, i.e., product innovation and process innovation. Negative binomial regression (NBR) was used to analyse product innovation, while binary logistic regression (BLR) was used to examine process innovation. Statistically, NBR has many appropriate properties to analyse data with characteristics found in this sample: positive integers, a large number of zeros (49% of firms had zero product innovation), and over-dispersed data (Long, 1997). Also, binary logistic regression (BLS) is widely used in empirical work because it has appropriate properties to analyse dichotomous dependent variables (Field, 2005).

## Results and Discussion

Previous studies on Thailand’s national innovation system revealed that meaningful interaction is somewhat limited among firms, universities, and governmental agencies that would lead to the exchange of valuable knowledge and transfer of technologies. The national innovation system is still under-developed and not yet able to create a meaningful interactive learning environment for the creation, dissemination, and application of new ideas (Intarakumnerd, Chairatana, & Tangchitpiboon, 2002; Intarakumnerd & Chaminade, 2011). This finding holds true in the case of the Thai food-processing innovation system (Tippakoon, 2017a, b & c).

Table 4 shows the frequency of interaction between food-processing firms and some organisations (their competitors, suppliers, clients, business service providers, universities, and governmental agencies) during the past three years, based on the author’s survey data (Tippakoon, 2017a). Food-processing firms are more likely to interact and exchange information with industrial organisations (competitors, suppliers, clients, and business service providers) than universities and governmental agencies. Among firms that have interacted “often” and “very often”, it was primarily with their clients and suppliers rather than other organisations. This information implies that they rely less on governmental agencies and universities for information and knowledge than their industrial partners. Firms seem to interact more with governmental agencies than universities. This is understandable as governmental agencies act both as supporters (e.g., providing information, financial assistance, technical services, etc.) and as regulators (e.g., monitoring production processes, testing product quality and safety, etc.). In this sense, food-processing firms are both incentivised and compelled to interact with governmental agencies.

**Table 4.** Frequency of Interaction by Type of Knowledge Sources

Type of Knowledge Sources	Frequency of Interaction (in the past three years)					
	Not at All	Very Few	Few	Sometimes	Often	Very Often
Competitors	32 (13.4)	40 (16.7)	67 (28.0)	51 (21.3)	35 (14.6)	14 (5.9)
Suppliers	29 (12.1)	32 (13.4)	53 (22.2)	64 (26.8)	45 (18.8)	16 (6.7)
Clients	24 (10.0)	28 (11.7)	42 (17.6)	73 (30.5)	50 (20.9)	22 (9.2)
Business service providers	43 (18.0)	44 (18.4)	47 (19.7)	58 (24.3)	41 (17.2)	6 (2.5)
Universities	46 (19.2)	56 (23.4)	61 (25.5)	46 (19.2)	24 (10.0)	6 (2.5)
Governmental agencies	46 (19.2)	47 (19.7)	58 (24.3)	53 (22.2)	26 (10.9)	9 (3.8)

*Note:* (1) N = 239 (60 cases were removed due to missing values); (2) percentage is shown in parenthesis

*Source:* Author’s Survey

Modes of firm-university interaction demonstrated in Table 5 were adopted from Perkmann and Walsh (2007), which typified university-industry linkage at three levels, based on the degree of collaboration, including transfer (low level), mobility (medium level), and relationship (high-level). In Table 5, items 1-3, 4-6, and 7-9 capture modes of interaction at the levels of transfer, mobility, and relationship, respectively.

The two most popular modes of interaction are using university published works (158 of 272 firms) and consultancy and training services (154 of 272). The least popular mode, which most firms (178 of 272) had never used, was internship programs and postgraduate training in the industry, followed by informal interaction such as attending seminars/conference (176 of 272). In general, modes of interaction at a higher level (e.g., relationship level) are less popular among firms. Moreover, firms interact less often with university counterparts at the higher level of collaboration. This information indicates that firms are less likely to interact and collaborate with universities to acquire knowledge and technology. This is particularly true for small enterprises, which constitute the vast majority of Thai food-processing firms, and lack absorptive capacities to acquire a university's knowledge and technology (Saigosoom, 2012).

**Table 5.** Mode and Frequency of Thai Food-processing Firms' Interaction with Universities

Modes of Firms' Interaction with Universities	Frequency of Interaction in the Past 3 Years					
	Not at All	Very Few	Few	Some-times	Often	Very Often
1. Informal interaction (e.g. attending seminar/conference)	176 (64.7)	48 (17.6)	47 (17.3)	54 (19.9)	27 (9.9)	20 (7.4)
2. Use of university's published works	114 (41.9)	60 (22.1)	28 (10.3)	37 (13.6)	16 (5.9)	17 (6.3)
3. Commercialization of intellectual properties	158 (58.1)	39 (14.3)	28 (10.3)	25 (9.2)	11 (4.0)	11 (4.0)
4. Use of consultancy and training services	118 (43.4)	44 (16.2)	33 (12.1)	37 (13.6)	19 (7.0)	21 (7.7)
5. Internship programs & postgraduate training in industry	178 (65.4)	34 (12.5)	17 (6.3)	16 (5.9)	17 (6.3)	10 (3.7)
6. Secondment to industry of university researchers	163 (59.9)	35 (12.9)	21 (7.7)	29 (10.7)	13 (4.8)	11 (4.0)
7. Share of research facilities with university	162 (59.6)	34 (12.5)	30 (11.0)	27 (9.9)	8 (2.9)	11 (4.0)
8. Commission of research-related activities to universities	163 (59.9)	38 (14.0)	19 (7.0)	25 (9.2)	13 (4.8)	14 (5.1)
9. Research partnership	166 (61.0)	33 (12.1)	22 (8.1)	19 (7.0)	18 (6.6)	14 (5.1)

Note: (1) N = 272 (17 cases were removed due to missing values); (2) percentage is shown in parenthesis

Source: Author's Survey

As indicated, food-processing firms have interacted with various knowledge sources. Does interaction lead to innovative outcomes, and which knowledge source plays a significant role in a food-processing firms' innovation? The author answers these questions by analysing the effects of firms' interaction with six principal knowledge sources on their product and process innovations. These knowledge sources include industrial organisations (i.e. competitors, suppliers, clients, and business service providers), universities, and governmental agencies.

Table 6 shows the regression results for the dependent variables *product innovation* and *process innovation*. A sample size reduction occurred due to the removal of cases with missing values. Little's Missing Completely at Random (MCAR) Test was performed to check the randomness of missing values. The Chi-square value was insignificant at the 5 percent level, justifying the removal of missing values. Therefore, the reduction of sample size should not affect the reliability of the regression analysis.

It can be seen from the Table that interaction with clients alone is significant for Thai food-processing firms to develop their new products. It can be argued that by interacting and exchanging knowledge with their clients, firms can identify market demand and opportunities for innovation (He & Wong, 2009), and also can reduce time-to-market of new products (Feng, Sun, Zhu, & Sohal, 2012). These arguments seem to hold in the case of Thai food firms.

For this sample, universities did not appear to be a significant source of knowledge for Thai food-processing firms' product and process innovation. Although the coefficient of this variable is positive in the

product innovation model, it is not statistically significant. In the process innovation model, the coefficient is negative but not significant. This finding highlights the weaknesses of university-industry linkages in Thailand, which have been documented in previous studies. These weaknesses occur on the part of universities and firms, and also in the institutional settings in which they are embedded. Universities are often criticised for not being interested in transferring their scientific knowledge into market use. University professors and research staff focus on publishing their research work more than collaborating with industry. As Thai universities have long concentrated only on conventional missions of teaching and research, they do not have experience in commercialising their knowledge. Despite the establishment of a technology transfer office (TTO) in many universities in recent years, they still cannot function effectively, mainly due to lack of expertise and financial support. A poor incentive system and inconsistencies in policies at various levels (government, higher education system, and university) are also mentioned as significant barriers to mobility and knowledge transfer from universities to firms. On the part of firms (especially SMEs), lacking absorptive capacity seems to be the most important obstacle preventing successful university-industry collaboration (Doner et al., 2013; Schiller, 2006; Schiller & Diez, 2007). Only collaborations between some large firms and a few strong public universities have proved to be successful cases for university-industry linkages (Brimble & Doner, 2007). All these factors may explain why the effect of a firm's interaction with universities was not statistically significant.

**Table 6.** Effects of Knowledge Interactions on Product and Process Innovations

Feature/Variable	Product Innovation				Process Innovation			
	$\beta$	SE	Sig.	Exp( $\beta$ )	$\beta$	SE	Sig.	Exp( $\beta$ )
Constant	-0.212	0.503	0.673	0.809	-1.063	0.871	0.223	0.346
Age	-0.260	0.162	0.108	0.771	-0.094	0.239	0.694	0.910
Size	0.245 <sup>b</sup>	0.101	0.016	1.277	0.519 <sup>a</sup>	0.170	0.002	1.680
Export	0.343	0.260	0.186	1.410	-0.564	0.394	0.153	0.569
R&D	1.396 <sup>a</sup>	0.324	0.000	4.038	0.737	0.559	0.188	2.089
Competitor	-0.095	0.067	0.154	0.909	0.125	0.105	0.230	1.134
Supplier	-0.061	0.101	0.545	0.941	0.160	0.155	0.300	1.174
Client	0.305 <sup>a</sup>	0.102	0.003	1.356	0.229	0.162	0.157	1.258
Business service provider	0.028	0.088	0.754	1.028	-0.277	0.157	0.077	0.758
University	0.036	0.075	0.630	1.037	-0.037	0.113	0.746	0.964
Governmental agency	-0.246 <sup>a</sup>	0.082	0.003	0.782	-0.076	0.112	0.498	0.927
<b>Industry Dummies</b>	<b>Included</b>				<b>Included</b>			
Likelihood Ratio Chi-Square (df)	166.89(15) <sup>a</sup>							
-2 Log likelihood					200.88 <sup>a</sup>			
Cox & Snell R Square					0.206			
N	183				196			

Note: (1) <sup>a</sup> & <sup>b</sup> denote a statistical significance at  $p < 0.01$  and  $p < 0.05$ , respectively; (2) in both product innovation and process innovation models, cases with missing values were removed. Source: Author's Estimate Based on Survey Data

Interestingly, interaction with governmental agencies has a significant negative impact on firms' product innovation and an insignificant effect on firms' process innovation. Most innovation system studies in Thailand focus more on the effectiveness of the government's science, technologies, and innovation policies, without sufficiently examining the role of governmental agencies on the functioning of the system. Thus, the latter issue is poorly understood. Based on the author's interviews, governmental agencies that firms interact with can be divided into two groups: the first group focuses on regulation enforcement, and the second on providing support (e.g. financial and technical support). The activities of the first group are mainly to monitor and supervise firms to ensure that they perform according to relevant regulations and standards. This group hardly provides information relevant for product and process improvement. For the second group, their technical support does not seem to draw on demands from the industry. Some training and technical service

programmes are designed on a top-down basis without consulting industrial users. These may be reasons why interaction with governmental agencies does not yield innovative outcomes for firms. Of four control variables, size and R&D are two significant factors. Size has positive and significant effects on both product and process innovations, consistent with the previous studies on Thai food firms' innovation, and confirming the idea that large firms possess more resources to invest in innovation-related activities. R&D is only positive and significant on product innovation, but not on process innovation, indicating that R&D activities carried out by Thai food-processing firms are mainly product R&D rather than process R&D. Thus, the critical policy problem is how to promote the innovative capabilities of small firms, which constitute the vast majority of Thai food-processing firms.

## **Conclusion**

This paper has highlighted the functioning of core elements in the Thai food-processing innovation system (firms, universities, governmental agencies) and the effect of knowledge interaction between food-processing firms and other knowledge sources on firms' innovation. Although Thai food firms have made efforts to invest in R&D in recent years, the vast majority of them (particularly, SMEs) still lack R&D capabilities, which limits their innovativeness. Thus, a critical challenge for promoting innovations in the Thai food industry is how to strengthen the innovative ability of SMEs.

Thai universities play a significant role in producing skilled labour in response to increasing demands in the food industry job market. Their ability to provide high-quality research tends to have increased over time, together with their stock of knowledge. However, universities' knowledge is hardly used by firms. Governmental agencies are also not proven to be a useful source of knowledge for innovation. Despite many changes in governmental science, technology, and innovation policies and practices in recent years, it is still too soon to expect success, as the Thai government has long been known for its inefficiency in enhancing the innovativeness of Thai industry as a whole.

Interaction between food-processing firms and the other two types of organisations (universities and governmental agencies) is still limited. There are only a few large firms that interact intensively with a high degree of collaboration. Apart from clients, other industrial knowledge sources (competitors, suppliers, and business service providers), universities, and governmental agencies do not seem to be a significant source of knowledge for firm innovation. At this point, it is possible to argue that the current Thai food-processing innovation system is not sufficiently conducive to interactive learning and knowledge exchange that leads to the enhancement of firms' innovativeness.

Some limitations of this study should be noted as implications for further research. The first limitation lies in the fact that the analysis in this paper is based on cross-sectional data. Hence, it can only examine the roles of firms, universities, and governmental agencies and the innovation effects of their interactions at a single point in time. With this sort of data, it is not possible to see the evolution of the roles played by these organisations and also not possible to examine the dynamics of their interactions. Further studies can address this problem by collecting panel data and using it for analysis. Moreover, qualitative analysis should be used to supplement the results derived from quantitative analysis. In this study, the author relied mainly on statistical analysis. Thus, the results can only show the overall picture of the roles of firms, universities, and governmental agencies in the context of the innovation system. Quantitative information based on in-depth interviews may be more suitable to examine how relationships between these organisations have been developed, what type of relationship is conducive for promoting innovation, and how to improve knowledge interactions and generate interactive learning among these three core components of the food-processing innovation system.

## **About the Author**

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