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The role of research and development as a strategy for SMEs development with particular reference to the case of the fisheries and seafood sector in Thailand

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Declaration of Author's Rights

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Abstract

This thesis aimed to study the impact of research and development (R&D) on the Thai seafood industry's development, particularly that of small and medium-sized enterprises (SMEs), which constitute the majority of the sector. This study evaluates expenditure on R&D, the effect of R&D on product and market performance, and the role of networking in supporting the R&D activities of SMEs in the seafood industry.

To explore the continuity of R&D investment and cross-check the rate at which R&D affects business development, the period selected for data collection was 2013–17. A 48% response rate is achieved, with 115 of 237 target firms (Thai SMEs in the seafood industry) participating in the questionnaire survey. This was followed by interviews with nine SMEs (chosen from those who completed the questionnaire survey) and four case studies. In addition, two representatives of universities and one from a government organisation were interviewed.

The findings of this research are that R&D improves the total sales and export revenues of Thai SMEs in the seafood industry. Furthermore, R&D supports product development in this sector. However, the application of R&D generates only minor changes in terms of product development. A small demand-pull effect and Thai SMEs' limited resources are not sufficient to support significant investment in R&D for product development. Meanwhile, Thai SMEs in the seafood industry are found to engage in external networking for specific purposes.

Limited R&D investment might be due to the lack of a R&D platform. Furthermore, the R&D policy direction in Thailand is not clear, and might be affecting the macro picture that drives this group. Therefore, it is recommended government organisations should establish R&D platforms that meet the needs of key players and have an economic impact. While academic institutions should support their experts to circulate knowledge from academia to business stakeholders.

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List of Abbreviations and Symbols

BOI	The Board of Investment of Thailand
C&D	Copy and Development
CEO	A chief executive officer,
df	Degree of freedom
EC	Council Regulation
EMS	Early Mortality Syndrome
EU	The European Union
EUR	Euro
FAO	The Food and Agriculture Organization
GDE	Gross Domestic Expenditure
GDP	Gross Domestic Product
GERD	Gross domestic expenditure on R&D
GHG	Greenhouse Gas
GMP	Good Manufacturing Practice
HACCP	Hazard analysis of critical control points
IMF	International Monetary Fund
IOC	Item-Objective Congruence
ISO22000	International Food Safety standard
IT	Information Technology
iTAP	Industrial Technology Assistant Programme
IUU	Illegal, Unreported and Unregulated
KRW	South Korean Won
LEs	Large-sized enterprises
NAV	Net Asset Value

NIA	National Innovation Agency
NICs	Newly Industrialised Countries
NIS	National Innovation System
NSTDA	The National Science and Technology Development Agency
OECD	The Organisation for Economic Co-operation and Development
OEM	in the original equipment manufacturing
QC	The Quality Control
R&D	Research and development
RFID	Radio-Frequency Identification
SMEs	Small and Medium-sized enterprises
STI	The National Science, Technology, and Innovation Policy Office
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TOWS	Threats, Opportunities, Weaknesses, and Strengths
UK	The United Kingdom
US/USA	The United States of America
USD	United States Dollar
WHO	World Health Organization

Chapter 1

Introduction

There is increasing awareness about the significance of the role that small and medium enterprises (SMEs) play as drivers of economic growth and development. Traditionally, they have been well known for their role as sources of job creation; more recently, they have been seen as potential sources of creativity and innovation, as well as policy instruments for addressing the challenges of regional development and social integration (Eurostat, 2009). Thus, the most significant challenge for SMEs is increasing their competitive efficiency and improving their productivity, not only to maintain their regional market share, but also to enhance their access to the global market (Neito and Santamaria, 2010; Nikolic, Cvetanovic and Desptovic, 2015). This raises the question of how SMEs would fare in the context of economies such as that of Thailand, which is seeking to become knowledge-based through the application of science and technology, capital and human creativity, which are organised in the form of Research and Development (R&D) initiatives, the effectiveness of which is sensitive to the size of firms (Nikolic *et al*., 2015). This would limit SMEs' access to R&D facilities. However, there is a growing body of evidence to suggest that SMEs could have an innovative comparative advantage over large enterprises (LEs) due to the flexible business environment they offer (Nieto and Santamaria, 2010). For SMEs to increase their competitiveness through innovative means and engagement in R&D, they would need to cooperate with partners from industry, the university or research sectors, and the government or policy sectors (Brimble and Doner, 2007).

Thailand is a major producer and exporter of fishery and seafood products across the world. The fishery and seafood sector in Thailand contributes to about 20 per cent of the total food exports of the country (Kasikorn Research Centre, 2013). Most Thai

food products are exported raw with little or no value added to them (Meerod *et al*., 2011). Therefore, their export earning ability is limited, as is their increase in the market share. To overcome these limitations, the Thai government has strategic policies to improve the efficiency of firms in the food industry in terms of both the quality and the quantity of the products (Kuldilok *et al*., 2013).

The seafood industry was chosen for investigation in this thesis for two main reasons: Firstly, most of the seafood industry in Thailand involves SMEs that have limited technology and innovation capabilities, unlike the LEs in the sector (Intarakumnerd *et al.*, 2002). Secondly, the rapid growth of the sector, both in terms of production and international marketing efforts, suggests that gains in the export market share for the products in this sector can only be maintained and increased via innovation and quality and price competitiveness. Correctly, the Department of Fisheries of the Government of Thailand has sought to promote the export performance of the sector (OECD-FAO Agricultural Outlook, 2013). To increase the competition in the global market, it was considered necessary to update the technological system on which the activities of the sector were based, with a view to managing the shorter product life cycles effectively and efficiently and improving product quality to achieve export competitiveness.

This thesis aims to examine how R&D would impact on the seafood industry in Thailand in terms of product and market performance. In addition, this research investigates the extent of cooperation between SMEs and external organisations to improve the R&D performance and outcome competitiveness of SMEs.

Chapter 1 is divided into four sections. Section 1.1 discusses the background for the research. Section 1.2 describes the research aim and the objectives of the research. Sections 1.3 and 1.4 explain the scope of the thesis and the thesis structure, respectively

1.1 Background for the research

Thailand is well known for its rich aquaculture resources and for its success in exploiting these resources through access to global markets. In 2016, the seafood industry contributed around 20% to the total value of Thailand's food exports, or approximately 191,005.6 billion baht and shared some part of 6% GDP contribution from food and beverage sector to the Thai economy (Kasikorn Research Centre, 2017).

Furthermore, in 2017, the total exports of processed and preserved food products was 5,786.4 million USD, or 20% of the total food exports of Thailand (U.S. Department of Agriculture: Foreign Agricultural Service, 2018). The Thai seafood industry provides either direct or indirect employment for over 650,000 workers in the nation (SEAFISH, 2015).

The seafood industry value chain can be divided into three parts: the aquaculture or fishery process, the processing processes and the wholesale trade (Johansena *et al.*, 2019). Meanwhile, Intarakumnerd *et al*. (2015) divide the Thai seafood industry's value chain into three streams: upstream, midstream and downstream (Figure 1.1). While the upstream section of the value chain encompasses the aquaculture processes, the midstream section comprises the mechanism for selling products in the centre of the market. Finally, the downstream section involves the product processor adding value to products.

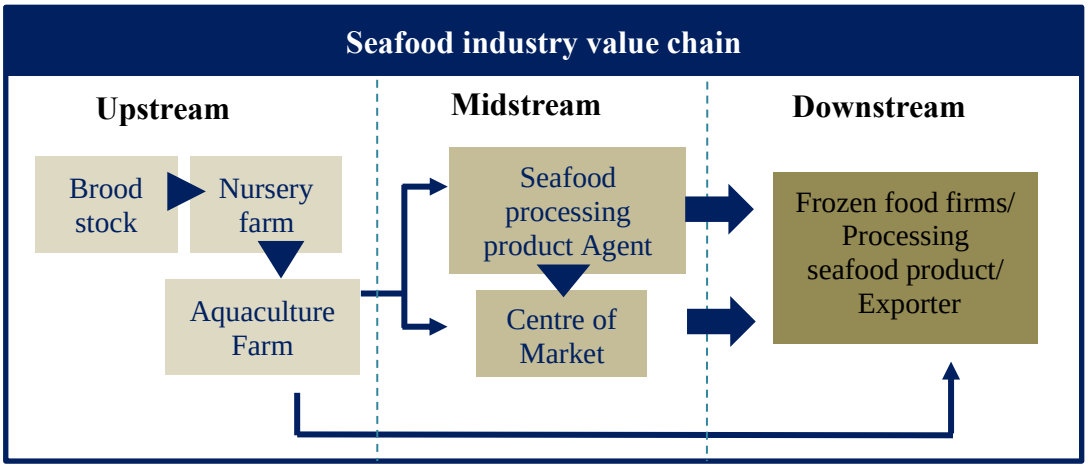


Figure 1.1: The value chain of the seafood industry in Thailand (Intarakumnerd *et al*., 2015)

However, Thai seafood and fishery products have encountered many challenges, as both internal and external factors have caused fluctuating export values in the past ten years. Thai seafood producers have been subject to anti-dumping[1] and countervailing duties from importing countries to decrease the volume of Thai seafood products in the world market. Furthermore, the Thai seafood industry has experienced trade tariff barriers in terms of high-quality control and traceability (Sowcharoensuk, 2019). In addition, fluctuating exchange rates have affected the development in the sector (National Food Institution, 2015; Sowcharoensuk, 2019).

Furthermore, internal factors such as natural disasters and virus outbreaks have affected the productivity of the seafood industry, particularly the export volume (Ongsritrakul and Hubbard, 1996; Department of Fisheries, 2019). The propagation of a disease called Early Mortality Syndrome (EMS)[2], technically known as Hepatopancreatic Acute Necrosis Syndrome, resulted in a 40% loss in Thai shrimp export production, which was worth around 27,117 billion baht in 2013 (Department of Fisheries, 2019).

Global developments underscore the importance of the seafood industry. As the global population continues to increase and is, in fact, expected to reach 9 billion by 2050, the amount of food required to support that population increases as well. At the same time, both the increasing global population and the need for increasing food production processes pose many challenges, such as the sustainable use of limited natural resources, e.g. land, water, and the need to control waste and pollution (World Bank, 2013). In addition, efforts to reduce global climate change to protect the world's

[1] Anti-dumping duties—protectionist tariffs imposed on imported products that domestic governments consider to be priced below the fair market value—are designed to control the price of imported products and thereby reduce the power of the import producer to intervene in local market mechanisms (Liu and Shi, 2017).

[2] EMS is the name of a syndrome that affects Asian shrimp species, mainly the giant tiger prawn (Penaeus monodon), the Pacific white shrimp (Penaeus vannamei) and the fleshy prawn (Penaeus chinensis). The source of the syndrome cannot be identified clearly, but is most likly due to pollution, insecticides or other pesticides. EMS affects the hepatopancreatic mechanism of shrimps, which then die rapidly (Food and Agricultural Organization of the United Nations, 2013).

natural capacities impact the manner in which economic activities are conducted (World Bank, 2013), and climate change itself affects the physical and ecological system of both the marine and aquaculture system. The warming temperature of water increases water evaporation and the density of nutrition in the water, which, in turn, impacts aquatic animals and plants.

In fact, food production generates 30% of greenhouse gas (GHG) emissions (Vermeulen *et al*., 2012) and accounts for 70% of freshwater use (Steffen *et al*., 2015). Furthermore, the World Bank (2013) expects these trends to increase as people turn to fish as a food that is high in protein, vitamins, minerals and polyunsaturated omega-3 fatty acids and low in saturated fats, carbohydrates and cholesterol (OECD-FAO Agricultural Outlook, 2013). This increasing consumption significantly contributes to the overexploitation of approximately 90% of the world's oceans, with 60% maintaining full capacities of fish stock and 30% experiencing overfishing (Willett *et al*., 2019). To meet these increasing consumer requirements while simultaneously meeting global environmental challenges, producers seek to harvest natural resources in new ways and with advanced tools. However, these efforts, combined with high demand, increase the price of products in the market.

Research and development (R&D) is an important factor in improved business performance, as improved productivity and profits have been proven to be the result of R&D in developed countries (Schiller and Diez, 2007). Much research has shown that technologies and innovations generate disruptive growth, particularly in the high-end market (Agarwal *et al*., 2007; Caballero, 2008). However, small and medium enterprises (SMEs), which dominate in terms of total number of businesses in the seafood industry in Thailand, are hindered by their limited access to R&D due to factors such as having less skilled labour, R&D facilities and equipment than are available to large enterprises (LEs) (Neito and Santamaria, 2010). In addition, SMEs bear a greater burden than do LEs in terms of the costs involved in transactions and in coordinating, managing and controlling their activities (Neito and Santamaria, 2010).

This begs the question about how SMEs would fare in the context of economies like that of Thailand, which is seeking to be knowledge-based through the application of science and technology, capital and human creativity, which are organized in the form of Research and Development (R&D) initiatives the effectiveness of which is sensitive to the size of firms (Nikolic, Cvetanovic and Desptovic, 2015). This would limit SMEs access to R&D facilities. However, there is a growing body of evidence to suggest that SMEs could have an innovative comparative advantage over LEs because of the flexible business environment they offer (Nieto and Santamaria, 2010). For SMEs to increase their competitiveness through innovative means and engagement in R&D, they would need to cooperate with partners from industry, the university or research sector, and the government or policy sector (Brimble and Doner, 2007).

It is a given that R&D is crucial for technological progress and improvements in productivity (OECD-FAO Agricultural Outlook, 2013). Thus, this thesis aims to examine how R&D engagement could impact on SMEs in the sector in terms of product performance and marketing performance. Furthermore, the specific characteristics of SMEs might be obstacles to engage in R&D, while networking could support the R&D activities of SMEs. Therefore, this research will study the role of participation with external organisations such as research agencies and government organisations to support the R&D engagement of Thai SMEs in the seafood industry.

Thus, it could be assumed that:

- SMEs may have the flexibility to engage in R&D and innovative activities, but have hitherto lacked funds for innovation, highly skilled personnel and technological awareness and, as a result, have remained R&D-inactive for the most part. Thus, most of the enterprises in Thailand that engage in R&D activities are LEs.
- R&D encourages the growth of productivity of businesses, which is reflected in their production and marketing performances.
- The Thai seafood industry is one of the world's biggest exporters. Although the seafood industry is categorised as a labour-intensive sector that operates the business through labour and capital funds, the R&D expenditure in the Thai

seafood industry has increased continuously. However, most of the R&D activities were conducted by LEs, not SMEs.

Based on these points, this research explores R&D engagement in SMEs and the role of R&D in enhancing their product and marketing performances; this research also investigates the mechanism of R&D networking in SMEs.

1.2 Research aim and research objectives

This thesis aims to explore the impact of R&D on Thai seafood business performance, particularly SMEs, which employ the bulk of the population in the Thai seafood sector. Also, this research aims to investigate the role of networking with the government, academic institutions and other businesses to support the R&D engagement mechanism in Thai SMEs in the seafood and fishery sectors. Based on this, the research seeks to achieve the following set of research objectives:

a. To investigate R&D activities in terms of the R&D expenditure of SMEs in the seafood and fishery industry in Thailand.

b. To explore the effect of R&D on the Thai SMEs in the seafood and fishery sectors' development concerning product performance and market performance.

c. To determine the significance of networking for R&D development and technological learning in the seafood industry in Thailand.

1.3 Scope of the thesis

This research aimed to explore the effects of R&D—in terms of product performance and market performance—on small and mid-size enterprises (SMEs) in the Thai seafood and fishery sectors. R&D among Thai SMEs in the seafood industry will be represented by firms' R&D expenditures.

To predict trends in R&D expenditure among Thai SMEs in the seafood industry, this research analysed five years of data since the updates in 2017 as well as data from the previous four years (2013–2016). R&D expenditures were analysed based on two main

activities: R&D expenditures on employment and R&D investment in machinery and tools. The effect of R&D on SMEs' development was assessed in terms of market performance and product performance. Market performance was revealed by the total sales and export revenue of two groups: SMEs that operate their businesses via capital funds and labour and SMEs that operate their businesses based on capital funds, labour and R&D. The product performances of the target group were assessed via interviews and four case studies. A questionnaire survey was employed to collect primary data regarding both market performance and product performance. Meanwhile, secondary data, including financial reports, annual business reports and related documents provided by the businesses, were utilised to measure the total sales, export revenue, total amount of new products and other important metrics for those companies. Finally, phone and face-to-face interviews were conducted to gather additional details about product development.

In addition, this research explored the interactions between Thai seafood SMEs and external organisations, which aimed to support the SMEs' R&D activity. In particular, the project studied the types of organisations with which the SMEs interacted and their motivations for participating in external networking.

According to the definition of SMEs, both R&D and the seafood sector might vary across countries, and the following chapters will discuss this potential diversity in detail. At this stage, however, the summary definitions, which provide the baseline to determine the scope of the research, are offered below;

SMEs are businesses that have a total of 50–200 employees or that have an asset value of fewer than 50 million baht to 200 million baht (Ministry of Industry, 2002).

R&D is defined either by businesses that, in the questionnaire survey, indicated that they engaged in R&D expenditures or businesses that reported their R&D expenditures via financial or annual reports or other papers they provided.

The seafood sector encompasses businesses that operate downstream of the seafood value chain in Thailand (see Figure 1.1; Intarakumnerd *et al*., 2015) that covered processed seafood producers.

The efficiency of a business relates to its capacity to complete a job to the same quality in the shortest time; efficiency can be learned, as can effectiveness (Chorafas, 2015). The scope of 'efficiency' in this thesis is all activities/processes that develop or improve the output/processes of a business with the same resources as others to be better than they are.

1.4 Structure of the thesis

This thesis is structured as follows: Chapter 2 consists of six parts. The first and second part discusses the literature on R&D theory as well as the contribution of R&D to both macroeconomic growth and small-level growth at the company scale. The third part explores the obstacles to engaging in R&D. The fourth part explores the definition of SMEs, the contribution of R&D to SMEs' growth and the effect of R&D on this group. And the fifth and sixth parts discuss the role of the seafood industry in the Thai economy and the role of networking to support business development.

Chapter 3 describes the input of both regular factors and R&D in driving the business and the business outcomes of these input factors. In addition, the mechanism of R&D is discussed in terms of its effect on creating innovative products or processes in relation to increasing the income of the business. The conceptual framework was derived from previous studies to investigate the role of R&D in Thai SMEs in the seafood industry. Furthermore, the method of collecting the data and the data analysis method are explained in this chapter.

Chapter 4 explains the analytical data, provides summaries of the interviews and a detailed discussion of the case studies. The analytical data have been divided into four parts, namely the business profile, the R&D expenditure details, the R&D collaboration and the effect of R&D on market performance and product performance. Moreover, the summaries of the interview results show the role of R&D on product development in this group. Lastly, four Thai SMEs in the seafood business used as case studies to examine how R&D impacts on business development.

Chapter 5 concludes the thesis. It first summarises the mains findings, such as the effect of R&D on market performance in terms of the total sales, export revenue and

product development of Thai SMEs in the seafood industry, as well as the effect of R&D collaboration with external agencies and the reasons for networking. This is followed by recommendations for future research and practice. A policy-driven recommendation is presented in the fourth part, and a summary of the thesis is provided in the concluding remarks.

Chapter 2

The Literature Review

This chapter presents the significance of research and development (R&D) for small and medium enterprises (SMEs), and illustrates the relationship of R&D with the development of SMEs' efficiency.

This chapter is divided into seven sections. The theoretical model of R&D is presented in Section 2.1. The contribution of R&D to economic growth is discussed in Section 2.2. The obstacles to R&D engagement are considered in Section 2.3. The significance of SMEs and the role of R&D in the development of SMEs is discussed in Section 2.4. Evidence of the seafood industry in Thailand is revealed in Section 2.5. The role of networking to support business development is discussed in Section 2.6. And Section 2.7 concludes this chapter.

2.1 Theoretical models of R&D

The high competition for differentiation and superior product performance amongst businesses has affected the intense technological development in industries (Rothwell, 1992). Thus, R&D has become an essential input factor that can transform existing products and processes into innovative products and procedures that are key to accessing the marketplace (Sanders, 2012).

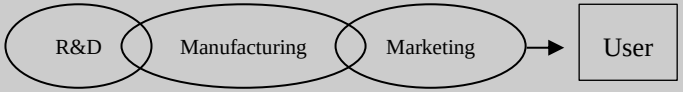
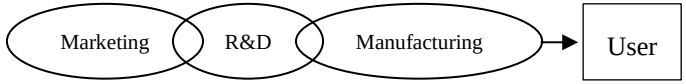
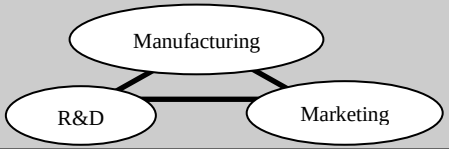
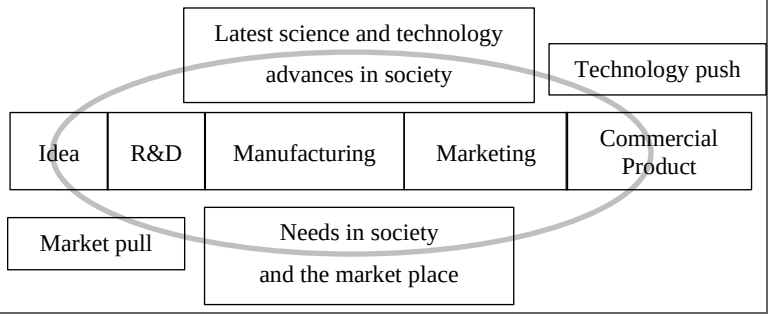
Apart from the strong technological competition amongst businesses, the sequential process of R&D intervention from the manufacturing process and providing the finished goods and services to the end-user has made finding the relationship model extremely challenging.

The chronology of the development of the innovative model for innovation management and new product development in the mid to late nineteenth century is presented in Table 2.1. In the late eighteenth century, the innovative model was described as a linear model. In the 1950s, the technology push model was established to explain the innovative model; the knowledge from scientific research was transferred to the manufacturing process to develop business products and processes, and these innovative products and processes could be sold directly to the customer via the marketplace.

It can be argued that the degree of market concentration may lead to the process of technological development (Garcia-Quevedo *et al*., 2014; Park *et al*., 2017); according to the Schumpeterian hypothesis, the focus was on the market power of R&D expenditure (Barge-Gil and Lopez, 2014). Thus, the market pull model was established to explain the innovative model in the 1970s. The market pull model retains the linear form as in the technology push model, while the form of the market pull model is the reverse of the technology push model.

Galbraith (1982) stated that direct interactions amongst skilled workers could increase the effectiveness of work in comparison to knowledge transmission from one worker to another. Thus, in the 1980s, the simultaneous coupling model was designed to explain the innovative mechanism amongst the same players as in the linear model; R&D, manufacturing and marketing. However, the simultaneous coupling model indicates the process of creating new things and processes via the interaction amongst these three factors at the same time.

Table 2.1: The chronology of the development of the innovative model for innovation management and new product development

Period	Model's name	The characteristic of the model	The mockup model
1950	Technology push model	The marketplace was considered to be a passive receptacle for R&D products and processes. Scientifically based knowledge was applied in the manufacturing process and to transmit the finished product to the market.	
1970s	Market pull or need pull model	Some R&D might result from the requirements of the customers. To become closer to the marketplace, firms used customers' needs as the starting point in R&D development.	
Early 1980s	Coupling model	The relationship of the key components changed from the linear cycle because innovative products require the simultaneous interaction of the main components.	
Late 1980s	Interactive model	Innovative ideas could originate via market pull and customers' requirements, as well as technology push or the readiness of a firm's technology. These ideas will drive the innovative process.	

Adapted from Rothwell (1992) and Trott (2005).

The innovation model was then developed as the interactive model in the 1980s. The interactive model is a combination of the technology push model and the market pull model. Organisational management has been considered to be one of the essential components for driving innovative processes and products in the industry (Rothwell, 1992).

2.2 The contribution of R&D to innovation and economic growth

The role of R&D in the economic growth in this section has been divided into two levels, namely the macro-economic level and the micro-scale business level. Theoretical details regarding R&D and the impact of R&D on the macro-economic level are discussed in Section 2.2.1. This is followed by the effect of R&D on business development in terms of product and market performance, while the effect of organisational management on supporting the R&D contribution to the business is explained in Section 2.2.2.

2.2.1 The relationship between R&D and economic growth

The contribution of R&D to innovation and economic growth is discussed extensively in contemporary literature based on a long line of theoretical and empirical studies on the role of technological knowledge in economic performance by a wide range of economists, including Joseph Schumpeter (1939), and even economists of neo-classical persuasions, such as Fabricant (1954), Abramovitz (1956), Solow (1957) and Denison (1962). The neo-classicists recognised technological knowledge or innovation as a factor that would result in an outward shift in the production function but considered it to be a *deus ex machina* outside of the market regime, thus relegating it to a 'residual' status after accounting for the contribution of primary resources such as capital and labour. Innovation is thus conceptualised as deriving from outside of the economic system, which means it is outside of the price mechanism.

Market externalities of public goods are thus used as the rationale for the intervention of the state to compensate for deficiencies in the market by making provision for the generation of technological knowledge through various means, including R&D. On the other hand, Schumpeter (1939) considered innovation to be internal to the economic system; that is, its direction and pace can be determined through policy measures, and long-term economic growth depends on the generation of innovation through investment in R&D initiatives. Thus, whereas neo-classicists saw innovation as data in the form of a 'black box', Schumpeterians would peep into the 'black box' to examine the process of innovation and the dynamics of the knowledge network in which innovation thrives.

This thesis is based on the Schumpeterian view that innovation and R&D activities should be seen as part of a systemic framework and not as isolated events that are subject to the whims of individual players. When a knowledge network has developed, it has spurred innovation, technological progress and economic growth. This can be seen in Figure 2.1, which shows that innovation, indicated by the size of R&D expenditure, is concentrated more in high-income than it is in low- to middle-income countries. Figure 2.1 also shows the steady growth of R&D expenditure as a percentage of GDP[3] in low- and middle-income countries, whereas the expenditure ratio appears to have levelled off in high-income countries (The World Bank, 2017b).

[3] Gross domestic product (GDP) is the total value of the final goods and services produced in the nation at a specific time.

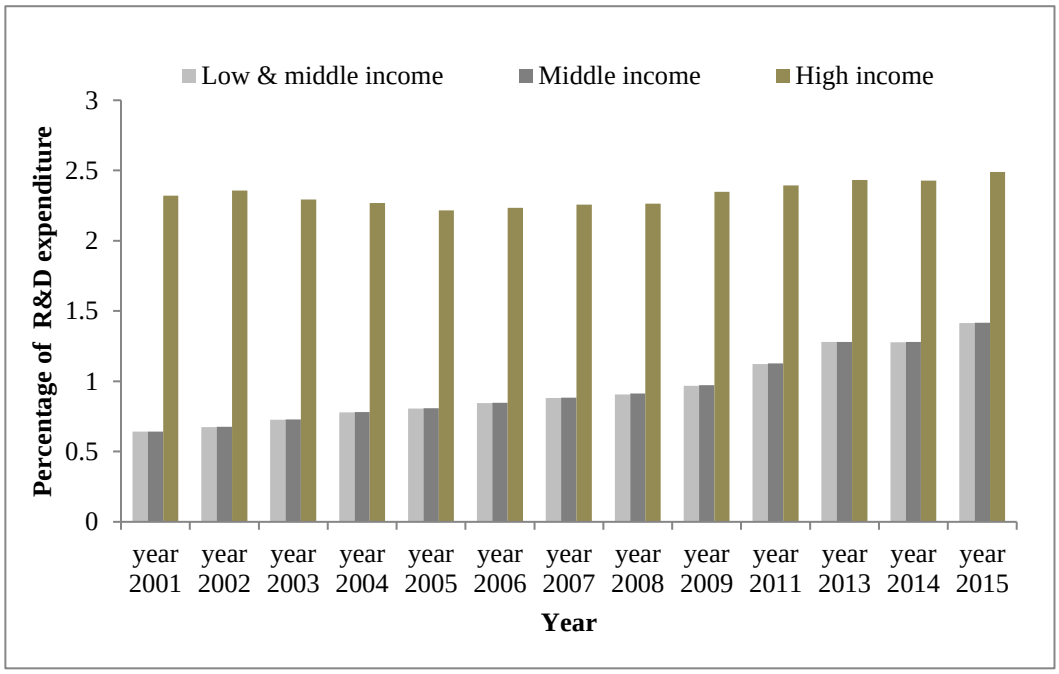


Figure 2.1: R&D expenditure per GDP for three types of countries: low middle income, middle income and high income (World Bank, 2017b)

In recent years, R&D activities have produced positive effects on economic growth—measured in terms of gross domestic product (GDP)—among newly industrialised countries (NICs). In fact, the World Bank (2017) has noted a continuous increase in research and development expenditures as a percentage of GDP among low-income, middle-income and high-income countries. Interestingly, the first and second countries with high R&D investment are Israel and South Korea; in both Israel and South Korea, R&D expenditures as a percentage of GDP have consistently exceeded the average of higher-income countries over the past decade (World Bank, 2017b).

The South Korean case demonstrates the ability of R&D investment to transform a developing economy from a low-productivity agricultural base in the 1990s into a newly industrialised country (NIC) 40 years later. As shown in Figure 2.2, the economies of South Korea and Thailand were largely similar during the 1960s and early 1970s. However, a developmental gap appeared in the mid-1970s when South Korea began to invest heavily in R&D. In time, South Korea grew to become a member of the Organisation for Economic Cooperation and Development (OECD) and was

recognised as a so-called 'Asian Tiger'[4] in the 2000s. In 2013, South Korea continued to exhibit the highest gross domestic expenditures on R&D (GERD) per GDP (GERD/GDP; 4.15%) in the Asian region (National Science Technology and Innovation Policy Office, 2016b). While the GERD/GDP ratios of Japan, Taiwan and China are lower than that of South Korea, the trend towards R&D investment in these countries has likewise demonstrated a continuous increase. Meanwhile, Thailand lacked R&D resources such as infrastructure, highly skilled and educated personnel and an innovation fund (World Bank, 2017a), and thus its economy remains predominantly agricultural.

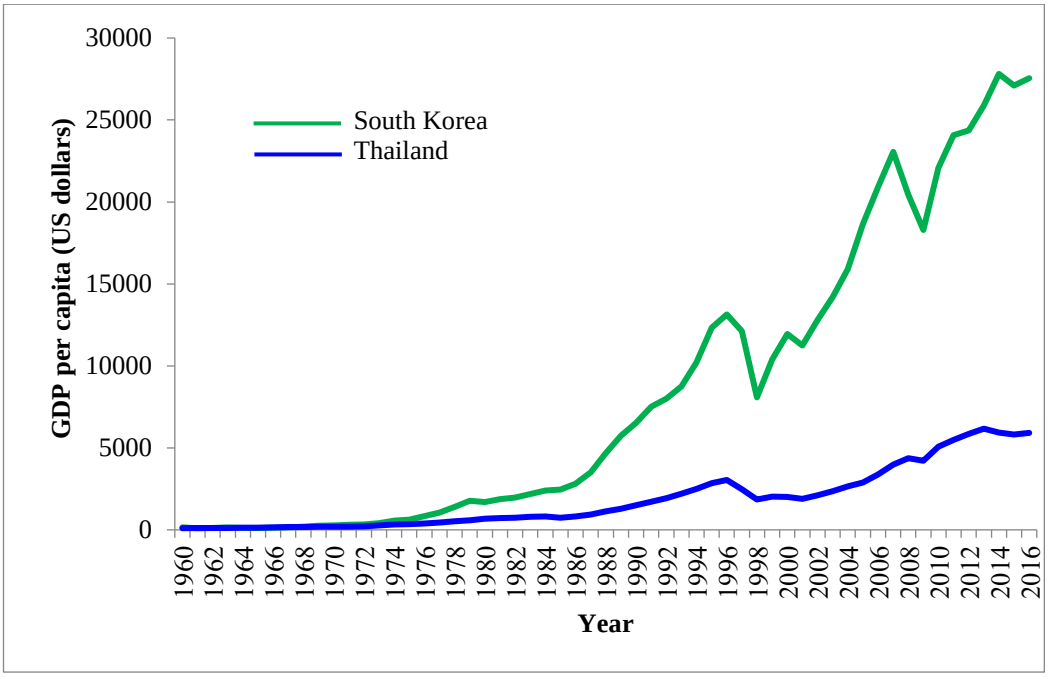


Figure 2.2: Comparison of GDP per capita between South Korea and Thailand during 1960-2016 (World Bank, 2017a)

In the Asian region, the bulk of the resources for R&D investment (more than 60%) is derived from private businesses (World Bank, 2017b). Indeed, private firms, particularly SMEs, are the key drivers of economic growth in South Korea (Ministry of SMEs and Startups, 2015). In addition, these R&D expenditures and innovation

[4] The term 'Asian Tigers' refers to Asian countries that exhibit continuous and dramatic growth greater than 7% GDP per year. These countries capitalized on dramatic manufacturing development between 1960–1990 to rank among the world's high-income countries in the 21st century (Radcliffe, 2017).

activities are affected by the retail share of an industry (Ghazaliah, 2012). Thus, as economies of scale increased, the role of innovation in SMEs expanded from the late 1970s onwards (Sedej & Justinek, 2012).

Although Thailand had progressed from a lower-income into a middle-income country by 1976, it remains at that same level of development today (Im & Rosenblatt, 2013). To overcome this stasis, Thailand has attempted to learn from developed countries and change its strategic direction by increasing the role of R&D activities in economic development. In 2014, Thailand's GERD/GDP grew approximately 0.48%; nevertheless, it remains more than ten times below South Korea's GERD/GDP ratio. In addition, R&D expenditures among private firms in Thailand remain 54% lower than in other Asian countries. Furthermore, the average size of the service sector relative to the agricultural sector is 63.6% to 5.9% globally. However, Thailand's agricultural sector comprises 13.3% of the country's economy (Wongsintuviset & Jarunpipatkul, 2017). According to Thailand, the abundance of natural resources has established the country as an agricultural-based economy and makes an immediately transition from agriculture to service impossible. This transition, however gradual, is nevertheless necessary to increase Thailand's global competitiveness. As the country pursues long-term economic growth, the South Korean case remains instructive: R&D is a crucial component to drive economic growth and to address the social and environmental impacts of economic development.

Thailand had moved from the lower-income to the middle-income category of countries by 1976, and has remained in this position ever since (Im and Rosenblatt, 2013). To overcome this 'locked-in' problem, Thailand would need to increase its R&D activities and promote activities on the knowledge network amongst a wide range of players from the production, research and policy sectors. Thailand had increased its GERD/GDP ratio to around 0.48% by 2014, but this ratio is approximately ten times lower than it is in South Korea (Figure 2.3).

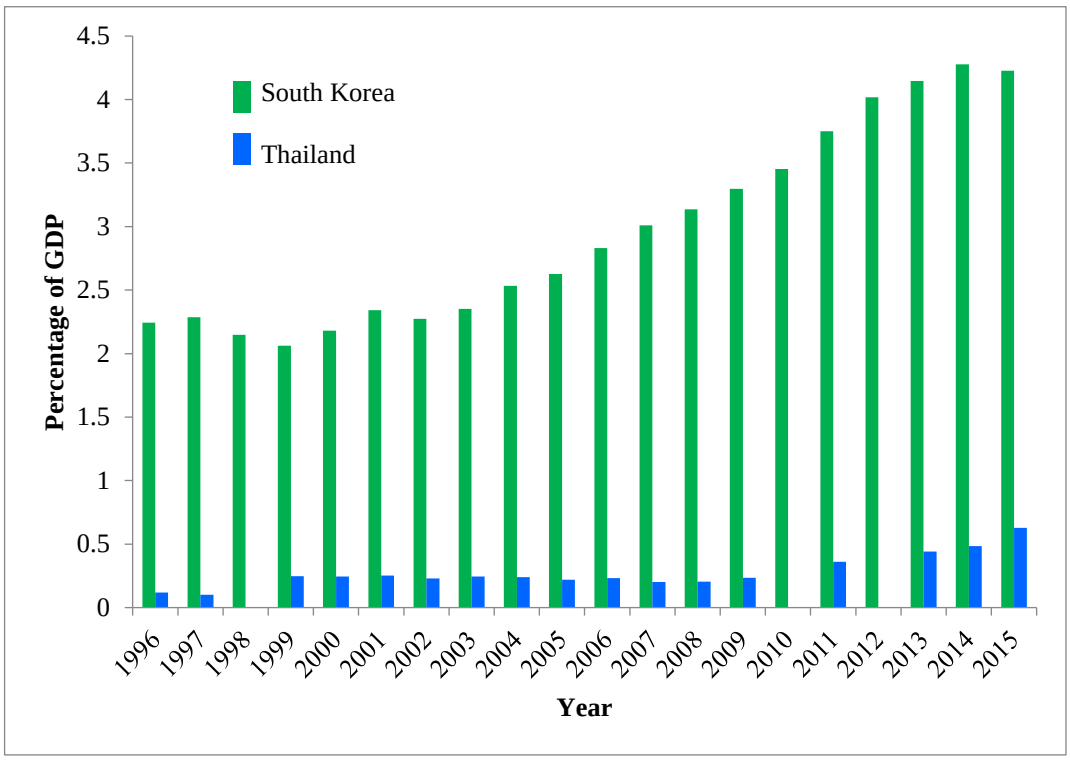


Figure 2.3: Comparison of R&D expenditure per Gross Domestic Product (GDP) between South Korea and Thailand during 1996-2015 (World Bank, 2017b)

2.2.2 The influence of R&D expenditure on business performance

The effect of R&D expenditure on business development has been acknowledged as having a positive relationship with output in terms of the increased quality of the products, reduced processing costs, extended access to markets, and so forth (O'regan and Ghobadian, 2004; Sedej and Justinek, 2012; Liik *et al*., 2014; Turnbull *et al*., 2019). A significant amount of research has explained the relationship between R&D and output; however, the influence of R&D expenditure on the business output can be divided into the three main aspects of product and process development, market expansion, and the development of organisational management (Turnbull *et al*., 2019) as discussed in details below;

2.2.2.1 R&D creates an innovative product or process and decreases failure in the production process

In essence, innovation is created via scientific knowledge or research, with the unique result being innovative items (Early, 1997; O'regan and Ghobadian, 2004); moreover, innovation decreases the time needed to improve novel products or processes (Schiller and Diez, 2007).

Kim *et al*. (2018) found that, in 2010, Korean businesses that invested in R&D human resources in one person could increase their innovative products by 0.41%, whereas a business that concentrated on R&D human resources combined with external R&D investment could increase their innovative products by 0.7%. Furthermore, Kim *et al*. (2018) indicated that the number of R&D human resources, the amount of external R&D expenditure and total sales had a significant effect on patent applications. The result showed that the number of R&D workers increased by one person and patent applications rose by 0.95%, while increasing the external R&D expenditure by one million Won[5] increased patent applications by 0.03%.

By contrast, during the period 2012-2014, businesses in England and Scotland that included innovative activities focused on innovative organisational management rather than on innovative products or processes. Most of the innovative activities in these businesses stemmed from internal R&D expenditure on training activities, or buying machines to support R&D activities in these firms (Turnbull *et al*., 2019).

Meanwhile, businesses and inventors could recover the cost of R&D investment via the mechanism of a patent (Encaoua *et al*., 2006). The patent mechanism is designed to protect the right of inventors to obtain income from their creations for a particular period to finance the creation of new products or processes (Encaoua *et al*., 2006). Therefore, patents have been chosen as an indicator to measure the degree of R&D expenditure on outcomes (Pakes and Griliches, 1984).

[5] The official currency of the South Korean Republic is Won (symbol: ₩; code: KRW; Kiprop, 2017). The exchange rate on the 8th of September 2020 was one Won to 0.0008 USD (Exchange Rates UK, 2020)

Thus, the quantitative evaluation of product or process performance is considered to be indicated by patents or publications (Artz *et al.*, 2010; Liik *et al*., 2014). However, not all innovative outcomes will be registered for patents due to the cost of patent applications. Artz *et al*. (2010) stated that products with high potential in the market were selected for patent applications to protect the rights of patent holders in the competitive market. Therefore, the market requirement is relevant to the direction of the R&D activities in a business. In addition, market outcomes such as total sales, reduced costs, product development and capital avoidance might be used as tools to evaluate R&D investment (Brown and Svenson, 1998; Lazzarotti *et al*., 2011; Kim and Kim, 2015).

2.2.2.2 R&D increases the profits of the business and expands its market

The market is crucial for transferring R&D results to the consumer through innovative products (Wang and Wu, 2012); the marketplace also allows for the return of profits to the business through increasing its output.

The increase in capital input due to R&D investment can contribute to developing product quality to global standards, and leads to the significant outcome of increasing the returns to the business (Ishii, 2014; Guarascio *et al*., 2016). The additional cost of R&D investment that has an effect on the increase in product quality can return a profit to the business by increasing the price of the product. As can be seen, the cost of R&D products is higher than is that of non-R&D products (Chiang and Masson, 1988).

R&D is symbolic of acceptable quality, and creates confidence in consumers. The quality of R&D products or processes can increase consumers' trust in these items, and they will be willing to pay a higher price to for items that are better quality (Highfill and McAsey, 2018; Lee, 2019). Thus, R&D products may soon dominate the demand side of the market.

Therefore, in order to maintain competitiveness in the market, a business that did not engage in the R&D must reduce the price of its products to maintain its market share or increase its efficiency via R&D in the same way as its competitors that have invested

in R&D. Subsequently, competition amongst business in terms of R&D will affect the customers, who will later receive quality products at a lower price.

In this regard, Lee (2019) stated that R&D expenditure was correlated positively with the market value in Korean Biotech firms. As can be seen, the decrease in R&D expenditure by these firms decreases their market value. Furthermore, the continuous increase in capitalised R&D may lead the market to expect biotech firms to invest massively in R&D in the future (Lee, 2019).

Moreover, R&D is a vital tool in the process of market expansion, particularly for international markets (Ganotakis and Love, 2011; Ghazalian, 2012; Dilling-Hansen and Smith, 2015; Guarascio *et al*., 2016; Carboni and Medda, 2018). The result of R&D in terms of export contribution to the Danish business sector indicated that businesses that engaged in R&D had greater export capability than did businesses that did not engage in R&D (Dilling-Hansen and Smith, 2015).

Export success has a significant relationship with the technological strength of the business (Guarascio *et al*., 2016). The main R&D activities in response to international market requirements focus on two main aspects in addition to the creation of unique products, namely R&D to increase the quality of the product to international standards and R&D to extend the shelf life of the product through packaging development to maintain the freshness and hygiene of the products (Bhatt *et al*., 2017). The guarantee of the high quality of Thai seafood products was key to increasing the export value of the seafood sector to 3,554 million USD, or around 44% of the export value of the nation, in 2001 (Department of Trade Negotiations, 2001).

Previous sections explained the role of R&D in increasing product performance that leads to improved market performance for the business. However, Máñez *et al*. (2020) argued that the key factor in supporting export activities in a business was innovative organisational management, while, Lee (2019) stated that R&D expenditure management could protect against the risk of R&D investment failure in a business. It can be assumed that organisational management might be at the root of a proactive plan to create sudden growth in a business or reduce or to solve problems stemming from external factors, such as market failure, to ensure the survival of the firm.

2.2.2.3 Good organisational management decreases the period required to achieve business goals and reduces R&D failure

Organisational management is the key to promoting R&D activities related to market integration, and the degree of success of the development of new products (Fain *et al*., 2011). Furthermore, government policies in terms of tax breaks and the granting of funds for R&D projects can alleviate the cost of R&D investment for businesses and increase their awareness of R&D activities (Ishii, 2014).

One successful example of the application of innovative organisation to increase business efficiency was cited by Boehm (2012), who described the case study of Mitsubishi Fuso, the largest truck firm in Japan, which planned to reduce the cost of R&D by 30% due to challenging market conditions. The effect of innovative organisational management on the R&D activities in the business is on-going, and the firm has achieved its goal and is experiencing stronger teamwork. This case study indicates that businesses can reduce costs while ensuring that the efficiency of the product continues to grow. Thus, it can be concluded that organisational management contributed to reducing the R&D expenditure of the business by 30%.

The government has attempted to increase the competitiveness of businesses through various methods. Ideally, the government is a crucial driver of the innovation system, particularly in developing countries (Meier and Stiglitz, 2000; Struthers, 2018).

Government organisations play an essential role in creating an innovative market mechanism. Normally, producers are controlled by their suppliers in terms of price, leaving small-sized businesses and agricultural producers, in particular, to face business losses. Thus, government organisations have the power to create a fair playing field for all product value chain participants through, for instance, setting up the standard pricing of products (Struthers, 2018). Furthermore, government organisations can reduce market interventions, particularly at the local level, by supporting quality improvements that allow local products to satisfy customers and replace imported products (Struthers, 2018).

Correspondingly, Villasana (2011) stated that technological transfer requires clear government policies to support the circular system in university-industry interactions. Specifically, supportive factors such as incentives and laws are success factors in the prevention of systematic innovation failure (Chunhavuthiyanon and Intarakumnerd, 2014).

Overall, R&D could generate new ideas stemming from an academic education and on-the-job learning; these ideas can then be developed as innovative products or processes. As the market is the connection point between the R&D unit and the end-users, R&D departments in firms could benefit from this aspect in two ways, namely the total sales and customer feedback, in order to create new ideas in response demand to maintain the income of the business. However, R&D expenditure requires a clear internal policy and plan to support and achieve the business' goals. Furthermore, the support of external organisations, such as government policies, helps to drive R&D expenditure in the private sector and decrease the failure of R&D investment. Thus, R&D is a crucial factor in supporting product performance, market performance and the organisational management performance of a business, which leads to the survival of the business in a competitive market. However, R&D remains difficult for some businesses to access for various reasons depending on the individual company. Addressing these obstacles will enable the development of optimal policies to increase awareness of and expenditure on R&D in businesses, which will lead to the long-term growth of the national economy.

2.3 Obstacles to R&D in a business

Even though R&D is a reasonable way to increase the efficiency of a business (Ghazalian, 2012), some businesses cannot access R&D successfully. Obstacles to R&D activities in a business are related to both internal and external factors, which vary depending on the size of the business, the type of industry, and policy support.

The amount of R&D investment, the outcome of the business, and the launching of the product should be correlated positively with the size of the business (Artz *et al*., 2010; Garcia-Quevedo *et al*., 2014). SMEs tend to have an innovative advantage over LEs

due to the flexible business environment. However, SMEs have fewer supportive factors such as skilled labour, R&D facilities and equipment than do LEs because the category conditions for businesses vary across countries (Neito and Santamaría, 2010). However, LEs did not experience liquidity constraints, have easy access to external finance, and have considerable internal funds due to accumulated profits (Neito and Santamaría, 2010). Thus, LEs can establish the R&D units or engage in activities to improve the product and process performance in their businesses (Garcia-Quevedo *et al*., 2014).

Business size is determined by considering the assets, capital funds or the number of workers, which can vary across sectors and countries; thus, it could be implied that the size of the business is related to its readiness to implement R&D in the company. Moreover, the age of the business has been suggested as one of the factors in the business' R&D participation (Kim *et al*., 2018). Artz *et al*. (2010) reported that older firms tended towards more conservative organisational management than did younger businesses because they need to employ professional managers to maintain the consistency of the business. In addition, the influence of investors might dominate the founders' innovative ideas. Therefore, creative productivity tends to decline as the business ages (Acs *et al*., 1994).

Liik *et al*. (2014) stated that the level of technology in the business was not related to efficiency or to the productivity level. However, R&D expenditure affects the productivity outcomes of high-technology industries more than it does in low-technology industries. Furthermore, the accumulative capital investment influences the development of productivity in low-tech or non-intensive industries. In other words, the low-tech sectors require capital funds to increase the efficiency of the outcomes more than they need R&D investment; by contrast, R&D expenditure has a positive effect on the product development of high-tech industries.

In summary, the main obstacles to R&D in firms are mainly internal factors in the business. Financial readiness has a significant and positive relationship with R&D investment (Esteve-Perez and Rodriguez, 2013). Theoretically, the characteristic of LEs indicate that they have both larger budgets and more workers than do SMEs. Thus, it could be assumed that larger businesses would be more likely to engage in R&D

activities than would smaller businesses. Therefore, the size of the business may be the main reason for the lack of R&D activities in some cases. In fact, hidden causes such as financial constraints and the lack of skilled workers might actually be due to the size of the business, and different characteristic of a business such as size, age, liquidity and so forth can affect the different outcomes (Garcia-Quevedo *et al*., 2014).

Accelerating the shift to a knowledge-based economy would require the adoption of an appropriate macro-economic policy and, at the micro-level, would require competent management to promote improvements in the skill profile of employees, as creativity, innovation and competitiveness are crucial (Early, 1997; Firlej and Żmija, 2017). Furthermore, firms need to have an absorptive capacity, and would also need to be open to acquiring new ideas and technologies on which they could build while remaining critical of them. Dora *et al*. (2013) noted that the skill of the workforce was a key factor in transferring lean manufacturing technology to the food industry in EU countries. Small firms may be unlikely candidates for engaging in in-house R&D initiatives, but they do have attributes such as flexibility and the speed of response to changes in production and market circumstances that would make them positively disposed towards innovative activities (Nieto and Santamaría, 2010). For SMEs to increase their competitiveness, they would need to cooperate with partners from industry, university or research sectors, as well as government or policy sectors. This triple-helix system of partnerships in the knowledge network would provide SMEs with access to complementary competencies and technologies, as well as with access to new and growing markets.

2.4 The significance of SMEs

SMEs are acknowledged as being the backbone of the socio-economic impact of any nation (Labudova and Janosova, 2019). According to the Organisation for Economic Cooperation and Development (OECD) (2000), many SMEs are an important source of job creation and they make a significant contribution to gross domestic product (GDP) globally.

A review of the literature on SMEs around the world shows that the way SMEs are defined depends on the characteristics of national industry, types of product and the total assets of the business. Generally, they are categorised according to a total headcount of staff, assets and revenue (Muriithi, 2017). However, by definition, most SMEs have a total staff headcount of fewer than 250 employees (Muriithi, 2017); additionally, any definition of SMEs must indicate that they have limited revenue and/or assets (Anand, 2015).

The limitations of SMEs stem from their compact structure, which functions with limited labour and capital investment. However, the specific structure of SMEs enables them to respond more flexibly to changing circumstances in production and marketing (World Bank, 2018a). SMEs account for 23% of export income in Estonia, 21% in Slovenia, 19% in Finland and 17% in Denmark (Dragnic, 2014). Furthermore, the contribution of SMEs to economic growth has a varied discussion. In most developed countries, such as OECD members, over 95% of SMEs are the source of 60–70% of total job creation, reaching as much as 78% in Japan (OECD, 2000). Also, their high resilience is a seedbed for innovative growth and brings about industrialisation or the abrupt development of SMEs (Muriithi, 2017).

Modernisation and R&D are important factors in improving business performance; their positive impact on productivity and profit has been proven in developed countries (Schiller and Diez, 2007). For example, research has repeatedly shown that technology and innovation create disruptive growth, especially in the high-end market (Agarwal, Audretsch and Sarkar, 2007; Caballero, 2008). However, most business R&D is conducted by large enterprises because of their readiness and resource capability in terms of investment funds, access to machines and tools, and high-skilled workforce (Hervas-Oliver, Garrigos and Gil-Pechuan, 2011). Gao & Hafsi (2015) state that R&D participation remains a sensitive point in SMEs and is given less attention when compared with large enterprises, which have a more efficient R&D contribution.

Nevertheless, Hervas-Oliver *et al*. (2011) suggest that the technology and innovation in SMEs do not specify in-house R&D units only because of the limited budget and skilled workers; however, SMEs, especially in the low technology sectors, can find

alternative methods or external sources of knowledge, which allows them to participate in R&D or innovative creativity.

In this section presents the definition of SMEs and the role of R&D in the improvement of SMEs. Then, Section 2.4.1 provides details about the specific characters of SMEs, as well as how the definition of SMEs varies across countries. In addition, the role of R&D in business improvement and examples of the impact of R&D on business development in Thailand are presented in Section 2.4.2

2.4.1 The SME landscape

The definition of a 'small enterprise' was first provided in 1971 by the Bolton Committee (Bolton, 1971). Small-sized firms in the manufacturing, retail and wholesale trades and other sectors were originally defined based on the total headcount of staff (200 employees or fewer), and total revenue (£50,000 - £200,000 or less), whereas having five vehicles or fewer was the requirement for qualifying as a small business in the road transport sector (Bolton, 1971).

At present, the definition of SMEs varies, as countries have individual specifications. In general, quantitative indicators such as staff headcount and annual turnover are considered to be the criteria for classification as an SME (Asian Development Bank, 2015). However, those countries that use the same quantitative measures do not necessarily use the same thresholds (Ibarrarán *et al*., 2009; Muriithi, 2017). For example, the Organisation for Economic Cooperation and Development (OECD, 2001) has divided SMEs into the three sub-categories of micro-enterprises (those with ten employees or fewer, or in which the turnover does not exceed two million EUR), small enterprises (those with 10 - 49 employees or fewer, or with a turnover not exceeding 10 million EUR), and medium enterprises (those with 50 - 249 employees or fewer, or with a turnover ceiling not exceeding 50 million EUR). By contrast, the categories of SMEs in Japan vary not only according to capital or the total number of employees, but also depending on the business sector. SMEs in the retail sector can

have a capital of less than 50 million Japanese Yen (¥)[6] or fewer than 50 employees; those in the wholesale sector can have a capital of less than 50 million or fewer than 100 employees, and SMEs in the manufacturing sector can have less than ¥300 million capital, or fewer than 300 employees (Economist Intelligence Unit, 2010) (Table 2.2).

Business demographic studies indicate that approximately half of new SMEs entering the market face the prospect of going out of business within five years (Eurostat Statistic Explained, 2017; OECD, 2000). Moreover, job turnover, which is a critical indicator of competitiveness, product performance and structural change, costs SMEs nearly 20% of their skilled workforce to countries as diverse as France, Sweden and the United States (World Trade Organisation, 2016). While SMEs have the advantage of being flexible in their adjustment to changing circumstances, they are also vulnerable to problems in the supply of investment capital and skilled labour, which affect not only their growth at the micro level but also the growth of the economy in general due to shortfalls in employment, added value and export earnings. Thus, the most significant challenges for SMEs involve increasing their competitive efficiency and improving their productivity—not only to maintain their regional market share but also to enhance their access to the global market.

[6] The exchange rate for Japanese Yen (¥) was one pound Sterling (GBP) to 141.4773 Japanese Yen on the 3rd of February 2020 (Bank of England, 2020).

Table 2.2: SME definition's variance in criteria across countries (among those selected) and the impact of SMEs on the economy

Countries/ Groups of countries	SME definition						The total number of a registered businesses	Contributions of SME sector (%)		Sources of information
	Staff headcount	Asset	Turnover	Capital	By sector	Balance sheet		GDP	Employment	
USA	✔		✔				97.20	65	50.4	Keskin *et al.*, 2010; Robu, 2013; Muriithi, 2017
EU	✔		✔			✔	99.80		88.8	European Commission, 2015
UK	✔		✔				96.00	51.4	62	Keskin *et al.*, 2010; Muriithi, 2017
OECD	✔		✔				99.80	44.0	64.7	The Organisation for Economic Cooperation and Development (OECD), 2000; Dragnic, 2014
China	✔	✔	✔		✔		99.00	66.28	81.89	Xiangfeng, 2008; Muriithi, 2017
Japan	✔			✔	✔		99.40	60.00	78	OECD, 2000; Economist Intelligence Unit, 2010; Keskin *et al.*, 2010; Robu, 2013
South Korea	✔		✔	✔	✔		97.80	34.5	86.5	Kim, 2007; Keskin *et al.*, 2010
Thailand	✔			✔	✔		99.79	43.6	85.47	Ministry of Industry, 2002; Monitoring and Analysis Team, 2019
Laos	✔	✔	✔		✔		99.00	8.0	82.4	Bihler, 2014; Kyophilavong *et al.*, 2017

2.4.2 The contribution of SMEs to Thailand's economy

In this thesis, SMEs are defined by the Thai Ministry of Industry (2002). The classification of Thai SMEs is based on the total number of employees and total asset values, which vary across sectors (Ministry of Industry, 2002). As Table 2.3 shows, small enterprises in the manufacturing and service sectors have fewer than 50 employees and asset values less than 50 million baht, while small businesses in the wholesale sector and the retail sector have fewer than 25 and 15 employees, respectively (Table 2.3).

Table 2.3: The small and medium enterprises categories in Thailand

Sector	Small enterprises		Medium enterprises	
	Employees (persons)	**Asset value (million baht)**	**Employees (persons)**	**Asset value (million baht)**
Manufacturing	Fewer than 50	Less than 50	50–200	More than 50–200
Trading				
• **Wholesale**	Fewer than 25	Less than 50	26–50	More than 50–100
• **Retail**	Fewer than 15	Less than 30	16–30	More than 30–60
Service	Fewer than 50	Less than 50	51–200	More than 50–200

(Industry Ministry, 2002)

Following the example of Japan and South Korea (Economist Intelligence Unit, 2010), SMEs have recently come to dominate the Thai economy, representing 99% of Thai businesses (Office of Small and Medium Enterprise Promotion, 2017c). Table 2.4 below reveals the significance of the contribution of SMEs to the Thai economy. SMEs accounted for 42.5% of total GDP, and while GDP grew at 3.3%, the contribution of SMEs grew at 4.9% on average (Office of Small and Medium Enterprise Promotion, 2017c).

Table 2.4: The growth of value and GDP extension of SMEs in the Thailand economy during the first quarter of 2017

Enterprises	Value	Ratio	Growth
Nation	3,798,430	100.0	3.3
Agricultural regions	351,914	9.3	7.7
Non-agricultural regions	3,446,516	90.7	2.9
- LEs	1,608,483	42.3	1.4
- SMEs	1,613,849	42.5	4.9
Small enterprises	1,140,614	30.0	5.3
Medium enterprises	473,235	12.5	3.8
- Other	224,184	5.9	0.2

(Office of Small and Medium Enterprise Promotion, 2017)

The distribution of SMEs across Thailand appears to be regionally concentrated, with 26% in the north-eastern regions (25.9%), 20% in Bangkok and 20% in the central regions (Export-Import Bank of Thailand, 2012). In terms of industry, nearly half of Thai SMEs were involved in the wholesale and retail (49.7%), industrial production (17.9%) and hotel and restaurant (9.3%) industries, respectively (Figure 2.4**:**; Export-Import Bank of Thailand, 2012).

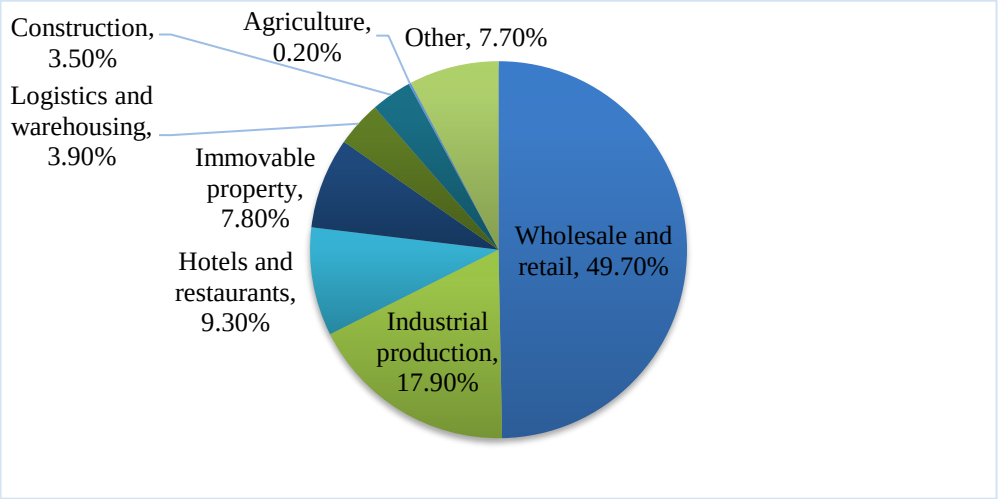


Figure 2.4: SME structure per business in Thailand (Export-Import Bank of Thailand, 2012)

Although, in 2017, Thai SME exports decreased by 7.4% from 2016, SMEs nevertheless represented a quarter of the country's total exports (25.5%; (Figure 2.5; Office of Small and Medium Enterprise Promotion, 2017). The most significant export products of SMEs in Thailand are jewelry and accessories (17.5%), vehicle and tools (7.8%), plastics and related products (7.8%), computers and tools (6.5%), electricity and tools (5.6%), candy and related products (5.0%), rubber and related products (4.7%) and wood products (3.1%; Office of Small and Medium Enterprise Promotion, 2017).

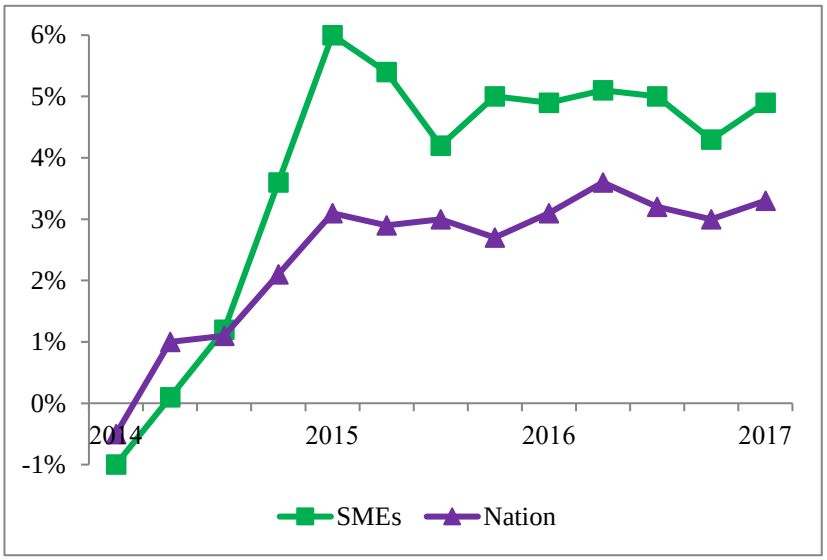


Figure 2.5: The value and GDP extension ratio of SMEs in Thailand for 2014-2017 (Office of Small and Medium Enterprise Promotion, 2017)

The main trading partner of SMEs in Thailand—accounting for almost 30% (53,781 million baht) of the country's trade volume—are the Association of Southeast Asian Nations (ASEANs; Office of Small and Medium Enterprise Promotion, 2017). This suggests that Thai SMEs have the efficiency to extend their markets beyond the region, but limited resources, such as capital funds and highly skilled personnel, continue to affect the growth rate or global expansion of the market.

The importance of SMEs for the Thai economy is partly demonstrated in reports SME investments in non-financial assets as a proportion of GDP. In fact, SME investments in non-financial assets as a proportion of GDP are the highest in Thailand, exceeding such investments even in developed countries, including France, Germany, Japan,

South Korea and the UK (World Bank, 2018b). By contrast, SMEs' contribution to the Thai economy—representing approximately 40% of the country's GDP—is slightly lower than that of SMEs in other developed countries such as France, Germany, Japan, South Korea, the UK and Germany (Economist Intelligence Unit, 2010; Export-Import Bank of Thailand, 2012).

2.5 The seafood industry in Thailand

Thailand is well known for its rich endowment of aquaculture-based resources and for its success in exploiting these resources through access to global markets. Approximately 70% of the value of exported seafood products derives from the export of tuna and shrimp products (Department of Fisheries, 2017). In 2017, the total export of processed and preserved food products was 5,786.4 million USD, or 20% of total Thai food exports (Figure 2.6; US Department of Agriculture: Foreign Agricultural Service, 2018). In 2017, the top export destinations for these products were Japan (19.17%), the US (17.61%), Australia (6.68%), Canada (4.27%) and China (3.28%) (US Department of Agriculture: Foreign Agricultural Service, 2018).

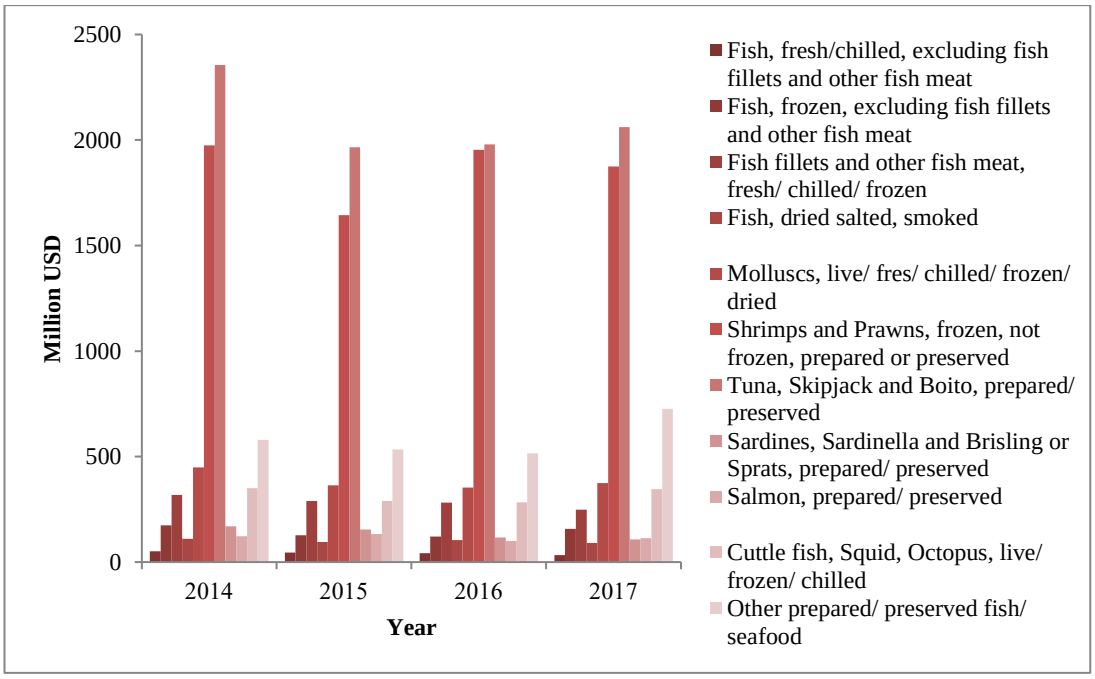


Figure 2.6: Thailand seafood exports during 2014-2017 (Ngamprasertkit, 2018)

As Thailand's economy continues to grow, R&D activity has enabled the seafood industry to produce a wide range of products—from semi-processed to high-value products—to support international demand (US Department of Agriculture: Foreign Agricultural Service, 2018). The main Thai export products from this sector are canned, primarily tuna, sardines and mackerel; other processed products of the sector include salmon, cuttlefish, squid and pollock (US Department of Agriculture: Foreign Agricultural Service, 2018). Most Thai producers are original equipment manufacturers (OEMs) and thus supply their products for major manufacturers' brands or foreign brands (US Department of Agriculture: Foreign Agricultural Service, 2018).

The Thai seafood industry provides direct and indirect employment to over 650,000 domestic workers (SEAFISH, 2015). Over 400,000 employees are employed in fish farms and related businesses, while 78,000 work in aquaculture farms and 184,000 in related business and plant processing (Dasgupta, Bhula-or, & Fakthong, 2013). Some 80% of shrimp products—over half a million metric tons—originate from some 25,000 local Thai farms, which are small businesses or family-owned business through LEs. In addition, the seafood industry includes more than 150 freezing factories and 50 canning factories, especially around the port of Samut Sakhon. However, the propagation of diseases, including early mortality syndrome (EMS) and acute hepatopancreatic necrosis disease (AHPND), caused the loss of 50% of Thai production, or around 540,000 metric tonnes, in 2012.

R&D is a process of creativity and systematic work that increases our knowledge stock (OECD, 2018). R&D also helps us to devise new applications using our available knowledge (OECD, 2018). The final output of R&D activities is not clear; it depends on the degree of financial support and individual management plans. There are five core types of activities that fall under R&D: novel, creative, uncertain, systematic, and transferable/reproducible (OECD, 2018). Also, R&D is acknowledged as being a crucial factor to support productivity growth, increase competitiveness, and ensure the survival of businesses, particularly SMEs. (Agarwal *et al*., 2007; Schiller and Diez, 2007; Caballero, 2008; Añón-Higón *et al*., 2015).

Although the size of the business might be an obstacle to market expansion aboard, this mainly affects sectors that more open to trade and high-tech industries (Guarascio

et al., 2016). Conversely, Máñez *et al*. (2020) argued that the size of the business was not a problem for extending the market aboard if the business had sufficiently intensive R&D to create innovative products or process to support the demand side. In this regard, Esteve-Perez and Rodriguez (2013) studied the correlations between SMEs and export activities in Spanish manufacturing SMEs from 1990 to 2006; the results indicated that R&D expenditure affected market expansion, particularly exports and broader technological opportunities. Furthermore, businesses that invested in R&D had a 22.5% greater probability of exporting in comparison to businesses that did not invest in R&D.

Thailand is an example of the establishment of SMEs and the application of R&D to rebuild the national economy. Thai SMEs[7] played a significant role in the recovery of the Thai economy after the Tom Yum Kung Crisis[8] in 1997 (Office of Small and Medium Enterprises Promotion, 1997). Since the official establishment of SMEs in Thailand in 2000, SMEs increased the national employment ratio by around 4.7% from the previous year, and accounted for 6.6 million in 2001 (Office of Small and Medium Enterprise Promotion, 2001). In 2017, Office of Small and Medium Enterprise Promotion (2017a) reported the number of Thai businesses per category as follows: 98.22 % of businesses in Thailand are registered as SMEs, 419,591 businesses are

[7] The classification of Thai SMEs is based on the total number of employees and asset value, which vary across sectors (Ministry of Industry, 2002). Small enterprises in the manufacturing and service sectors are those with fewer than 50 employees, or of which the asset value is less than 50 million Baht, while small businesses in the wholesale sector are defined as having fewer than 25 people and, in the retail sector, that have fewer than 15 people (Ministry of Industry, 2002).

[8] The Tom Yum Kung Crisis was an economic meltdown that occurred in 1997. The name of this crisis was derived from the name of popular dish in Thailand as a reminder of where the crisis originated. The Thai currency was attacked by hedge funds. The currency of the nation changed from the pegged exchange rate to the managed float. That was the reason that the Thai currency experienced a dramatic decrease in value from 25 Baht per one US dollar to 40-50 Baht per one US dollar. The debt of private companies almost doubled overnight and financial institutions, banks and private companies closed. This resulted in a large number of loans to the Thai economy to repay this debt to the International Monetary Fund (IMF) (Charoensuthipan, 2017; Iverson, 2017; Kitnaphathanapong, 2018)

small in size, 11,618 businesses are medium-sized, and the other 7,882 businesses are large sized.

In addition, Thailand is well known for its rich aquaculture-based resources and for its success in exploiting these resources through access to global markets. Approximately 70 % of the value of exported Thai products is seafood products, mainly the export of tuna and shrimp products (Department of Fisheries, 2017). In 2017, the total export value of processed and preserved food products was 5,786.4 million USD, or 20 % of the total value of food exports from Thailand (US Department of Agriculture: Foreign Agricultural Service, 2018). In 2017, the top importers were Japan (19.17 %), the USA (17.61 %), Australia (6.68 %), Canada (4.27 %) and China (3.28 %) (U.S. Department of Agriculture: Foreign Agricultural Service, 2018).

R&D has been applied to improve the quality of products in the Thai seafood industry since the early 1990s (Suwanrangsi, 1997a). The application of technology to increase the value of the products has been established in the businesses via joint ventures or in-house R&D. Furthermore, the scope of technological development focuses on the frozen, canned, retort pouch and comminuted products (Suwanrangsi, 1997a). In addition, the development of machines and tools has extended the shelf life and upgraded the quality of dried and fermented products (Suwanrangsi, 1997a).

In 2016, the R&D expenditure of Thailand was 3.8% of the total investment of the nation. Most of the R&D expenditure focused on training (55%) and only 1% was allocated to innovation activity (National Science Technology and Innovation Policy Office, 2017). R&D aimed at innovation is largely limited to the industrial and commercial sectors. Food and beverage have the highest R&D expenditure (12,063 million baht) compared to other sectors. R&D investment by LEs in the seafood industry is 77.68%, followed by medium enterprises (13.61%), and small enterprises (8.71%) (National Science Technology and Innovation Policy Office, 2016b).

Although the National Science Technology and Innovation Policy Office (2016a) reported that R&D expenditure in the Thai seafood industry had been increasing continuously, the R&D projects in these businesses are carried out by individuals and address specific problems based on customer requirements; thus, they cannot be

widely applicable to other sectors (Intarakumnerd *et al*., 2015). Most of the R&D in SMEs was conducted by in-house units in order to solve a specific problem or identify the necessary R&D.

As has been shown, Thailand is one of the biggest seafood exporters in the world; moreover, seafood products are the main export products of Thailand at present. However, the continuous growth of the Thai seafood sector has mainly involved LEs, while SMEs, which employs most of the population in the seafood sector, have received less mention in terms of their contribution to the national economy. However, although R&D is a crucial tool for driving economic growth in various sectors, little has been published about the contribution of R&D to Thai SMEs in the seafood sector.

Much of the demand for Thailand's seafood products comes from abroad, and these consumers require traceable information on the source, quality and safety of the products they chose to consume (Bhatt *et al*., 2017). Furthermore, partner countries utilise trade barriers and non-trade barriers to reduce the power of the seafood industry in Thailand (Kasikorn Research Centre, 2017). Therefore, continuous quality improvement efforts and efforts to adhere to the quality standards of partner countries are essential to facilitate the growth of the Thai seafood industry in international markets. Currently, Intarakumnerd *et al*. (2015) indicated that firms in the seafood industry apply knowledge and technology based on the research to improve their products across four domains (Table 2.5):

Table 2.5: The type of technology in the Thai seafood industry

Type of technologies	Details of technology
Production technology	To increase production efficiency and waste reduction, LEs in the seafood sector work to apply technologies from abroad. While local markets favour freshness, international markets require food products that are 'ready-to-eat' and long-lasting, which, in turn, requires advanced production and transportation technologies. Unfortunately, small and medium enterprises (SMEs) have limited resources and, therefore, cannot always adopt sufficient technology to meet these needs.
Quality technology	To maintain a leading position in global markets, the Thai seafood industry must adhere to rigorous quality standards. Technologies to increase quality pursue three aims: quality control, testing and certification, and traceability.
	Quality control: The FAO/WHO Codex Alimentarius Commission (Codex) has identified both Hazard Analysis and Critical Control Points (HACCP) and Good Manufacturing Practices (GMP) as universal systems of standards. Therefore, the Thai Ministry of Commerce's Department of International Trade Promotion announced that seafood products must fulfil both systems' standards before export. Because the main market of the Thai seafood sector is international, entrepreneurs in this sector must follow these quality control regulations.
	Traceability: Food safety is a significant factor in customers' decisions about what food to eat. However, Thailand has not enacted standards regulating traceability. Therefore, traceability technology remains optional for firms, and most of Thai firms, especially SMEs, do not have money to invest in this technology.
Packaging technology:	Although attractive, clean, functional and flexible packaging affects the price and profitability of a product, packaging technology has, thus far, garnered less interest from researchers. The limited research in this field, in turn, contributes to high prices for packaging material
Logistics technology:	The ability to reduce delivery times, maintain freshness and safety and keep prices low are key factors that affect firms' competitive efficiency. However, the Thai seafood industry—and SMEs, in particular—lack the management technology, storage technology and data record technology to support adequate logistics systems. Furthermore, most Thai seafood firms must use land transport, which is subject to fluctuating fuel prices. These weaknesses of logistics technology hinder the competitive advantage of the Thai seafood industry.

(Intarakumnerd *et al*., 2015)

R&D across these four domains is necessary to promote macroeconomic growth not only in developed countries but also in developing countries and emerging markets. While R&D is not scoped in the high-technology sector, it must be abundant in low-

technology sectors, such as the food and agricultural sector which is one of the most significant producers of exports in tropical countries like Thailand. Statistics show that in the previous year, Thailand was the world leader in the seafood industry, especially in tuna and shrimp exports. However, the dominance of Thai seafood products in global markets has slightly declined because of non-tariff barriers, such as the quality of products and packaging and tariff barriers from partner countries.

Accordingly, the seafood industry has turned to R&D interventions to meet the demands of global trade. Thus, some firms and parts of firms have been awarded and learnt to develop their products via R&D. However, these projects are led by individuals, and their objectives are often tailored to specific problems and customer requirements; therefore, their results are not widely applicable (Intarakumnerd, Chairatana, & Kamondetdacha, 2015). Meanwhile, R&D among other firms, especially SMEs in the seafood industry, is even more limited. These firms have limited access to R&D and, therefore, continue to operate via routine practices while driving business via capital and labour. Limited access to innovation funds and to supportive government policies and facilities further accelerates the demise of these firms, especially SMEs.

Thus, this study aims to demonstrate the impact of R&D interventions on SMEs' performance in the areas of production, marketing and organisational management. In doing so, it seeks to increase seafood SMEs' awareness of R&D interventions. Meanwhile, it will offer top-down policy recommendations to support R&D mechanisms in this sector.

2.6 The significant role of networking to support business development

Innovation facilitates the rise of the entrepreneurial sector. In particular, it enables SMEs to survive and their products and processes to fuel the nation's economic growth. Recently, collaboration between the Thai state, businesses and universities has been especially important in helping SMEs increase their efficiency. To this end, the national innovation system (NIS) has been established to enhance national

competitiveness, economic development and innovation capacity (Datta *et. al*., 2019). Leydesdorff and Etzkowitz (1996) created their triple helix model precisely to capitalise on the NIS structure by expanding collaboration for innovation across state organisations and Thai universities and reshaping the corporate system of universities, government and industry to develop the nation together (Etzkowitz and Leydesdorff, 2000). In other words, the triple helix model was created to bridge scientific knowledge, government support and technological outcomes and thereby contribute to national economic development (Kim *et al*., 2012). Recognising that innovation is a necessary tool for fiscal development in a knowledge-based society, the triple helix model highlights the university's crucial role in innovation (Etzkowitz & Leydesdorff, 2000), especially in supplying the qualitative labour that enables product or process improvements.

Hou and Mohnen (2013) demonstrated that, in China, cooperation between triple helix stakeholders increased not only R&D activities among businesses but also the number of product innovators per employee. In the United States, meanwhile, the successful implementation of the triple helix model has engendered rapid economic growth in the Silicon Valley and Boston Route 128 regions (Wonglimpiyarat, 2005). Such collaboration between partners enables technological transfer from academic institutions to firms (Wonglimpiyarat, 2005). Via the triple helix model, individual interactions between stakeholders have developed into active collaboration with sectoral and national impacts. Consequently, these collaborations within the triple helix model have garnered considerable attention.

In some sectors, however, firms remain uncertain about this linkage between universities and industry and the potential of such collaboration to improve their products via the NIS (Intarakumnerd and Sittivijan, 2005). In intensely competitive environments, in fact, hesitancy to engage in interactions between stakeholders, especially between firms (Wang & Wu, 2012), hinders the application of the triple helix strategy for SMEs' development in developing countries (Yuwawutto *et al.*, 2010). Some empirical studies identify recipient firms, university experts and intermediaries as crucial factors for the successful adoption of the triple helix model in developing countries, such as Thailand (Chunhavuthiyanon and Intarakumnerd,

2014). Indeed, almost all empirical studies identify these functional triple helix components while emphasising the role of intermediaries, but they do not examine internal differentiation between firms. Thus, the interaction between triple helix components could vary.

As developing countries learn and adapt the triple helix model from its application in developed countries, government policies have established the infrastructure and enabling factors, such as the NIS and tax incentives, to capitalize on potential collaborations and thereby improve their countries' economic efficiency. However, the main obstacles to these collaborations remain the different levels of technological development exhibited by firms in developing countries. Thus, the challenge developing countries face involves not only catching up with the R&D trend that affects the economic growth of the nation but also creating an optimal triple helix system as a bridge to transform R&D knowledge into financial profit. Nowhere is this challenge more apparent than among SMEs, which are the leading producers of the Thai market. Thus, additional research is needed to explore and enhance the impact of R&D on these primary sectors.

In the food industry, innovation entails not only the creation of machines and techniques but also the expansion of workers' knowledge and skill (Early, 1997). Employment in the food industry represents 20%, or 1.012 million baht, of total employment in Thai industries (National Food Institute, 2015). Employment in the food industry can be further divided by type of firm, with small businesses, medium businesses and large businesses accounting for 35%, 25% and 40% of employment, respectively (National Food Institute, 2015). Interestingly, science and technology personnel account for 3,373 employees per year in the food industry (National Science Technology and Innovation Policy Office, 2016a).

Still, triple helix collaborations between the food industry and academic institutions remain limited—perhaps because the traditional role of the university has involved conducting translational research, organising training programmes for entrepreneurs and engaging in community development (Dzikowski & Tomaszewski, 2014). Typically, collaboration among businesses, governments and academic institutions involves three main activities: internships, training programmes and testing services.

Furthermore, large and small enterprises are more inclined to cooperate with other partners than are medium businesses. In contrast to these traditional forms of collaboration, however, Kim, Kim and Yang (2012) report that 88%—or almost all—of the interactions among the three actors in the model involve consulting. More specifically, the major interactions between universities and industries focus on research grants and contracts (59%) or research training (38%; Kim, Kim, & Yang, 2012). Therefore, these scholars assert that the university plays the role of 'entrepreneurial mediator' in the triple helix model. To facilitate the economic growth of the nation, however, the government must function as an intermediary by making policies to reduce 'ivory tower' behaviour among academics and promote what has come to be known as the 'third mission' of university (Yuwawutto *et al*., 2010).

Although innovation plays a vital role in firms' growth, the limited resources of SMEs impede their efforts to engage in R&D activities, training programmes, technology transfer arrangements and market promotion. Thus, the government must assume an additional role in redressing these disadvantages via public policies (Villasana, 2011). One such policy provision focuses on the development of a triple helix network. A growing body of knowledge underscores the significance of R&D in enhancing SMEs' innovation and competitiveness and increasing their market shares locally and internationally (Nieto and Santamaría, 2010). Indeed, SMEs are not only knowledge exploiters but also 'bridges of innovation' that circulate knowledge across the entire innovation system (Sedej & Justinek, 2012). It is through this innovation system—i.e. the triple helix model—that SMEs access knowledge and funding support and thus mitigate the factors that constrain their competitive growth. However, their success in these endeavours depends on their responsiveness to the incentives that are made available to them via the triple helix system.

Cooperation between universities and industry within the triple helix framework is essential for SMEs to improve their market and technological awareness (Brimble & Doner, 2007; Intarakumnerd & Sittivijan, 2005). Some successful cases of university-industry linkages can be found in the Thai hard-disk drive industry and in agro-industry development activities in the biotechnology sector. However, such cases are, to date, few and far between in Thailand (Brimble & Doner, 2007). Although the

seafood industry is categorised as a labour-intensive sector, it is, as an active major export sector, also expected to improve the price and quality competitiveness of its products and increase its market share through involvement in triple helix-based R&D activities. In this respect, a major research interest in the context of SME development in Thailand involves investigating to what extent the production and export performance of the seafood industry, in general, and the tuna and shrimp sub-sector, in particular, have benefited from triple helix-driven R&D activities. This paper provides the background and context for precisely such a study.

2.7 Conclusion

R&D is recognised as an important factor in improved business performance, as both improved productivity and profit have been observed in developed countries (Schiller and Diez, 2007). Much research has shown that technologies and innovations create disruptive growth, particularly in the high-end market (Agarwal *et al.*, 2007; Caballero, 2008).

Thus, R&D will be the common factor in macro-economic growth, not only in developed countries but also in some developing countries and emerging markets. In addition, R&D is not absent from the high-technology sector, but needs to be applied extensively in low-technology sectors such as food and agriculture, which are the sources of the major export products of tropical countries such as Thailand.

Thailand is well known as a world leader in seafood exports, particularly tuna and shrimp products (National Food Institute, 2015). The structural analysis of seafood indicated that the sector is dominated by SMEs; by contrast, the main income in the industry is derived from LEs (Office of Small and Medium Enterprise Promotion, 2001). The specific characteristics of SMEs, such as limited labour or capital, might be the reason for them being less productive. Conversely, the specific structure of SMEs enables them to be more flexible in response to changing production and marketing circumstances. Moreover, their high degree of resilience is a seedbed for innovative growth and can lead to the industrialisation or rapid development of SMEs.

Even though the cumulative increase in R&D expenditure by Thai businesses during 2013-2017 signals a positive outcome for the Thai economy, particularly in the food and beverage sector, many studies have shown that technology and innovation are essential for the development of the seafood industry (Fujii *et al*., 2018; Bergesen and Tveteras, 2019; Chang and Lee, 2019). However, the effect of R&D on SMEs' efficiency has not been studied previously. Therefore, R&D has been categorised as one of the risk input factors in SMEs, and the outcomes of R&D cannot be predicted.

A difficult obstacle to overcome in order to increase R&D investment in the seafood sector is that R&D is a risk input factor that does not provide a blueprint for success. Therefore, the crucial question in this research is the role of R&D in the performance of the Thai seafood industry, particularly for SMEs. This research will point out the existence of R&D in the seafood industry, show how SMEs engage in R&D, and discuss the economic contribution of R&D. Finally, this research will make suggestions for policy recommendations for Thai SMEs in the seafood industry.

Chapter 3

Research Design and Methodology

This chapter discusses the research design of this thesis, including the methods of data collection and analysis. The data for this research were drawn from primary and secondary sources. The primary data were obtained via questionnaires that were distributed to a sample of firms in the seafood sector and from interviews with people involved in the industry, relevant government agencies, and universities and research centres. The secondary data were obtained from reports and documents archived by industries, government agencies, and universities and research centres. The data collected via the interviews were used to enrich the case study narrative, which aimed to shed light on the results of an analysis of the data derived from the administration of questionnaires to firms in the seafood industry in the sample survey.

This chapter is divided into five sections—the conceptual framework is explained in Section 3.1. The research methodology and data collection methods are presented in Sections 3.2 and 3.3, respectively. Section 3.4 explains the data management processes. Then, the analytical data method is showed in Section 3.5. Lastly, the conclusion is presented in Section 3.6.

3.1 Conceptual Framework

Traditionally, business outcomes have been considered to be affected directly by production costs, such as the current stock and labour (Schumpeter, 2012; Aghion and Akcigit, 2015). However, these input factors do not always increase, particularly in SMEs, while the output of the business continues to grow. This implies that businesses have additional input factors that allow the business to maintain continuous growth

while basic input factors, such as the capital fund and the total number of workers, remain the same.

In this regard, the continuous growth of the total GDP in some developed countries such as the USA, Germany and so on are linked to the investment in R&D by those countries in the early nineteenth century (Economicsconcepts.com, 2015). Furthermore, R&D's contribution to the economy has been proven in South Korea, where R&D played a crucial role in transforming the South Korean economy, which had been based on agriculture, into that of a Newly Industrialised Country (NIC) over 40 years (1960-2000) (World Bank, 2017a). Therefore, it could be concluded that R&D has a direct effect on the economic contribution of businesses.

It has recently been predicted that, under the new theoretical model of economic growth, R&D expenditure will become an advanced input factor in encouraging novelty in businesses and in extending their markets both locally and internationally (Nieto and Santamaria, 2010; Ghazalian, 2012; Schumpeter, 2012). Nonetheless, the innovative models that originated from R&D activities in businesses vary across countries, as well as according to the type of manufacture and the business' size.

Empirical studies have revealed a positive relationship between R&D investment and the competitiveness of a business (Early, 1997; Ghazalian, 2012; Sedej and Justinek, 2012; Carboni and Medda, 2018). The R&D outputs of businesses have been evaluated based on various factors. The Organisation for Economic Cooperation and Development (OECD; 1999) and Saigosoom (2012) indicated that R&D, or innovation, resulted in changes to four structural aspects of businesses, namely product development, process development, market development and organisational management performance.

Empirical studies have also indicated that R&D could create a novel product or process in a business (Early, 1997). Furthermore, innovation has been linked to less time being needed to improve a novel product or process (Schiller and Diez, 2007). Thus, sales, new products and new technology have been used as significant factors to study the R&D outcomes of a business (Chang *et al*., 2015).

Sales, which are the initial output of the finished goods, are frequently used to measure R&D development in a business (Hall *et al*., 2009; Chang *et al*., 2015). Furthermore, the enhanced efficiency of businesses due to R&D activities leads to wider economic growth and maintains the competitiveness in local and international markets (Ghazalian, 2012; Sedej and Justinek, 2012). Thus, export revenue has been used to measure the effect of R&D expenditure on the expansion of markets. Carboni and Medda (2018) reported positive correlations between R&D investment and international markets.

R&D activities vary depending on the age of the business, the size of the business, the sector, and the country. R&D in the Thai seafood industry, in which Thailand is one of the world-leading producers, has made significant progress in the last five years (2013-2017). However, R&D expenditure in the Thai seafood and fishery sectors has mainly come from LEs, while SMEs, which are the major population in the sectors, account for only a small part of the total amount of R&D expenditure (National Science Technology and Innovation Policy Office, 2019).

In addition, R&D activities or models have specific characteristics in the sector. R&D projects or activities in the seafood and fishery industries must be driven by market pressure or customers' requirements (Saigosoom, 2012; Bhatt *et al*., 2017). Moreover, R&D in Thai SMEs consists mainly of informal activities, and is always conducted in-house; this is particularly true for process and product development (Saigosoom, 2012; Intarakumnerd, 2017). Figure 3.1 shows the conceptual framework for this research. The three input factors in this research were capital funds, employees and R&D.

Quite often, the final outcome of the business is based on many input factors, which makes it impossible to identify the impact on success for each input factor. Thus, the input factors in this research consisted of capital funds and employees, which are necessary input factors that drive the business routine, while R&D was an optional input factor. The additional input factor, which was R&D in this case, will disrupt the regular organisational management and make it more innovative.

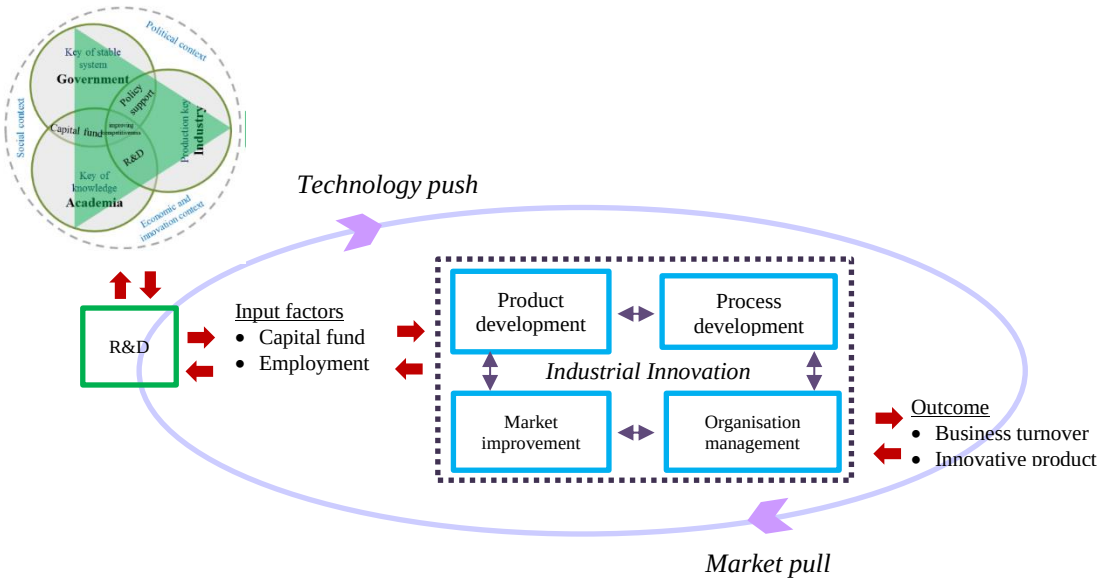


Figure 3.1: The conceptual framework for developing the thesis structure (Adapted from Rothwell, 1992; Trott, 2005; Saigosoom, 2012)

The input factors have been managed, and resulted in a change of process and product development that leads to market development. A significant outcome that could reflect the effect of these inputs on business development is the total amount of business outcome, such as total sales, export revenue and the number of products, including new products, and the total number of products that can be produced in each cycle.

Producing advanced innovative products or processes that do not meet the market's requirements cannot lead to sales or other benefits. Thus, the R&D trend in a business depends on two main factors, namely the technological push and the market's pull power. Increases in the trend towards the use of technology might be because researchers can develop the existing technology to extend to new products and processes depending on the purpose of the research. Updated technology or innovation might support the mechanism of the existing technology and make it more efficient, or it might replace the existing technology. Therefore, the mechanism of product and process development may need to be processed according to the conditions of the firm's available technology.

In addition, the final product produced via innovative technology or innovations might result in a change in products, leading to market accessibility that might extend or change the target group. On the other hand, each business can set its goal to make as much profit as it can. Thus, knowledge of the customers' requirements is crucial for all businesses in order to develop their products in response to consumer requirements. Therefore, the trends in R&D or the form of R&D applied in the business related to the manufacturer's technologies should match the customers' requirements.

However, the specific characteristics of SMEs, which are limited funds and the number of workers, mean that SMEs cannot provide all the business functions themselves. Creating links with external organisations, such as government organisations, universities and the other private companies might support the flow of R&D mechanisms and make businesses more efficient.

This thesis aims to explore the effect of R&D on the Thai SMEs in the seafood industry development; also, this research aims to explore the role of networking to support the R&D activities in this group. The three main input factors in business processes, namely capital funds, labour and R&D investment, are considered in the analysis because these input factors are crucial for business growth in terms of product development, process development, market development and organisational management. The result of the input factors is then analysed based on the two main outcomes of market growth, namely total sales and export revenue, and innovative products, such as new products on the market/year, the total yield per crop and so forth.

However, investment in R&D is not common in the Thai seafood industry, particularly for SMEs. In developing countries, almost 70 per cent of R&D investment comes from government organisations or academic institutions (Meerod *et al.*, 2011); thus, insufficient support by the government in the form of incentives and laws is an additional factor in the systematic failure of innovation (Chunhavuthiyanon and Intarakumnerd, 2014). Furthermore, universities have a new role to play as leaders of a knowledge network (Etzkowitz and Leydesdorff, 2000). Universities could share their R&D for commercial purposes, thereby finding new ideas for developing their projects while providing the industry with new knowledge, technologies or other resources that are required. Thus, networking might be an essential factor in enabling

ill-equipped businesses to add essential or advanced R&D factors. Therefore, it is necessary to study the role of networking in supporting business mechanisms in the Thai seafood industry.

3.2 Research Methodology

Both qualitative and quantitative methods were used in this research. The quantitative analysis of the data aims to generate results from which generalisations about the production and innovative capabilities of firms in the sector could be made, as well as to provide the empirical basis for predicting R&D and innovation trends in the sector, and to identify the factors affecting SMEs' engagement in R&D activities. The qualitative data obtained from the survey were used to shed light on aspects that could not be considered using quantitative data (Creswell and Clark, 2007).

To explore the role of R&D in the market performance of Thai SMEs in the seafood industry, the participants were divided into two groups, one 'without R&D' and one 'with R&D'.

The 'without R&D' group consisted of SMEs that answered, in the questionnaire, that they did not engage in R&D expenditure and did not show R&D expenditure in their annual reports. The two inputs in the 'without R&D' group were capital funds and labour.

The 'with R&D' group consisted of SMEs that answered, in the questionnaire, that they engaged in R&D expenditure or showed R&D expenditure in their annual reports. There were three inputs in the 'without R&D' group, namely capital funds, labour and R&D expenditure.

The data were analysed in four stages. The factors, the details of the analysis, and the sample per stage are presented in Table 3.1

Table 3.1: The stages of the data analysis

Stage	Factor	Detail of the analysis	Sample
Stage 1: Business profile	1.1 Age 1.2 Capital fund 1.3 Employees	- An analysis of the profiles of the businesses in terms of age, capital funds, and the total number of employees in 2017 - A comparison of the business profiles of the two groups	Both the 'without R&D' group and the 'with R&D' group
Stage 2: R&D expenditure profile	2.1 Total R&D expenditure 2.2 Types of R&D activities 2.3 The goal of R&D investment	- A study of the total R&D expenditure of SMEs in the seafood industry during 2013-2017 - An analysis of the main R&D activities in SMEs during 2013-2017 - A consideration of the purpose of the R&D activities of the sample	'with R&D' group only
Stage 3: R&D networking	3.1 Type of organisational network 3.2 The reason for creating an R&D network with an external organisation 3.3 Why SMEs in the seafood industry did not create R&D networks	- A consideration of the external R&D networks of SMEs in the seafood industry in 2017 - An analysis of the purpose of R&D collaboration with external units - A study of the reasons for not engaging in external R&D networks	'with R&D' group only
Stage 4: The outcome of the business	4.1 Market performance 4.1.1 Total sales 4.1.2 Export revenue 4.2 Product performance	- An analysis of the outcomes of the businesses in terms of total sales and export revenue during 2013-2017 - A comparison of the business outcomes of the Without R&D group and the With R&D group during 2013-2017	Both the 'without R&D' group and the 'with R&D' group

The research (see Table 3.1) was then divided into four stages, as explained in detail below:

Stage 1 Business profile: The business profiles of the businesses in both groups were analysed based on three main factors, namely the age of the business, capital funds and the total number of employees during 2013-2017. A comparison of the business profiles of the two groups was then conducted to determine whether the characteristics of the businesses were related to the decision to include R&D in the business.

Stage 2 R&D expenditure profile: The sample in this stage consisted only of the 'with R&D' group. Firstly, the total R&D expenditure of this group over five years (2013-2017) was examined. The R&D activities were then analysed in depth. Lastly, this stage examined the reasons for R&D investment in the businesses to determine whether these might be linked to the network creation in Stage 3.

Stage 3 R&D networking: The first step in this stage was the examination of the types of external organisations. The reasons for engaging in R&D collaboration with the external organisations were examined in the second step. Furthermore, the reasons for not engaging in R&D collaboration with external agencies were analysed in the final step in this stage.

Stage 4 The outcome of the business: The development of the businesses in the two groups when receiving different input factors was analysed in this stage. The outcomes of the businesses were divided into two factors, which were total sales and export revenue. The comparison of the 'without R&D' and the 'with R&D' groups could explain the effect of R&D on business performance.

3.3 Data collection methods

As mentioned before, both qualitative and quantitative methods have been applied in this thesis. The research design increases strengths and reduces weaknesses by complementing the quantitative methods—a large amount of sample, generalisation, and trends—with qualitative methods on a small target population for in-depth detail (Creswell and Clark, 2007).

Figure 3.2 shows a schematic outline of the data collection process. Primary data were obtained via the questionnaires, interviews and a case study. The surveys were implemented online using Qualtrics survey software and an e-mail survey, and in-person through a door-to-door survey.

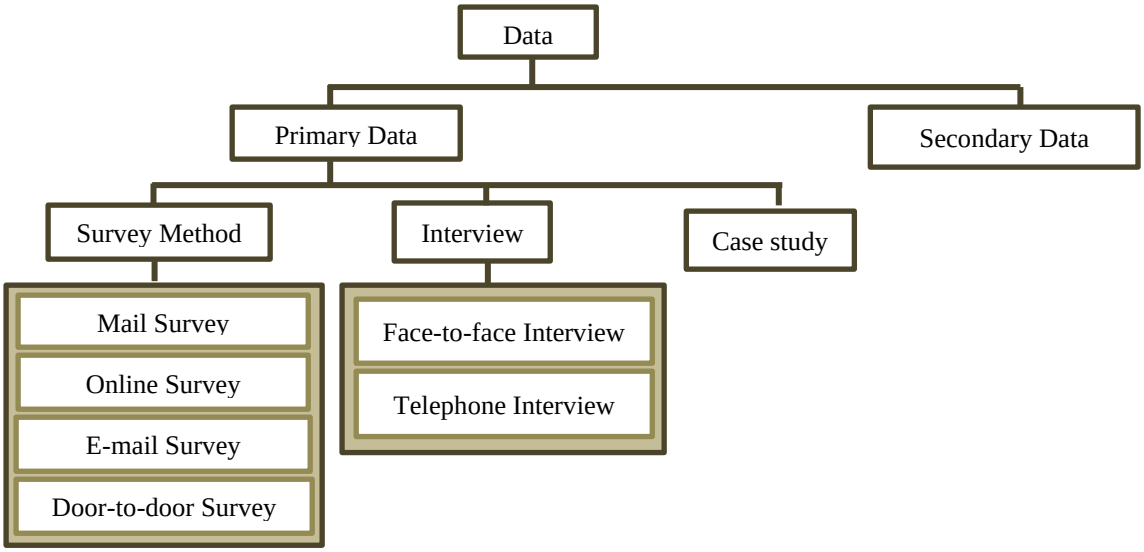


Figure 3.2: The method of data collection and sources of the data

Moreover, face-to-face and telephone interviews were conducted to obtain in-depth information for the case study. In addition, both published and unpublished secondary data, such as annual company reports, including financial statements and product innovation, were obtained to complement the survey. Collecting and cleaning the secondary data took 12 months. Primary data collection took place in the first to fifth months. Then, complete survey data and clean the data with secondary data, e.g. the company's annual report, the business's financial report, from the fifth month to twelfth month that showed the details of activities on Table 3.2.

The processes for the quantitative and qualitative analyses included identifying the target population, a determination of the sample size, the selection of the research instrument, and the statistical method to be used to clarify the results of the questionnaire data, as explained in detail below.

Table 3.2: The list of activities and period for data collection

Source of data	Activities	Month					
		1	2	3	4	5	6-12
1) Primary data	1.1) Survey data collection						
	- Mail survey	→	→	→	→	→	
	- Online survey	→	→	→	→	→	
	- E-mail survey	→	→	→	→	→	
	- Door-to-door survey	→	→	→	→		
	1.2) Interview process	→	→	→	→		
	1.3) Case study interview	→	→	→	→		
2) Secondary data	2.1) Filling the gap of incomplete data by the published documents from the companies					x	x
	2.2) Cleaning the data with the RDI survey for 2013-2017						x

Note:
x/ ⟶: the period of activities
Month 1: 19th September – 18th October 2018
Month 2: 19th October – 18th November 2018
Month 3: 19th November – 18th December 2018
Month 4: 19th December 2018 – 18th January 2019
Month 5: 19th January – 4th February 2019
Months 6–12: 2019 – July 2019
RDI survey is the data that came from the survey data provided by the STI Office

The tools applied for collecting the data in this research consisted of three methods, namely the questionnaire survey method, the in-depth interview method, and a case study. The questionnaire survey method is discussed in Section 3.3.1, including details about improving the questionnaire, the method used to determine the reliability, validity and internal consistency of the questionnaire, and the ethical approval process. The target population, the methods used to develop the interview format and the method of collecting the interview data are presented in Section 3.3.2. Lastly, the method used to explore the case study and the method of approaching the case study are explained in Section 3.3.3.

3.3.1 The questionnaire data collection method

This section describes the method used to collect the quantitative data via the questionnaire survey, as well as the scope of the sample, the size of the sample in this research, and the tool used to collect the quantitative data. Section 3.3.1.1 provides details about the target population, which was drawn from a list of members of the five

main associations related to the seafood and fishery industry. The tool used the quantitative data collection is presented in Section 3.3.1.2.

3.3.1.1 The target population and determining the sample size for the questionnaire data collection method

In 2017, the Office of Small and Medium Enterprise Promotion (2017a) reported that the total number of SMEs in the Thai agricultural, forest, and fishery sector consists of 42,266 companies from 3,004,679 firms in total, and that those businesses provided 69,753 jobs in the market out of 11,747,093 jobs in total. The total number of Thai SMEs in the seafood and agricultural sector appears to be unavailable, but this thesis focuses on seafood sector's downstream value chain, shown in Figure 1.1. Therefore, the target population for the questionnaire was sourced from both the upstream and downstream ends of R&D activities in the export-oriented seafood sector

The target population was drawn from the following five groups (with number of respondents in each case in brackets):

1) Members of the Thai Frozen Association (135 companies);
2) members of the Thai Shrimp Association (11 companies);
3) members of the Thai Tuna Association (37 companies);
4) members of the Thai Food Processor Association (13 companies); and
5) the Research and Development Indicator database for 2013-2017 (41 companies).

The target population in these categories was 237 firms in total. However, it was not possible to access the entire target population due to the limited time and budget allocated for the study. Therefore, this thesis selected a sample of firms using Taro Yamane's (1973) method at a 95 per cent confidence level based on the formula below:

$$n = \frac{N}{1+Ne^2}$$

Formula 3.1: The formula for calculating sample size

Where n = Sample population
N = Target population
e = Proper error

This equates to:

$$n = \frac{237}{1 + 237 * (0.05)^2}$$

$$n = 148.82$$

Accordingly, the sample population was drawn from 149 firms. The number of respondents per target population group will present in chapter 4.

3.3.1.2 The tool for the questionnaire data collection method

The design, development and implementation of the questionnaire considered the following points suggested by Radhakrishna (2007) and Sinjaru (2017):

1) Alignment with the research context, and the underlying concepts and principles;
2) the research aim and objectives;
3) specification of the data for quantitative and qualitative analyses;
4) pre-testing of the questionnaire to establish the reliability, validity and internal consistency of the questions asked; and
5) the questionnaire must be aligned with the research ethics, which means that ethical clearance must be obtained before the questionnaire is administered to the target population.

The draft of the questionnaire was approved for style and content by the research supervisor. The views and advice of five experts working in the seafood industry or related sectors were then solicited with the aim of improving the quality of the questionnaire in terms of content and the clarity of expression of the questions after translation into the Thai language.

Participants in the interview process consists of three groups: the businesses (both SMEs and LEs), government organisations, and universities. Among the businesses, SMEs who participated in the questionnaire were invited to interview and given more details about their answers in the questionnaires.

The interviewees from businesses are denoted by the code ‘B’. Interviewees were invited from both LEs and SMEs in the seafood industry. LEs dominate the total income of businesses in the seafood sector (see Table 3.3). The systematic management of LEs could drive their success in terms of income, as well as harnessing R&D to improve their performance. The interview findings could help to identify the gap between LEs and SMEs that, if closed, could improve SMEs’ performance.

Meanwhile, government organisations and members of the academia are key players in supporting the seafood industry’s development in terms of regulation, knowledge contribution (see Table 3.3). Hence, why this thesis explores the roles of both in supporting seafood companies, particularly Thai SMEs. Interviewees from government organisations and academia are denoted by the codes ‘G’ and ‘U’, respectively.

Table 3.3: Participants' management in the interview process

Type of participant	Code of interviewees	Description of the interviewees	Reason for invitation
1) Private sector	‘B’	Participants from large and small-to-medium-sized enterprises in the seafood industry, particularly in the processed products business.	Studying the management and strategies used to run their businesses, comparing LEs with SMEs
2) Government organisation	‘G’	Participants from granting agencies, regulation units.	Exploring the role of government organisations in supporting seafood companies in Thailand
3) Academia	‘U’	Participants from universities, training agencies.	Determining the role of academia in driving the seafood sector and the ways of work for Thai seafood businesses

The details of the target population for interviewing will be explained in Section 3.3.2.1. The experts consulted were two science policy experts, two business owners, and one university in the field of food science. The qualitative testing of the

questionnaire as a research tool was conducted using the optimal content and the literacy style, as well as Item-Objective Congruence (IOC) (Formula 3.2).

$$IOC = \frac{\Sigma R}{N}$$

Formula 3.2: The formula for calculating the IOC

Where ΣR = the total score per question allocated by the experts
N = the number of experts

Note:

IOC > 0.05 means the question was in accordance with the objectives of the study
IOC ≤ 0.05 means the question was not in accordance with the objectives of the study

The IOC scores based on feedback from the experts are presented in detail in Appendix VI

Although all of the questions aimed to be in accordance with the objectives of the study, the experts suggested that the questionnaire contained more questions than necessary, which might create 'questionnaire fatigue' amongst the respondents. In addition, half of the questions requiring numerical answers were found to be difficult to answer in a short period and might need to be posed to different units in the business, such as the human resource unit, the R&D unit, the planning and policy unit and so on. In the circumstances, the researcher needed to obtain secondary data to complete the form and to confirm the values provided by the businesses. This had the effect of prolonging the survey period. Furthermore, the use of the English language would prevent potential respondents who did not understand the language from participating in the survey. Therefore, the experts recommended that the questionnaire be translated into Thai before being distributed to the survey participants. Accordingly, the researcher translated the questionnaire from English into Thai (see Appendix III), and addressed it to the respondents with a covering letter, which was also written in Thai (see Appendix IV), explaining the aim, objectives and scope of the research and of the survey. Furthermore, secondary data were extracted from the annual reports of businesses and from the archives of The National Science Technology and Innovation Policy Office to supplement, corroborate and countercheck the survey data.

The questionnaire was pre-tested in 30 seafood businesses that were selected randomly from the total target population. Reliability, validity and internal consistency tests were then applied (Figure 3.3).

Cronbach's alpha was used to test the reliability and internal consistency of the responses to the questions (Formula 3.3) (Vaske *et al*., 2017). In other words, α estimates the proportion of variance that was systematic or consistent in a set of survey responses. In this research, the alpha value used to test the reliability of the questionnaire was determined as follows:

$$\alpha = \frac{N}{N-1}\left(\frac{\sigma_X^2 - \sum_{i=1}^{N}\sigma_{Y_i}^2}{\sigma_X^2}\right)$$

Formula 3.3: The formula for calculating the Cronbach's alpha

Where N = the number of survey items on the scale
σ_X^2 = the variance in the observed total scores
$\sigma_{Y_i}^2$ = the variance in item i for person y

Alpha values between 0.65 – 0.80 are suitable for the scale of social science research (Vaske *et al*., 2017). An alpha (α) value of 0.666 means the reliability of the questionnaire is acceptable (see Appendix VII).

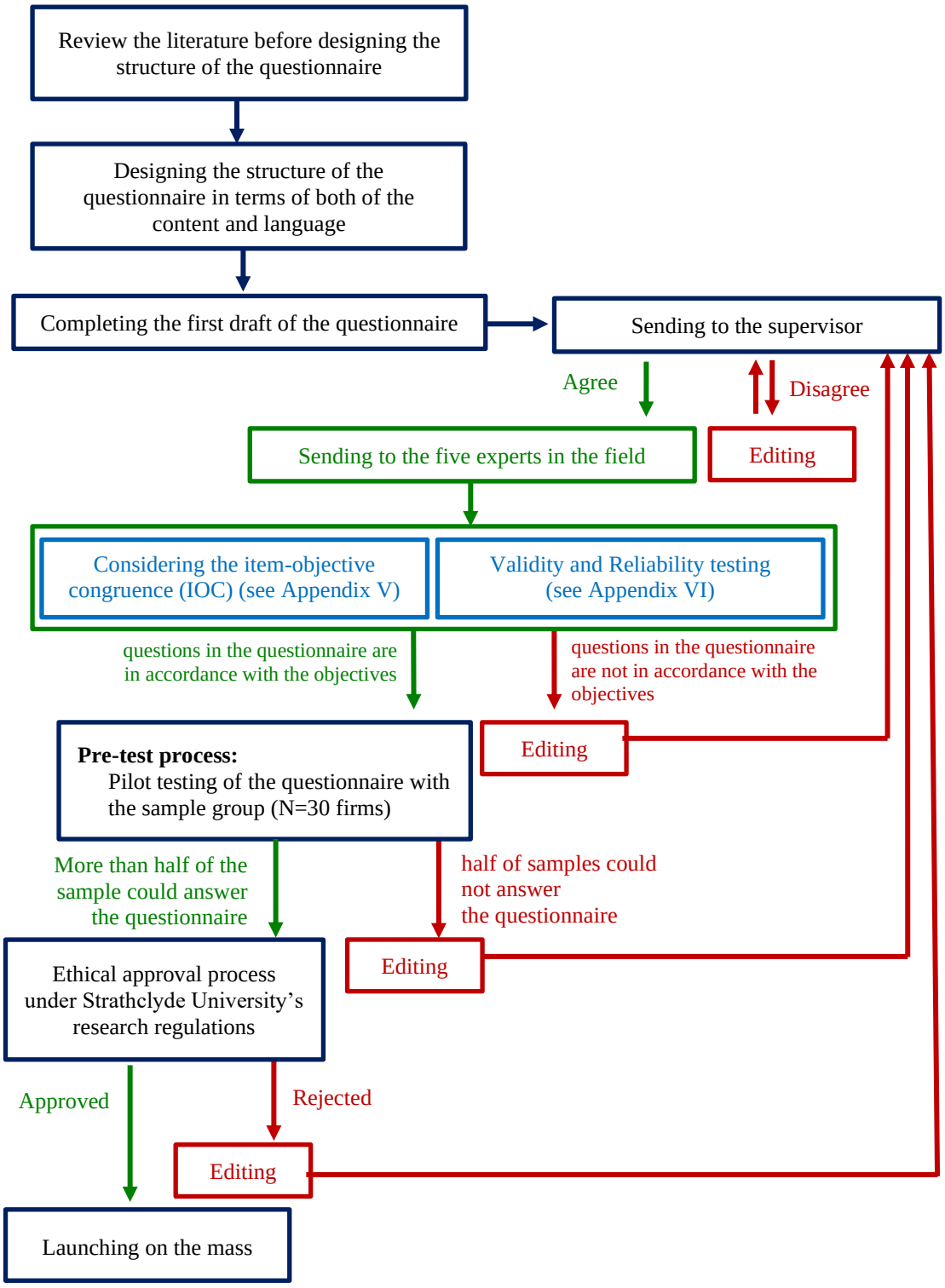


Figure 3.3: The process of creating the questionnaire

Lastly, the application for ethical clearance was prepared with the aim of protecting the rights, dignity, safety and well-being of all actual and potential participants through the management of a data security system that guaranteed the anonymity and security of the participants' data. The Participant Information Sheet, the questionnaire, and the open-ended interview questions were ethically approved according to the University of Strathclyde's research regulations, as shown in Appendices I and III, respectively.

The final version of the questionnaire consisted of six parts:

1) General information about the firm;
2) information about its R&D activities;
3) the process of production;
4) marketing;
5) engagement in cooperative activities; and
6) follow-up interviews with the respondents to the questionnaire who had agreed to be contacted later to provide more information about their respective companies and to offer suggestions if required to do so.

3.3.2 The interview method

Interviews are a qualitative research technique that entails intensive individual participation and understanding the story behind a participant's experiences. Furthermore, this technique does not require a large target population, as the aim of this method is to determine specific evidence (Dudovskiy, 2018). This research used semi-structured interviews by creating the main structure of the interview format and asking additional questions during the interview to clarify the answers and expand on them (Dudovskiy, 2018).

This section shows the process of data collection via the interview method. The target population of the interview method is presented in Section 3.3.2.1, and the tool used in the interview method is explained in Section 3.3.2.2.

3.3.2.1 The target population for the interviews

This research aimed to explore how R&D impacts development in SMEs in the Thai seafood industry, as well as to examine the role of networking with government, academic institutions and other businesses to support R&D engagement.

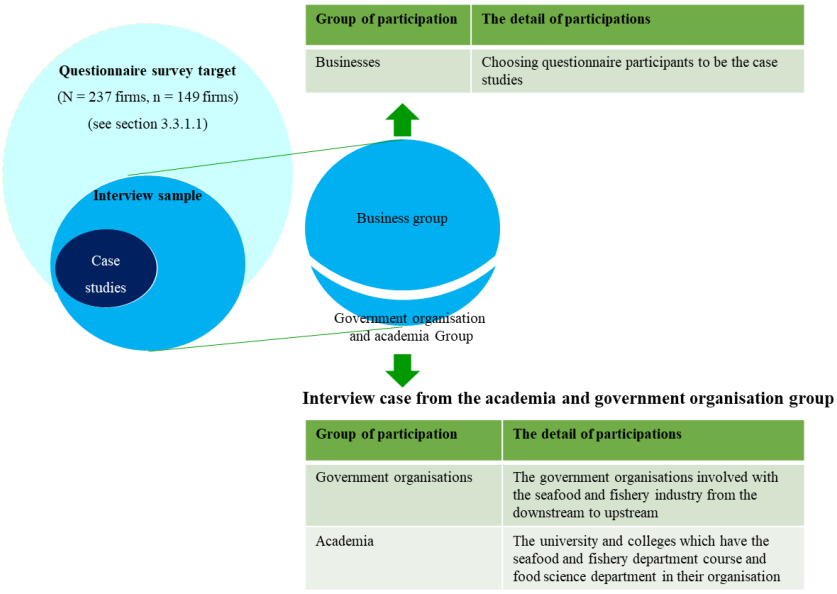
The business groups consisted of some businesses that participated in the questionnaire and indicated that they were available for follow-up interviews. Furthermore, some representatives of the LEs and other associations were asked for permission to be interviewed.

Academia groups that had fishery-related classes or courses and food science departments or related classes were invited to be interviewed in this thesis.

Government organisations whose work was related to the seafood industry, the agencies encouraging exports, the financial support agencies, SME support agencies, food industry support organisations, and the R&D agencies or related organisations were invited to be interviewed.

Some of the target population from the business sector may have been the same participants who answered the questionnaire. However, the target populations from academic and government organisations were included in the list of interview participants in the research by Intarakumnerd *et al.* (2011); thus they were considered to be the main structure and were added to other organisations, such as the SMEs support agencies and R&D support organisations to achieve the research aim.

The number of interviews per group is unlimited, as the amount depended on the willingness of the interview participants during the period of data collection from the 19th September 2018 to the 4th February 2019.



Group of participation	The detail of participations
Businesses	Choosing questionnaire participants to be the case studies

Group of participation	The detail of participations
Government organisations	The government organisations involved with the seafood and fishery industry from the downstream to upstream
Academia	The university and colleges which have the seafood and fishery department course and food science department in their organisation

Figure 3.4: The structure of the target population for the interviews

3.3.2.2 The interview method and the interview process

The interview method was used to obtain qualitative data that could not be obtained via the questionnaires, although the former were mainly conducted based on the result of the latter. This research applied the standardised, semi-structured interview method. Semi-structured interviews allow for responses to be compared and decrease potential biases when analysing the answers of several interviewees (Box 3.1). The task of the interviewer in this case is to request more details to flesh out the respondents' previous answers to the questionnaire.

Specifically, the interviews were intended to explore the role of the triple helix network consisting of actors from the government, academia and the industry in promoting the innovativeness and competitiveness of firms (Etzkowitz and Leydesdorff, 2000), particularly of SMEs, in the seafood sector. Thus, the interview formats were designed as three versions of the primary form in order to align with the duties of the informants from the government units, the academic institutions and the industrial sector.

The interviews were structured based on a tree diagram[9], which allows for the addition of minor questions to the main construction.

Box 3.1: Semi-structured interview question

Seafood business:

1) What was your business development from 2013 – 2017?
2) What were the important factors/players in developing your business?
3) Has your company implemented R&D and IT strategies/policies/units?
4) What is the benefit of R&D activities in your business regarding product and marketing performance?
5) What is the benefit of IT activities in your business regarding product and marketing performance?
6) Did your organisation have policies/ strategies to develop internal resources such as labour, machinery and tools to improve business growth? If so, how?
7) Does engagement in cooperative and collaborative activities help to increase business efficiency? If so, how?

Academic institution:

1) What is the role of an academic institution in increasing business efficiency?
2) Has your department been involved in business development? How?
3) Have your activities strengthened product performance, marketing performance, or organisational management performance in the seafood business? Please give examples.
4) What is the benefit of create cooperative and collaborative activities between business and universities?
5) What are the key obstacles to firm-university linkages?

Government Units / Research Institutions:

1) What is the role of your organisation in the seafood business?
2) What kind of activity is your organisation engaged?
3) Does your organisation have a strategy or policy for increasing R&D activity or IT use in the business?
4) What are the difficult reasons/factors entailed in increasing SMEs' efficiency via R&D and IT?
5) Does your organisation have a policy/ strategy/ activity/ project to support SMEs' development via the use of R&D or IT?
6) What are the additional supportive factors/players for developing SMEs in the seafood industry via the use of R&D or IT?

[9] A tree diagram is a simple tool that is also known as a systematic diagram, or an analytical tree. This tool is used to determine the root cause by dividing the key factors into separate lists, then breaking down the reasons for these lists into increasingly smaller units. Due to the analytical process entailed in this tool, the diagram resembles the roots of a tree; therefore, it is called a tree diagram (Dinulescu, 2016).

The interviews were audio-recorded with the permission of the interviewees. Furthermore, as the respondents' answers were provided within a limited time, published and unpublished documents concerning the companies surveyed, including annual reports, were sought and obtained to supplement the participants' responses.

3.3.3 The case study method

The case study method is widely used in social and life-science research (Heale and Twycross, 2018). This method was developed to decrease the risks arising from the limitations of the quantitative method by sourcing in-depth information that would help the researcher to obtain a better understanding of specific contexts (Zainal, 2007). Furthermore, the case study method helps researchers to understand the respondents' behaviour (Zainal, 2007). This section explains the case study method used to collect the data in this research. This section is divided into two parts describing the target population and the tools used to collect the data via this method. Section 3.3.3.1 presents the target population for the case study method, while the tool for collecting the data is explained in Section 3.3.3.2.

3.3.3.1 The target population for the case study method

The case study method uses single or multiple cases that are able to produce generalisable results with regard to the subjects being studied. Dyer and Wilkins (1991) suggested that the number of cases identified was less important than was the ability of the method to describe the context of the case. However, Gustafsson (2017) argued that results derived from multiple case studies were more robust and reliable than were those obtained from a single case study because multiple cases enable the comparison of diverse cases and can thus produce more realistic reflections of the wider contexts from which the cases are extracted. Thus, Gustafsson (2017) advocated the adoption of multiple case studies to ensure the generalisability of case study-based research and to give it strong empirical appeal.

Therefore, in order to understand the development of the seafood business in more depth, the researchers divided the sample into three groups – one for each type of product. The products were categorised by the level of technology required to produce the product and the characteristics of the final product. This latter criterion stems from the interview with the Vice President for Academic Affairs.

1) Traditional products: This type of product uses simple technologies, such as drying technology or pickling technology, in the production process. The final product remains the same physically as the original material or has changed only slightly.

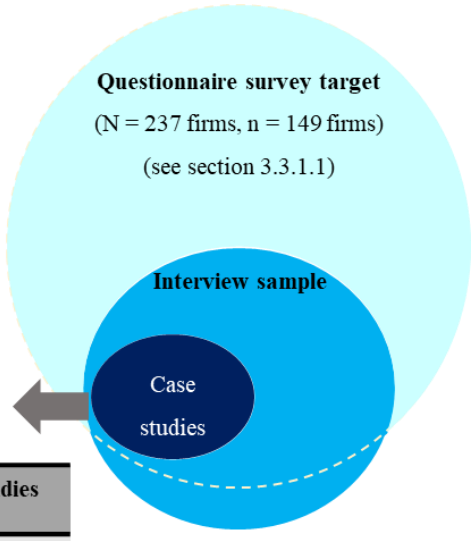
2) Value-added products: This type of product is created using middle to high technology or added the value of waste to be the new line of product. The final product has some parts of the original product, and the customer could identify the original material from the final product.

3) Innovative products: This type of product is produced using advanced technology or high technology, such as oil refining or vitamin extraction. The final product has been transformed into a new form, such as capsules or oil, so that customers cannot identify the original material.

The target population for the case study method included six cases from the main group that participated in the questionnaire and agreed to be interviewed. Two cases were selected randomly from each group. The selected cases were the following:

1) a dehydrated shrimp company
2) a processed jellyfish company
3) a fried shrimp head snack company
4) a crispy anchovy company
5) an oil extraction from tuna company
6) a vitamin from seafood product company

The SMEs that were chosen as the case studies will not be used again for the interviews (Figure 3.5).



Case studies: choosing randomly six questionnaire participants to be the case studies that divided into three groups;

Group of case studies	Total amount of case studies
Traditional product firms	2
Value added product firms	2
Innovative product firms	2

Figure 3.5: The structure of the target population planned for the case study method

However, innovative product firms were not used in this research. This was because one of the innovative product businesses is located in an area at high risk of terrorist attacks. Another innovative product company did not allow visits or interviews because of its secrecy policy.

As a result, the four case studies in this research are two cases of traditional product companies and two cases of value-added product companies that showed the result in Section 4.5.

3.3.3.2 The method used to collect the data from the case studies

The study involved collecting data that reflected the process of work in the individual businesses covered in the sample; that is, the data included information about inputs, knowledge support systems and network engagement to support the growth of the business. These data were obtained first-hand based on the experiences of business owners and company employees, as well as from company literature, including annual

reports and related archival documents. The data obtained from multiple case studies were used for the analyses across the cases.

3.4 The data management processes

In this thesis, secondary data has been used to compensate for primary data defects and to cross-check the questionnaire's answers as a result of the limited period in which primary data could be accessed during the Thai fieldwork that was carried out.

With regards to the data from the survey, businesses' answers may vary or be incomplete if a different stakeholder at each business answered due to the limited period in which they could return the questionnaire. Hence, why the primary data has been checked using secondary data, e.g. the businesses' financial reports, annual reports, websites, to complete or contextualise the data gained in the early stage of the study.

The stages of data management are shown in detail in Figure 3.6, encompassing the raw data stage, filling the gaps stage and cleaning the data stage.

Stage 1: Raw data stage – Manages data from the questionnaire returned by Thai SMEs' in the seafood industry.

Stage 2: Filling the gaps – Fills gaps in the case of incomplete answers.

Stage 3: Cleaning the data –R&D expenditure of Thai SMEs in the seafood industry is cleaned by checking it against STI survey data for 2013–2017.

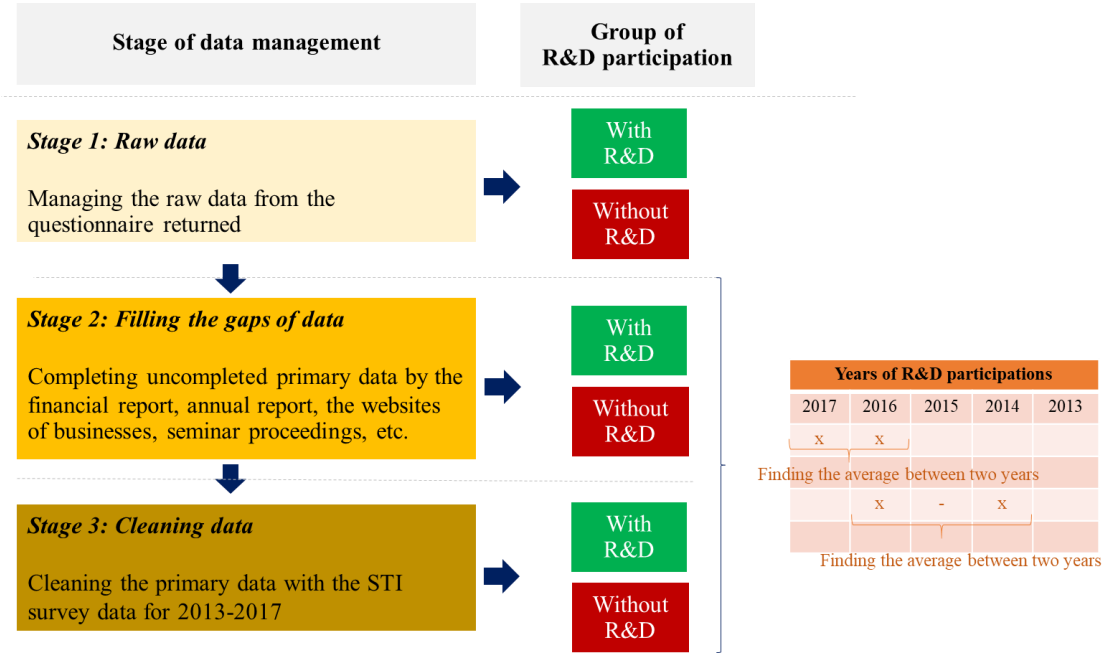


Figure 3.6: The stages of data management in this thesis

Notes:

1) 'With R&D' means Thai SMEs in the seafood industry engage with R&D in their business activities
2) 'Without R&D' means Thai SMEs in the seafood industry do not engage with R&D in their business activities
3) 'STI office' is the National Science Technology and Innovation Policy Office
4) 'RDI survey data' is that from the Research Development and Innovation survey
5) The period of data management is February–September 2019

The number of respondents across the three stages of data management will be presented in Chapter 4.

3.5 Methods of Data Analysis

The quantitative and qualitative analyses were used to explore the role of R&D in the development of the seafood industry. The data analysis method was divided into two parts in accordance with the different types of data, which consisted of the quantitative analytical method to analyse the data from the questionnaire survey and the qualitative analytical method to analyse the data from the interview and case study methods. The quantitative data analysis is explained in Section 3.4.1, while the qualitative data analysis is presented in Section 3.4.2.

3.5.1 The quantitative data analysis

The quantitative analysis predicted trends in the development of the sector based on data from the survey. It was also used to compare the market and productivity performances of SMEs 'with R&D' and SMEs 'without R&D' engagement using the cross-tabulation method.

The quantitative data obtained for this research were categorised as follows:

1) General information;
2) details of R&D expenditure such as the R&D investment on employee, R&D investment on machine and tools;
3) the role of networking to support the R&D engagement in Thai SMEs in the seafood sector, and
4) details concerning business performance in terms of market performance.

Cross-tabulation analyses were applied to the data to reveal the associations amongst the variables obtained from the survey data (Qualtrics, 2019). The chi-square test was used to identify the significance of the associations amongst the variables.

3.5.2 The qualitative data analysis

The qualitative method of analysis examines the behavioural aspects underlying the phenomenon described by the quantitative data (Schutt, 2019). For example, in order to understand why businesses chose whether to engage in R&D activities, the qualitative method of analysis would need to be employed. According to Intarakumnerd *et al*., (2011), in order to understand cooperation in knowledge networks involving knowledge producers (academia), knowledge users (industry) and knowledge regulators (government), the investigator needs to enquire about the role of each player in the knowledge network, including the barriers and opportunities envisaged in the process of interaction amongst the players. This can be explored via a content analysis based on the interview transcripts and company-related documents.

Content analysis is a suitable analytical method for qualitative information (Adams *et al*., 2007), and was duly applied to explain the relationships amongst variables relating to key players in the seafood sector (Figure 3.77). The qualitative analysis was based on information derived from in-depth interviews and case studies, as well as from published and unpublished reports. A SWOT analysis was used to process the qualitative data obtained from the interviews to generate policies that would support the development of seafood businesses, particularly those engaged in R&D activities.

3.6 Conclusion

The analytical framework used for this thesis of the importance of R&D in Thai SMEs in the seafood and fishery industries was based on a literature review. Research questions were then generated to highlight the point of the research and to guide the flow of the thesis. The methodology used to answer the questions in Section 3.3.1 was then chosen. According to the research design, quantitative data are required for the study of R&D behaviour and activities that encourage R&D activities in Thai SMEs in the seafood industry, and to determine the reasons for networks or relationships between SMEs and related organisations to support R&D activities.

The quantitative and qualitative methods approach provided the tools to answer the research questions because the quantitative data and the interview responses combined were able to explain the numerical information obtained in this research. The methodology consisted of four parts, which were business profiles, R&D expenditure by Thai SMEs in the seafood industry, the influence of networking in R&D engagement by the target groups, and the effect of R&D investment on business efficiency.

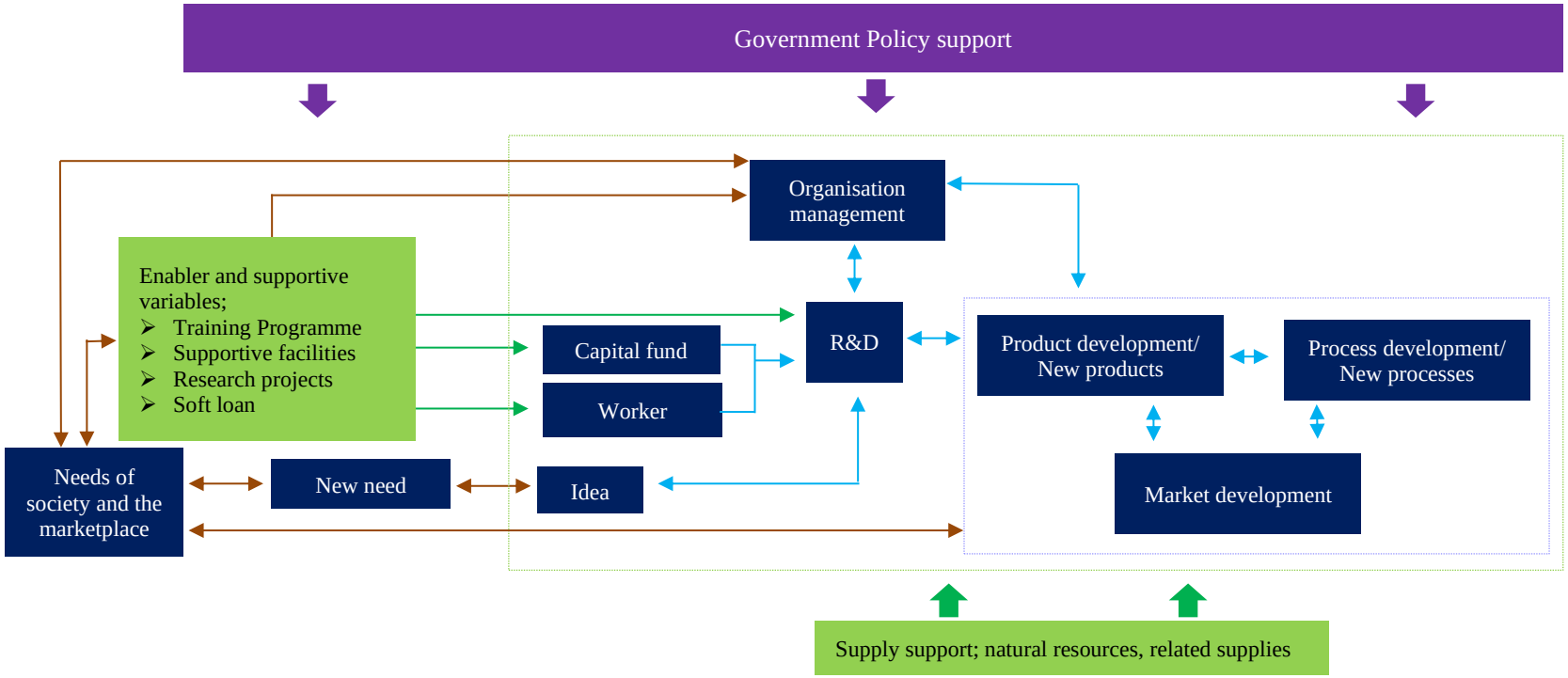


Figure 3.7: The linkage of variables that have influenced the performance of Thai SMEs in the seafood industry (adapted from Porter, 1990; Rothwell, 1992; The Organisation for Economic Cooperation and Development (OECD), 1999)

Chapter 4

How does R&D impact the business performance of Thai SMEs in the seafood sector, and how does a network effect R&D in business?

In order to investigate the engagement of SMEs in R&D activities, the sample was divided into two groups, namely firms with R&D and firms without R&D. The data management result, profile of the survey data and data analysis was divided into eight parts. Firstly, the data management result is explained in Section 4.1. Secondly, The business profile consisted of the age of the business, the capital funds, and the total number of workers in a sample group; this will be analysed in Section 4.2. Thirdly, the R&D activities were divided into two main activities, namely R&D employment and R&D investment in machinery and tools be explored in Section 4.3. A detailed analysis of R&D collaboration of the Thai seafood SMEs, particularly with government organisations, is presented in Section 4.4. Then, the interview results and case study analysis are presented in Section 4.5 and Section 4.6, respectively. The effect of R&D on business development will be analysed in Section 4.7. Finally, the conclusion is presented in Section 4.8

4.1 The data management result

The research aimed to investigate how R&D affects the development of SMEs in the Thai seafood industry. Thus, the structure of the analysis considered two groups. The first group consisted of businesses that answered the questionnaire and stated that they

did not use R&D in their business activities; this group is called ‘without R&D’ henceforth. The second group consisted of businesses that stated that they did use R&D in their business activities; this group is called ‘with R&D’ henceforth.

As Section 3.4 explained, three stages of data management were employed in this thesis, which are illustrated in Figure 4.1. The business numbers included at each stage are as follows.

Stage 1: Raw data stage – This stage managed the data from the questionnaires returned by Thai SMEs in the seafood industry. Questionnaires were returned from 115 firms, of the 237 firms invited to take part. Of those, the ratio of SMEs ‘with R&D’ compared to those ‘without R&D’ was 24 to 91 companies, respectively.

Stage 2: Filling the data gaps – This stage filled data gaps as all 115 SMEs who returned their questionnaire did not provide complete data. Seven firms were moved to the ‘with R&D’ group as they reported R&D activities in publications found elsewhere.

Furthermore, this stage involved partial cleaning of the primary data by means of access to secondary data. If the primary data from the questionnaire conflicted with that in an official report—such as an annual report, financial report, the company website, and so on—the data was cross-checked with more than two sources to confirm the actual amount of R&D investment. Then, average data from the two sources replaced the original primary data. The final number of SMEs in the ‘with R&D group’ was adjusted to 32 firms, leaving 83 firms in the ‘without R&D’ group.

Stage 3: Cleaning the data – R&D expenditure was cleaned again using STI survey data for 2013–2017. The R&D expenditure of Thai SMEs in the seafood industry was checked against the STI office’s survey data. That RDI survey data was averaged with the data in the documents from stage 2. The final number of SMEs in the ‘with R&D’ group was 52 firms, with just 63 in the ‘without R&D’ group.

Table 4.1 details the SMEs that participated in the questionnaire for this thesis in relation to their associations and the data sources for those businesses.

Table 4.1: Summary of the numbers of SMEs in the Thai seafood industry that participated in this research in relation to their associations and the sources of data

Name of source	Number of firms invited (companies)	Number of questionnaire respondents (companies)
Thai Frozen Association	135	64
Thai Shrimp Association	11	0
Thai Tuna Association	37	11
Thai Food Processor Association	13	8
RDI survey data	41	32
Total amount	237	115

Notes:

1) RDI survey data comes from the STI office's survey on research, development and innovation investment among businesses in Thailand during 2013–2017.

2) The period of data collection is 19th September 2018–4th February 2019.

It can be assumed that the 'without R&D' group operated their businesses based on capital funds and workers, while the 'with R&D' group utilised R&D as an additional factor, as well as capital funds and employees. The analysis thus compared data from the two groups to clarify the contributions of R&D to these businesses, as will be discussed in the final section. Raw data from the questionnaire, whether filled out using the paper version or online, were transferred to a data bank in the form of a Microsoft Excel sheet, and specific codes were used to replace the names of the businesses.

The quantitative data consisted of the age of the business, its capital funds, the number of workers, R&D expenditure, total sales, and export revenue, each based on actual figures. Due to the range of the quantitative data, the actual figures were grouped according to class intervals. Meanwhile, a business's degree of satisfaction or opinion was reflected by a score of 0–4, with 0 meaning never, 1 rarely, 2 sometimes, 3 very often, and 4 always. The data were analysed via cross-tabulation.

The core contents of the interview data were stored in a Word file and were analysed to explain the figures and to reflect the businesses' attitudes towards R&D or their R&D intentions.

4.2 The business profiles of the sample groups

This section presents the analytical results of the business profiles, including the age profile of the businesses in Section 4.1.1, the capital fund profiles of the businesses in Section 4.1.2, and the total headcount of employees in Section 4.1.3.

4.2.1 The age profiles of the firms

As seen in Section 2.5.1, in the SMEs' landscape, business demographic reports showed that half of the SMEs faced the prospect of bankruptcy within five years (The Organisation for Economic Cooperation and Development (OECD), 2000; Eurostat, 2017). The age of the business is one of the factors that affect engagement in R&D activities (Acs *et al*., 1994; Artz *et al.*, 2010; Kim *et al*., 2018). Of note, the R&D expenditure of a business will decrease as the business ages (Acs *et al*., 1994). Thus, the first analysis explores noise factors, such as the age of the business, which might limit the R&D engagement of the business (see Figure 4.1).

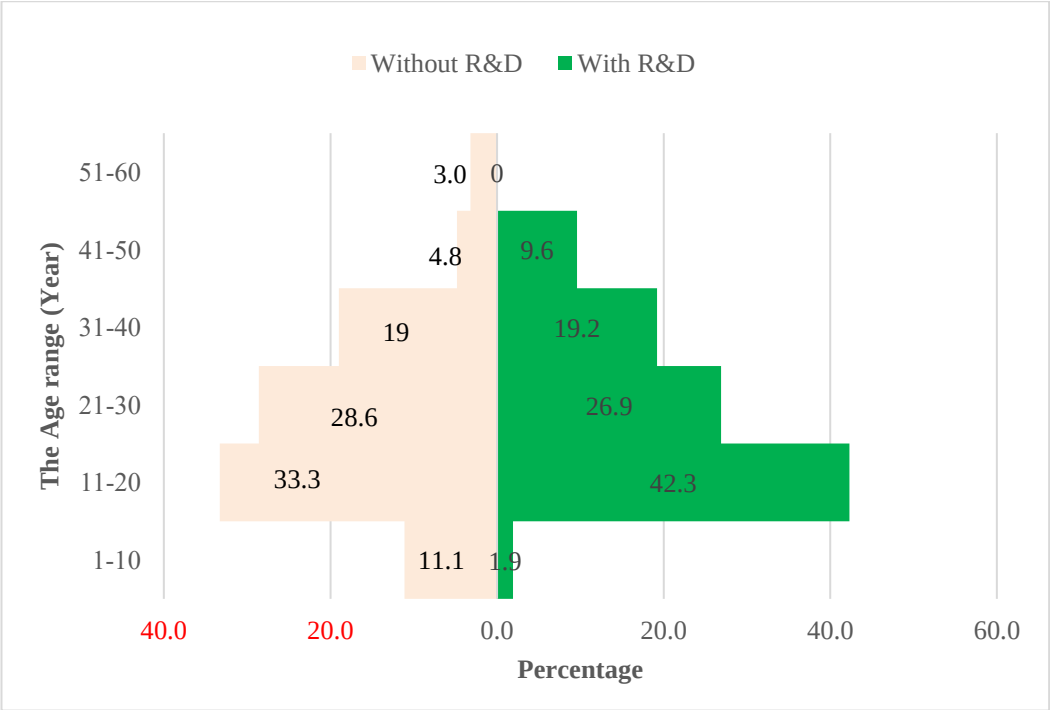


Figure 4.1: The age profile of the survey in Thai SMEs in the seafood industry in 2017

Notes:

1) The total amount of sample is 115 SMEs in the seafood industry in Thailand
2) The total number of sample in the Without R&D group is 63 SMEs in the seafood business in Thailand
3) The total number of sample in the With R&D group is 52 SMEs in the seafood business in Thailand
4) The period of data collection is 19th September 2018 – 4th February 2019

The age profile analysis considered six age ranges, namely 1-10 years, 11-20 years, 21-30 years, 31-40 years, 41-50 years and 51-60 years. The analyses of the age profiles were conducted separately per group and to compare two groups, namely Without R&D and With R&D.

In the 'Without R&D' group, most of the companies fell into the category of 11–20 years (33.3%); see Figure 4.1. The percentage of the business per age range reduces when they are aged. It appears that the survival rate of the business might decrease every year. As shown in Figure 4.1, 28.6% of companies fell into the range of 21–30 years; 19% into the range of 31–40 years; 4.8% into the range of 41–50 years; and 3.0% into the range of 51–60 years; while 11.1% fell into the range of 1–10 years.

The With R&D group showed the same trends in the proportion of age ranges as the Without R&D group. The highest percentage for the sample in the With R&D group fell into the range of 11-20 years (43.3%). The next highest proportion in the With R&D group was 21 – 30 years (26.9%), followed by 31 - 40 years (19.2%), and 41-50 years (9.6%), respectively. The percentage for the category of 1-10 years had the smallest 1.9% in the entire group. Moreover, the age range of 51-60 years was not represented in the With R&D category. However, the statistical analysis indicated that the age difference did not affect the R&D participation of the businesses at a 95% significance level; see Table VIII.1 (see Appendix VIII).

In summary, the age profiles of most of the samples in this research fell within the range of 11-40 years. Most of the samples fell into the category of 11-20 years in both groups, while the second- and third-ranked categories for both groups were 21-30 years and 31-40 years.

Furthermore, the interviews in this research confirmed that there were fewer opportunities for new firms to enter the market in Thailand, particularly in the seafood and fishery industries (see Appendix IX). The limited natural resources, the lack of skilled workers, and insufficient funds are barriers to the establishment of new firms in this sector. Moreover, the profit margins of the products in the fishery and seafood sectors is very low; thus, the way for businesses to survive in the market is to increase the quantity or the quality of the products. Increasing the quantity in the seafood business requires an extensive budget to invest items such as materials, workers, machinery, tools on so forth. Moreover, some businesses have to compete for materials with other businesses in the market. Although the quality of the products could be increased by applying R&D to support the production process, most SMEs experience financial constraints and do not have sufficient money or skilled workers to improve the business via R&D.

The reason for the small proportion of businesses in the range of 1-10 years is because of the high turnover rate of businesses in the seafood sector. Previous studies have indicated that SMEs around the world are in danger of experiencing bankruptcy during the first five years due to financial constraints and limited opportunities for growth (The Organisation for Economic Cooperation and Development (OECD), 2000;

Eurostat, 2017). By contrast, Cincera *et al*. (2016) argued that the cash flow of a business had a positive effect on R&D investment in young businesses in the EU countries. Thus, some SMEs could have sufficient budgets to run their businesses and to compete for market share. However, young firms tend to be sensitive to demand-pull factors such as export revenue and market accessibility rather than being driven by technological push because they need to resolve the liquidity constraints of the business (Garcia-Quevedo *et al*., 2014). However, R&D investment is an indirect risk factor for businesses because a once-off R&D investment might have a long-lasting impact on firms. Furthermore, growing businesses have limited access to appropriate finance because of a lack of credibility and networking in the market (Testa *et al*., 2019). Thus, few young firms engaged in R&D because the early stages of establishing a business entail many different aspects and require market research to achieve the goal of attaining sufficient market share in order to have a sufficient budget for R&D development or research at a later stage.

By contrast, most of the business owners interviewed for this research had inherited the business from their parents; some of them were the third generation (see the Case of T1 detail and Appendix IX). They were unable to make dramatic changes in the business due to the stakeholders' involvement or family control. In this regard, Suehiro (1993) and Suehiro and Wailerdsak (2004) reported that family businesses had driven the industry in Thailand, particularly sectors such as textiles, trading, commerce and related activities that the families could control. Furthermore, De Massis *et al*. (2012) reported that R&D investment was significantly lower in family businesses. Thus, it is likely that there will be less R&D investment in older seafood businesses because their structural organisation or management policies might involve the consideration of the organisational committee.

4.2.2 The capital fund profiles of the businesses

Capital funds were selected for the analysis of the business profile because both capital funds and the total number of employees are key factors in determining the category of a business. The Ministry of Industry (2002) defines SMEs in the manufacturing and

service sectors as having either fewer than 50 employees or a net asset value (NAV) of less than 50 million baht.

The NAV reflects a company's market value at a particular time after the total expenses and debt have been deducted from the capital (Stock Exchange of Thailand, 2015). A capital fund is a balance that can be considered to be legal capital (Bank of Thailand, 2015), and is composed of the debt (bonds) and equity (stock) of the business (Twin, 2019). Thus, capital funds and the total headcount of staff in businesses selected as part of the business profiles in this research. The class intervals of the capital funds in this research have been divided into seven ranges, which are 1-200 million baht, 200-400 million baht, 400-600 million baht, 400-600 million baht, 600-800 million baht, 800-1,000 million baht, 1,000-1,200 million baht, and more than 1,200-2,600 million baht.

The survey data showed that most SMEs in the seafood sector had capital funds in the range of 1 - 200 million baht, both in the Without R&D and in the With R&D groups (see Figure 4.2), As has been shown, 88.5% of the With R&D group fell into the category of 1-400 million baht in capital funds, of which 75% were the range of 1-200 million baht and 13.5% were in the range of 200 – 400 million baht. Moreover, 82.6% of the Without R&D group were in the capital fund range of 1-600 million baht, which is a greater wider range than is that of the Without R&D group. The 1-200 million baht category was the majority for both groups, and accounted for 55.6% of the Without R&D group; however, the percentages in the ranges of 400-600 million baht and 200-400 million baht were 14.3% and 12.7% for the Without R&D and With R&D groups, respectively.

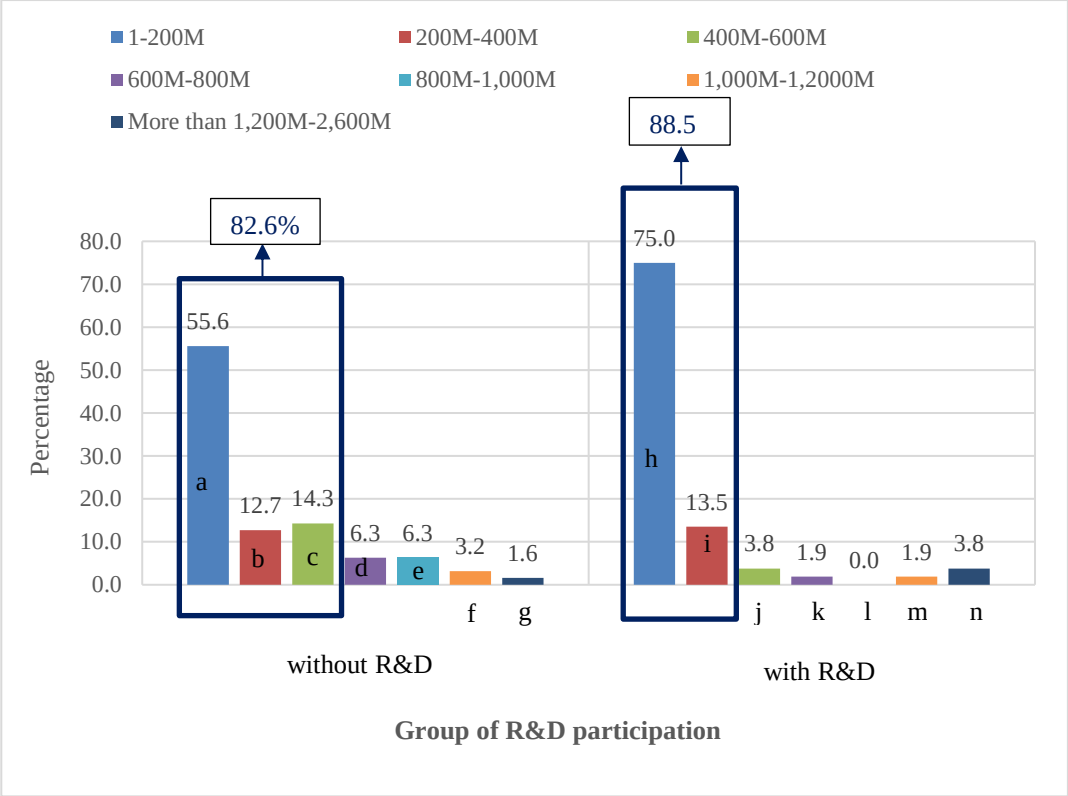


Figure 4.2: Details of the capital funds of the survey in Thai SMEs in the seafood industry in 2017

Notes:

1) M denotes million Thai baht.
2) The total number of the sample is 115 SMEs in the seafood industry in Thailand.
3) The total number of the sample in the 'Without R&D' group is 63 SMEs in Thailand's seafood business.
4) The total number of the sample in the 'With R&D' group is 52 SMEs in Thailand's seafood business.
5) The period of data collection is 19th September 2018 – 4th February 2019.
6) a denotes the capital fund of SMEs in the 'Without R&D' group range of 1–200 million baht (55.6%).
7) b denotes SMEs' capital fund in the 'Without R&D' group range of 200–400 million baht (12.7%).
8) c denotes SMEs' capital fund in the 'Without R&D' group range of 400–600 million baht (14.3%).
9) d denotes SMEs' capital fund in the 'Without R&D' group range of 600–800 million baht (6.3%).
10) e denotes SMEs' capital fund in the 'Without R&D' group range of 800–1,000 million baht (6.3%).
11) f denotes SMEs' capital fund in the 'Without R&D' group range of 1,000–1,200 million baht (3.2%).
12) g denotes SMEs' capital fund in the 'Without R&D' group range of more than 1,200–2,600 million baht (1.6%).
13) h denotes SMEs' capital fund in the 'With R&D' group range of 1–200 million baht (75%).
14) i denotes the capital fund of SMEs in the 'With R&D' group range of 200–400 million baht (13.5%).
15) j denotes SMEs' capital fund in the 'With R&D' group range of 400–600 million baht (3.8%).
16) k denotes SMEs' capital fund in the 'With R&D' group range of 600–800 million baht (1.9%).
17) l denotes SMEs' capital fund in the 'With R&D' group range of 800–1,000 million baht (0%).
18) m denotes the capital fund of SMEs in the 'With R&D' group range of 1,000–1,200 million baht (1.9%).
19) n denotes SMEs' capital fund in the 'With R&D' group range of more than 1,200–2,600 million baht (3.8%).

As mentioned earlier, this main target in this research was SMEs in the seafood and fishery industries. According to the Ministry of Industry's ruling, Thai SMEs in the manufacturing and the service sectors should have fewer than 50 employees, or an asset value of less than 50 million baht (Ministry of Industry, 2002). Thus, the main range forecast for the capital funds of the sample should not differ from the condition. However, the survey data indicated that Thai SMEs could have capital funds that exceeded the minimum criteria based on the ministry's laws. It can be assumed that the Thai SMEs in the seafood industry in this research did not experience financial constraints.

Although much research has stated that SMEs experience financial constraints that are obstacles to R&D engagement; Liu *et al.* (2019) argued that financial assets could not guarantee the precise financial status of a business because financial assets could distort in the business profile.

4.2.3 Total headcount of SME employees

According to the Ministry of Industry (2002), the criteria for registering SMEs are either an asset value in the range of 50 - 200 million baht, or having fewer than 200 employees in the manufacturing sector. Thus, most of the SMEs in the seafood industry have organised their businesses in such a way that the total number of employees is in the 1 - 200 range

The proportion of total employment figures differed in the Without R&D and With R&D groups (see Table VIII.3, Appendix VIII). The range of total headcount was divided according to every 25 people; 25-50 people had 14 ranges from 1-25 people to more than 1,000 – 3,000 people. The most significant category for the total headcount in the Without R&D group range was 1 - 100 employees (66.7 %). By contrast, the majority of businesses in the With R&D group had 226 – 500 employees (34.6%) (see Figure 4.3).

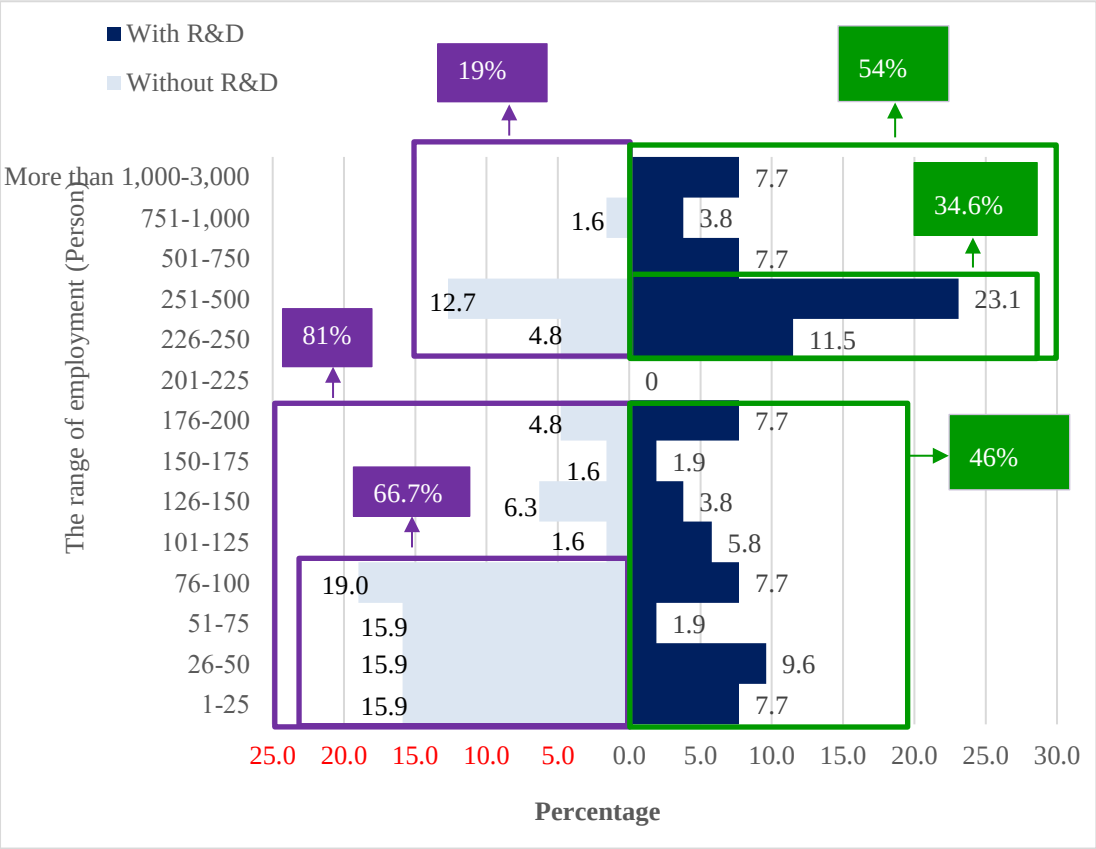


Figure 4.3: The proportion of total employment figures for the Without R&D and With R&D groups in 2017

Notes:

1) The total amount of sample is 115 SMEs in the seafood industry in Thailand
2) The total number of sample in the Without R&D group is 63 SMEs in the seafood business in Thailand
3) The total number of sample in the With R&D group is 52 SMEs in the seafood business in Thailand
4) The period of data collection is 19th September 2018 – 4th February 2019

The total headcount of the businesses indicated that almost 80% of the Without R&D group had fewer than 200 employees, and only around 20% employed between 226 and 3,000 people. On the other hand, fewer than half (45%) of the With R&D group employed 1-200 people, while almost 55% of these companies had 201 to 3,000 employees. It seems that the With R&D group employed more people than did the Without R&D group. The chi-square test does not show that the difference in the

employment profiles of the two groups was significant at 95% (see Table VIII.3, Appendix VIII).

In addition, most of the labour force in the seafood and fishery sectors was employed by small-sized businesses, and few of them worked in the post-harvest process (Food and Agricultural Organization of the United Nations, 2018). However, 70% of workers in large-sized businesses (3.5 million people) were employed in the post-harvest process. Therefore, the likelihood of large-scale businesses, which have readiness in terms of budget, hiring a highly skilled worker was greater than it was for small-scale businesses. So, the application of technology and innovation to support working processes were more likely in large-scale firms than in small-sized businesses.

Although human capital is one of the main inputs in economic growth, most of the existing research has shed light on the relationship between knowledge distribution and the growth of productivity in a business (Gallie and Legros, 2012). On the contrary, the relationship between the number of employees and the outcome of the business is unclear. Kanama and Nishikawa (2015) stated that limited financial resources to support workers might be an obstacle to improving the efficiency of employees. Moreover, Alnahedh *et al*. (2019) found that cash-flow uncertainty and the expenses entailed in having a large staff had a negative impact on employers. This implies that the readiness and liquidity of a business has a considerable effect on the employment rate in terms of numbers and pay.

As can be seen, the main factors in the R&D expenditure of a company might vary according to the age of the business, size of the business, the total amount of capital fund and the total amount of employees of the business. Correspondingly, Lai *et al.* (2015) reported the definite advantage created by the capacity for business innovation, which is related to a company's liquidity and R&D activities. Capital resources are associated with the number of R&D activities in Japanese businesses, but the organisations' management has a greater effect on R&D activities in Taiwanese and Korean businesses. Thus, the income of the businesses is most likely related to both the physical resources and to R&D.

Therefore, the next section will explore R&D activities and their role in Thai SMEs in the seafood sector. The section has been divided into two parts: One concerns the people employed in R&D, and the other investment in machinery and tools. Thus, this research will discuss R&D activities in terms of total R&D expenditure, R&D investment on employees, and investment in machinery and tools. R&D investment will be linked to the total sales of the businesses. The total revenue of the company has also been divided into two parts, namely export revenue and domestic income that will be discussed in Section 4.6.1.

4.3 R&D expenditure of SMEs in the Thai seafood industry

The R&D expenditure of Thai SMEs in the seafood industry was studied based on the With R&D group. The raw data from the questionnaire were transferred to a Microsoft Excel file, and were categorised into the class intervals. A cross-tabulation analysis was applied to analyse the statistics.

However, some of the firms indicated that they had R&D activities in their businesses, but did not provide the amount of R&D expenditure on the questionnaire; this group is called the 'None group' henceforth. The other group was categorised according to the optimal interval class, which varied across the range of data inter analysis of each group.

The main focus of R&D expenditure can be divided into two main aspects; R&D employment and R&D infrastructure investment, such as laboratory, machinery and tools (National Science Technology and Innovation Policy Office, 2019). Thus, this research analysed the R&D expenditure in Thai SMEs in the seafood business in terms of R&D employment and the investment in machinery and tools.

The macro picture of R&D in Thai SMEs in the seafood industry in this survey showed that the R&D in this group increased steadily from 2013 to 2016, followed by a slight decrease in 2017, as can be seen in Figure 4.4 and Table VIII.4 (see Appendix VIII).

In 2013, the R&D expenditure of SMEs in the seafood business was less than it was in 2014-2017. R&D investment in 2013 ranged from 500,000 baht to 3.5 million baht but, during 2014 – 2017, this increased to more than 20 million baht. In 2013, the most common range of R&D investment was in the 2.5 – 3.0 million baht category (see Figure 4.4). The 0.5-1, 1 million -1.5 million, and 3 million -3.5 million baht categories each accounted for 3.8% of SMEs, with statistically significant differences at the 0.05 level.

The fluctuation in R&D investment during 2013-2017 might have been the result of indirect effects, such as natural disasters and trade barriers. A shocking natural disaster affecting the Thai seafood industry occurred in 2012; it was the transmission of a disease called Early Mortality Syndrome (EMS), technically known as Hepatopancreatic Acute Necrosis Syndrome, which resulted in the loss of 40% of Thai shrimp export production that was worth around 27,117 billion baht in 2013 (Department of Fisheries, 2019).

Even though the seafood industry's contribution to the GDP has remained positive and significant, the sector's quarter-on-quarter output observed fluctuations, particularly in 2006, 2012 and 2014, in response to the anti-dumping effect, the disease outbreak in shrimp, the Tier 3 watch list[10] from the USA and the yellow card effect[11] from the EU, respectively (Office of The National Economic and Social Development, 2019)

[10] The Tier 3 ranking on the Watch List means the that the government of Thailand is considered to have a poor official track record of controlling the human trafficking situation and does not appear to implement the necessary standards (ASEAN Information Centre, 2015).

[11] The European Commission placed Thailand in the pre-identification stage due to its lack of progress in addressing illegal, unreported and unregulated (IUU) fishing (Iamsudha, 2011) under Council Regulation (EC) No. 1005/2008 of the 29th of September 2008, also called the 'yellow card' (European Commission, 2008). This yellow card caution has affected the Thai fishery industry by resulting in social and economic problems. Fishery products from Thailand were banned in European countries, causing seafood businesses to slow down their production lines and lay off workers, while also affecting the international export value (Prime Minister's Delivery Unit, 2018).

However, the R&D expenditure of Thailand increased continuously; R&D expenditure in the seafood industry also increased, from 166.49 million baht in 2013 to 256.93 million baht in 2017, which reflects the critical role of R&D in the development of the Thai seafood sector.

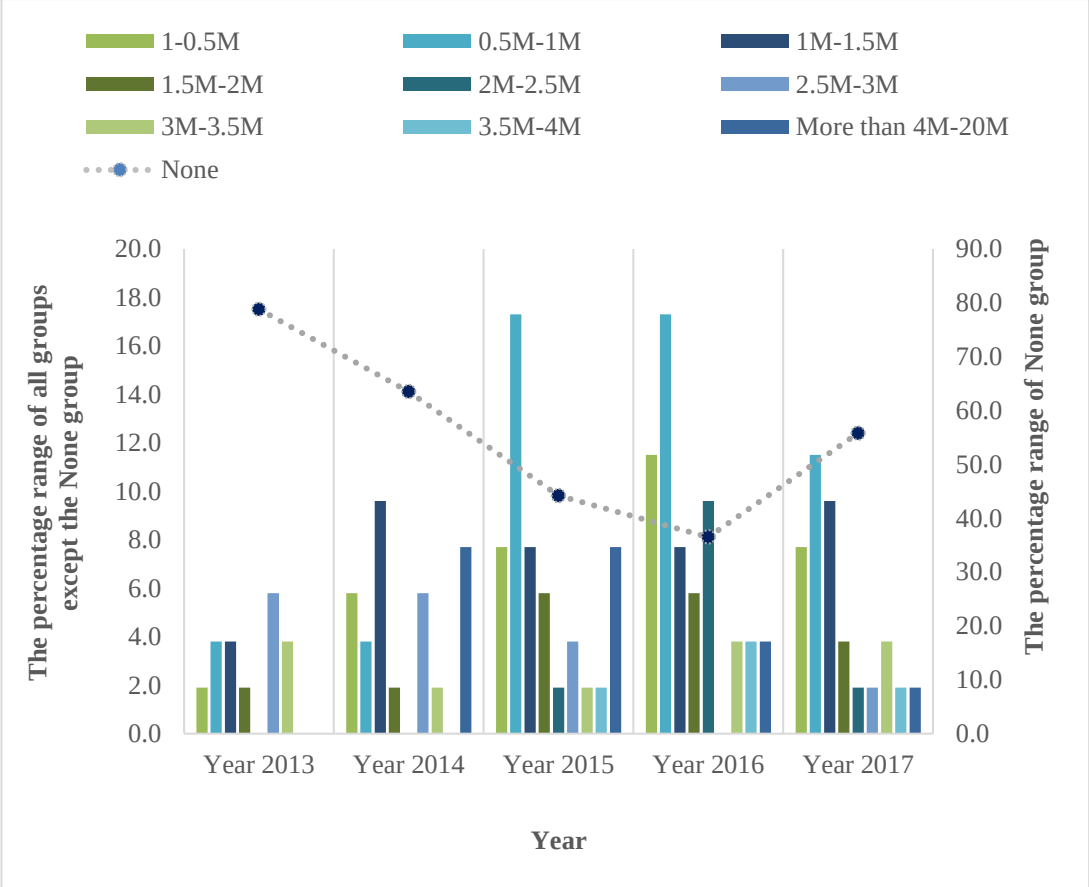


Figure 4.4: Structure of R&D expenditure across SMEs in the seafood sector (2013-2017) in Thailand

Notes:

1) M means million Thai baht
2) None is the participants in the With R&D group did not indicate the details of their R&D expenditure in their answers
3) The total number of the sample which is SMEs in the seafood business in Thailand is 52
4) The period of data collection is 19th September 2018 – 4th February 2019

As one of Thailand's objectives during 2012-2016 was to drive social development and the economy, this brought R&D to the fore as a tool to increase the efficiency of the nation (Office of The National Economic and Social Development Council, 2011). However, the action plan was not clear until 2015, after the Thailand Board of Investment was encouraged the measure the support for business development via R&D, particularly for SMEs (Thailand Board of Investment, 2014).

It could be assumed that external disturbances were the reason for the fluctuation in R&D expenditure in Thai SMEs in the seafood industry. Although the analytical result in Section 4.2.2 indicated that Thai SMEs in the seafood industry had a positive financial flow, funds may have been diverted from R&D to other objectives to sustain the business during the crisis.

The measures for supporting the development of businesses via R&D, particularly SMEs has been divided into three main points; investment in machinery and tools, employee development via R&D, and the creation of knowledge networks with both local and international R&D units (Thailand Board of Investment, 2014, 2017). The evaluation of R&D investment in the Thai national plan was based on the investment in machinery and tools, the number and quality of employees, and publications to monitor the effect of R&D on the development of the business (Office of The National Economic and Social Development Council, 2011; Office of The National Economic and Social Development, 2016). Thus, this research studied the pattern of R&D investment based on two objectives, which were R&D investment in machinery and tools and R&D expenditure on employees. R&D collaboration will be analysed in Section 4.3.

4.3.1 The R&D expenditure on employment in Thai SMEs in the seafood business

The OECD (2018) indicates that R&D activities covered in the training programme were excluded from standard education programmes and could apply to business. Furthermore, the R&D training of individuals in research techniques where such

activities occur utilises the same facilities as other research and development activities (OECD, 2018).

Meanwhile, the National Science Technology and Innovation Policy Office (2019) reports the R&D expenditure on employment covered the companies' R&D personal employment and the number of R&D graduate students from various fields, such as engineering, science, mathematics and so forth in many ranges of degrees.

The quantitative data enables cleaning the data with the secondary data from business publications and the RDI survey data surveyed by the STI Office (see Figure 4.1). Thus, the scope of R&D expenditure on employment in this thesis in part 4.2.1 covered the activities of R&D personal employment. Then, the R&D expenditure on employment in Thai SMEs in the seafood industry in the interview results (Section 4.4), and the case study analysis (Section 4.5) covered the activities of the following:

a) R&D personal employment;
b) expert employment for maintenance machine and tools; and
c) R&D training programmes such as quality control courses, tools' usage courses, R&D seminars, and so forth.

In 2013 and 2014, most of the R&D expenditure on employment in term of salary paid fell within the range of 700,001 to 1,050,000 baht (11.5%) but, from 2015 to 2017, most R&D expenditure on employment ranged from 350,001 to 700,000 baht. Moreover, R&D expenditure on employment has been decreasing continuously in terms of the amount of money paid to R&D employees from 2013 to 2017. However, the None group maintained its level of a high percentage. The statistical analysis finds a difference in the data during the year 2013-2016, except in the year 2017 at the 95% significance level (see Table VIII.5, Appendix VIII).

The report from the Office of Small and Medium Enterprises Promotion indicated that the situation of employment in Thailand suffered the effects of increasing of the minimum wage for labour to 300 baht per day and 15,000 baht per month for workers with bachelor's degrees (Office of Small and Medium Enterprises Promotion, 2013). Furthermore, Thailand experienced disastrous floods in 2012, which prevented some

businesses from operating at full capacity (Office of Small and Medium Enterprises Promotion, 2013), resulting in significant unemployment. Thus, the R&D expenditure on employment in Thai SMEs in the seafood industry in 2013 was very low. As can be seen, the highest percentages of R&D expenditure on employment fell within the ranges of 350,001 -700,001 baht and 1-350,000 baht and 700,001-1,050,000 baht (see Figure 4.5).

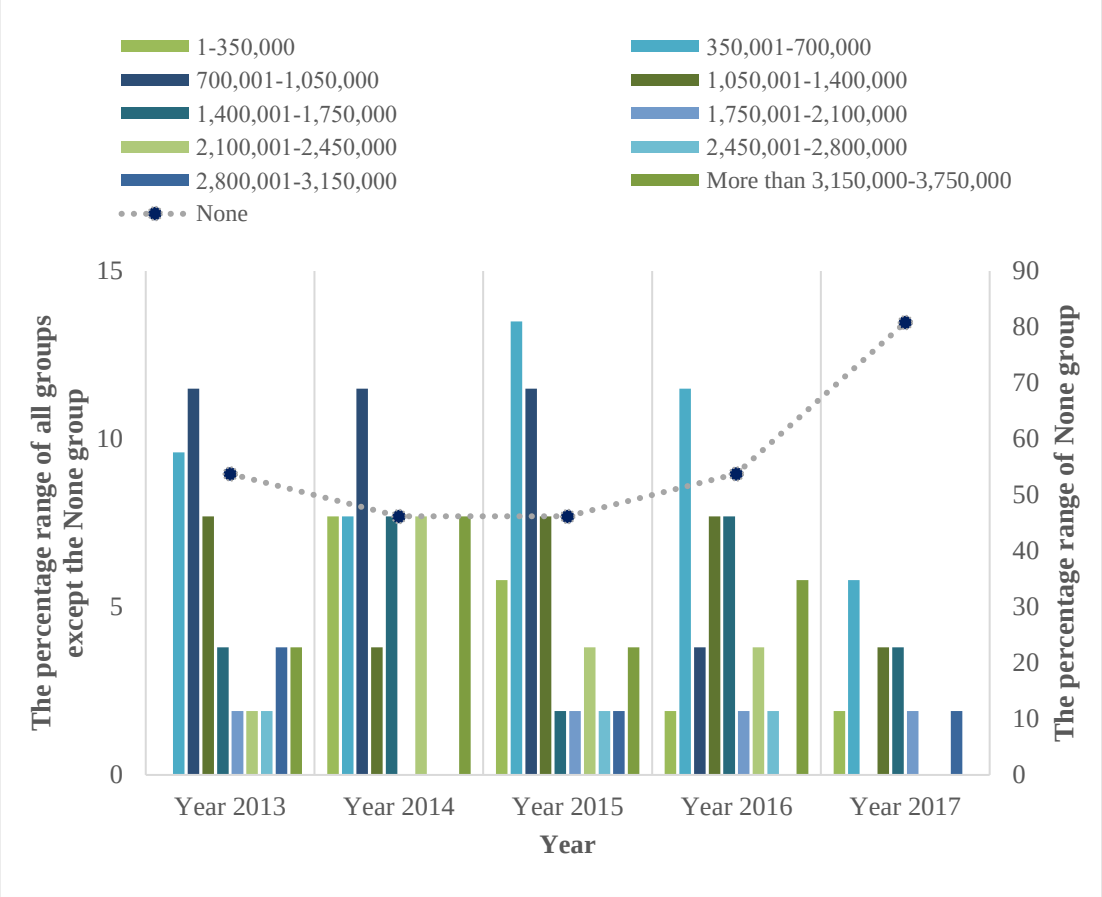


Figure 4.5: R&D expenditure on employment in terms of salary paid by SMEs in the Thai seafood sector (2013-2017)

Notes:

1) None is the participants in the With R&D group did not indicate the details of their R&D expenditure in their answers
2) The total number of the sample which is SMEs in the seafood business in Thailand is 52
3) The period of data collection is 19th September 2018 – 4th February 2019

Thailand then experienced internal political problems; in addition, the world's economy experienced a continuous decline in 2014. Thus, in 2014, the national economy suffered the direct effects of those problems, which resulted in SMEs employing fewer people in 2014 than in 2013 (Department of International Trade Promotion at Guangzhou, 2014).

To maintain Thai SMEs' survival and recover from the effects of the economic crisis, the Thailand Board of Investment announced measures for supporting SMEs' development in 2015 (Thailand Board of Investment, 2014). One of the primary steps was to increase employee skill via R&D training programmes or support other activities that lead to R&D activities that increase employees' talent (Thailand Board of Investment, 2014). Furthermore, the exact measure details indicated that SMEs could import the machines and tools with a tax exemption discussed in Section 4.2.2. It is related to the increased requirement of expertise of R&D employees to support the machines' operation. Therefore, this may be the reason that the number of employees in Thai SMEs in 2015, particularly in terms of R&D, was higher than it was in the previous year.

The R&D employment ratio of Thailand increased from 10.50 people per 10,000 in 2013 to 13.6 people per 10,000 in 2015; however, this ratio was lower than the national expectation, as the goal was 15 people per 10,000 (Office of the National Economic and Social Development Council, 2017).

However, average labour productivity[12] exceeded the target of at least 3% per year; moreover, the labour productivity of Thailand was 4.12% (Office of the National Economic and Social Development Council, 2017). Thus, the low level of R&D

[12] Labour productivity is the output per unit in a period of time (OECD, 2002; Pettinger, 2019).

$$Labour\ productivity\ = \frac{GDP\ at\ constant\ prices}{Number\ of\ employed\ persons}$$

Formula 4.1: The formula for calculating labour productivity

investment in employment in Thai seafood SMEs might be due to SMEs focusing on increasing the quality of workers rather than hiring new staff members.

The stagnant economy is one of the problems affecting the liquidity of SMEs in the seafood industry in Thailand, as we saw in the literature review section. Barbieri *et al*. (2019) showed how the financial crisis had slowed the development of R&D in businesses. They indicated two options for a business to survive in the economic crisis: One was to purchase machinery and tools to replace the employees in the system, and the other was to reduce the price of products to attract buyers.

Therefore, the physical aspects of a business, such as structure and liquidity, might affect their decisions to invest in R&D expenditure, machinery and tools could replace part of the labour force. Thus, the next section will compare the ratio of investment in machinery and tools investment to that of R&D employment in Thai SMEs in the seafood sector, and will analyse the R&D behaviour of Thai SMEs in the seafood industry.

4.3.2 Machinery and tool investment by Thai SMEs in the seafood industry

The range of investment in machine and tools is wide, from one million to more than 20 million baht while the None group was predominated percentage like in the previous section. The survey data showed the investments in machinery and tools by Thai SMEs in the seafood industry from 2013 to 2017. The amount that most companies invested was in the 1-500,000 baht category (see Figure 4.6).

The greatest amount of R&D investment in machinery and tools occurred in 2015. The analytical data indicated that the companies that invested in the range of 1 – 0.5 million baht and 0.5 million – 1 million baht had an equal percentage (3.8%) in 2013. A smaller percentage (1.8%) fell within the range of 1.5 million – 2 million baht. Meanwhile, The lowest amount of R&D investment in machinery and tools occurred in 2013. Although the R&D investment in machinery and tools was a small portion of the investment in 2014 and 2017, the maximum value of R&D investment fell within the range of more than 4-20 million baht (see Table VIII.6, Appendix VIII).

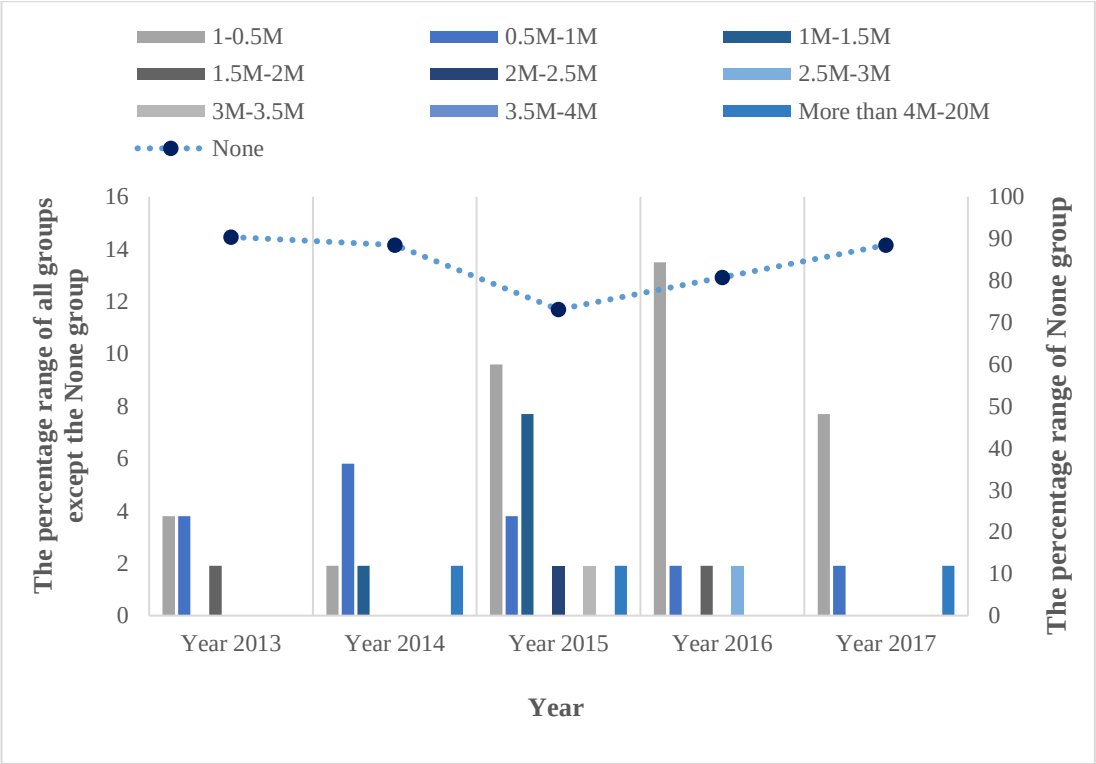


Figure 4.6: Investment in machinery and tools by Thai seafood SMEs during 2013-2017

Notes:

1) M means million Thai baht
2) None is the participants in the With R&D group did not indicate the details of their R&D expenditure in their answers
3) The total number of the sample which is SMEs in the seafood business in Thailand is 52
4) The period of data collection is 19th September 2018 – 4th February 2019

The dramatic increasing in R&D investment in machinery and tools in this research might be an effect of the measures to improve SMEs that were encouraged by The Thailand Board of Investment in 2014. The objective of these measures was to increase the efficiency of businesses, particularly SMEs, by offering a tax exemption of up to 200% in import duty if they refrained from importing machinery and tools (Thailand Board of Investment, 2014). In more detail, this measure indicated that SMEs could import used machinery, but that the value such machinery could not exceed 10 million baht (Thailand Board of Investment, 2014). Therefore, the reason for the low investment in machinery and tools during 2013-2014 might be because the SMEs did not receive incentives from the government. As can be seen, investments in machinery

and tools increased dramatically in 2015 after the announcement of measures to support SMEs; however, these investments were low in value (less than 5 million baht) because of the conditions limiting the support of government policies.

However, the portion of investment in machinery and tools for Thai SMEs in the seafood industry is meagre. The results of this section should foster guidelines for future work to verify the levels of technology that SMEs possess for R&D, e.g. the types of technologies. The target population area might expand to cover all sizes of businesses in the seafood and fishery industry, which might reflect the trend of technology that businesses in this sector are harnessing to support their development.

4.4 Details of R&D collaboration of Thai SMEs in the seafood industry with external agencies

R&D expenditure and R&D collaboration had positive impacts on the development of SMEs. Specifically, R&D is an essential tool for increasing the income efficiency of SMEs, and R&D collaboration is a supportive factor for SMEs to overcome their limited resources and to create innovative products or processes for the market (Suh and Kim, 2012). Furthermore, Nooteboom (1999) stated that an essential factor in creating innovation was not the size of the business, but the strength of the links and the degree of integration. Networking is a tool for overcoming the limited capacities for innovation of individual firms, and increasing the return on sales (Mancinelli and Mazzanti, 2009).

Figure 4.7 shows the R&D participation behaviour of Thai SMEs in the seafood industry in 2017. The level of business collaboration has been categorised according to five levels ranging from ‘Never’ to ‘Always’. The minimum level was ‘Never’, indicating that the business had never engaged in collaboration with such organisations to improve their businesses. The maximum level was ‘Always’, indicating that the business engaged in regular collaboration with these organisations. The interpretation of the data categorised the results according to three groups: negative collaboration included ‘Never’ and ‘Rarely’, neutral pertained to ‘Sometimes’, and positive collaboration included ‘Very often’ and ‘Always’.

Negative collaboration means that participants in this thesis did not work with external organisations, or they rarely worked with them. The group of participants that answered that they 'Never' or 'Rarely' work with external organisations has been classified as a negative collaborative group in this thesis.

Neutral collaboration means that participants in this thesis have discontinuously worked with external organisations. The group of participants who answered that they 'Sometimes' work with external organisations has been classified as a neutral collaborative group in this thesis.

Positive collaboration means that participants in this thesis have frequently worked with external organisations. The group of participants that answered that they 'Very often' or 'Always' work with external organisations has been classified as a positive collaborative group in this thesis.

More than 70% of Thai SMEs in the seafood industry were not inclined to collaborate with external organisations with regard to R&D activities. Furthermore, 100% of the participants in this research reported that they had never engaged in R&D collaboration with external organisations, particularly with other SMEs, business services such as management consultants and marketing consultants, or technical service providers such as engineering consultants in information technology.

By contrast, almost 30% of the SMEs showed positive behaviour with their parent companies, while 13.4% of SMEs exhibited positive behaviour with international suppliers and 11.5% with local suppliers. In addition, SMEs exhibited minor positive behaviour with non-profit organisations (5.8%), customers (5.8%), LEs (5.7%), government (5.7%), associations (1.9%) and universities (1.9%).

Furthermore, some SMEs in the seafood industry exhibited neutral behaviour towards external agencies in terms of combined R&D activities. Almost 10% of them exhibited neutral behaviour towards international suppliers, 3.8% towards local suppliers, 3.8% towards government units, and 1.9% towards non-profit organisations, LEs and universities.

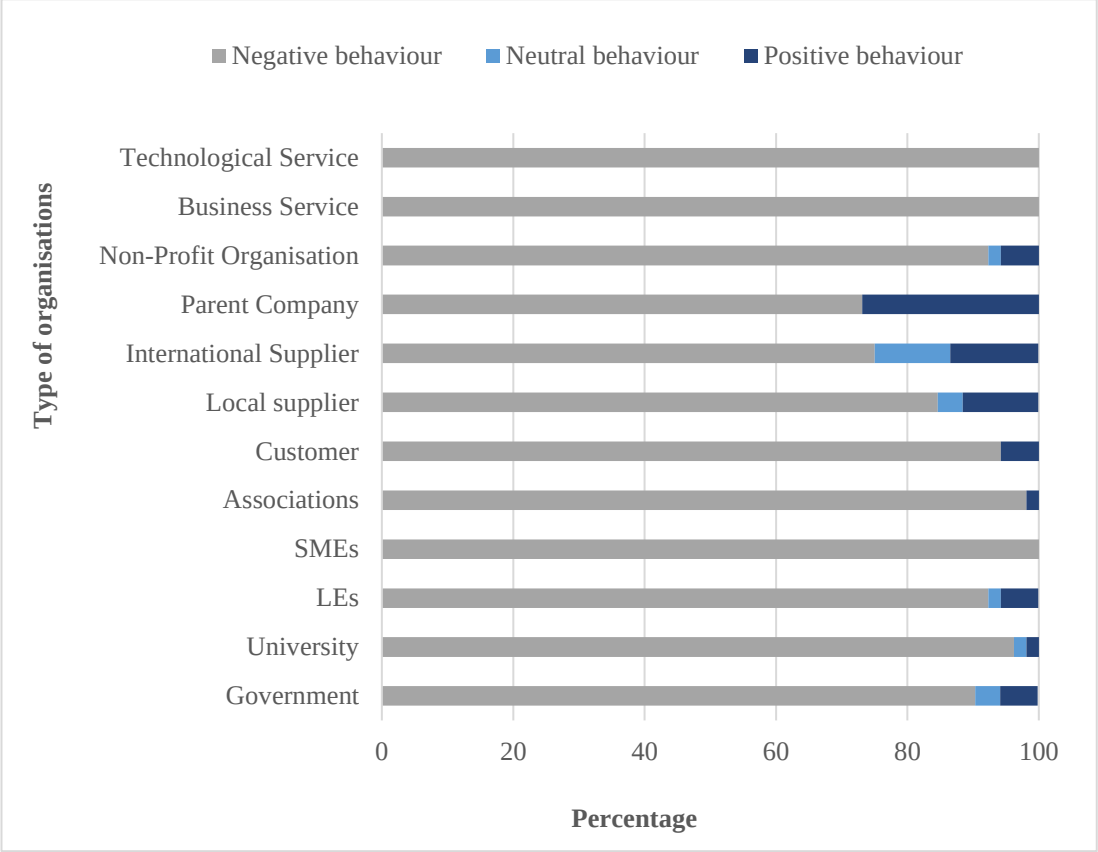


Figure 4.7: Business collaborations with external agencies by Thai SMEs in the seafood business in the With R&D group in 2017 (n=27)

Notes:

1) The total number of respondents is 27 SMEs
2) The total number of the sample which is SMEs in the seafood business in Thailand is 52
3) The negative behaviour is Thai SMEs in the seafood sector which answer in the questionnaire that they 'Never' and 'Rarely' create a network with the external organisation in all those lists of organisations
4) The neutral behaviour is Thai SMEs in the seafood sector which answer in the questionnaire that they 'Sometimes' create a network with the external organisation in all those lists of organisations
5) The positive behaviour is Thai SMEs in the seafood sector which answer in the questionnaire that they 'Very often' and 'Always' create a network with the external organisation in all those lists of organisations
6) The period of data collection is 19th September 2018 – 4th February 2019

Universities have tried to extend beyond providing highly educated workers by becoming active company partners in the application of academic research to effectively strengthen national economic growth. In the past few decades in the UK, the learning-partnership model has shown a significant positive effect on business growth (Boyd *et al.*, 2003). However, the data show that Thai SMEs in the seafood business had a limited degree of R&D networking with external agencies. More specifically, SMEs tended to work with the private sector rather than with academic institutions or government organisations. Although some of the participants in this research engaged in R&D activities and R&D networking, their main collaborative groups were private company or their customers.

Nevertheless, the survey data showed that 27 of 115 SMEs were aware of the R&D and innovation options provided by government organisations, although only 21 of them participated in R&D activities with government units. Most of the SMEs in this research were aware of the services provided by the National Science and Technology Development Agency (NSTDA), the Board of Investment of Thailand (BOI), the National Innovation Agency (NIA), the National Science, Technology, and Innovation Policy Office (STI), the National Research Council of Thailand, the Agricultural Research Development Agency (public organisation), the Thailand Research Fund and the Regional Science Parks (Figure 4.8).

As noted, 21 of the 27 SMEs that were aware of the sources of R&D funding registered to obtain services from these government organisations. Specifically, most SMEs in the seafood industry participated in the product-based incentive projects provided by BOI, the Industrial Technology Assistant Programme (iTAP) provided by NSTDA, and the testing and analytical services provided by NSTDA.

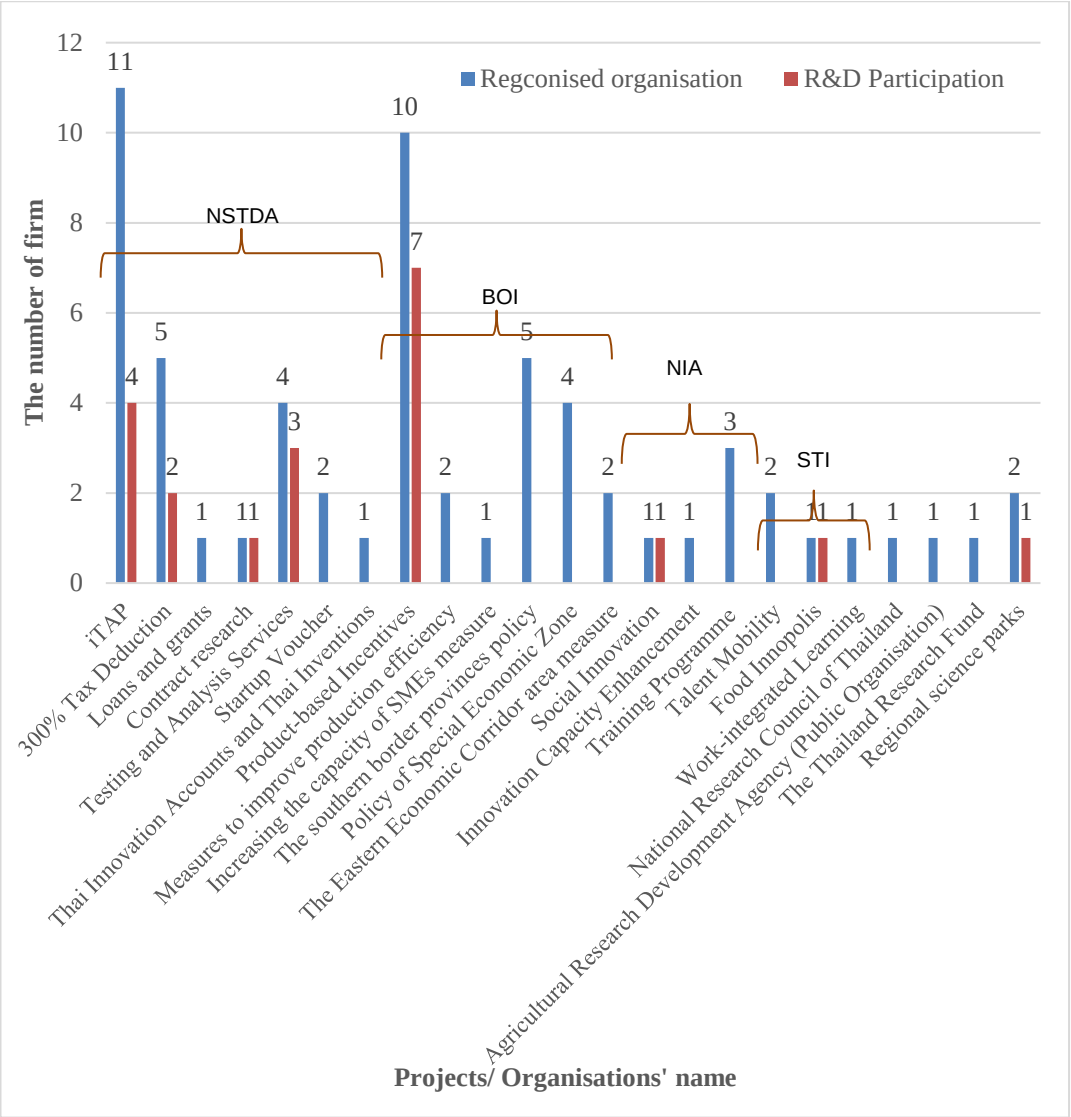


Figure 4.8: The list of supportive R&D projects or supportive R&D government organisations' names from the perspective of Thai SMEs in the seafood industry in 2017

Notes:

1) The total number of SMEs in the seafood business who answers in the questionnaire that they know the name of the R&D organisation is 27 firms

2) The total number of the SMEs in the seafood business who answers in the questionnaire that they created the linkage with an external organisation is 21 firms

3) The recognised organisation is the project or organisation which well know in the role of R&D supporter

4) R&D participation is SMEs in the seafood industry that has the R&D participation with the external organisation on those lists

5) The period of data collection is 19th September 2018 – 4th February 2019

The reasons for not collaborating with R&D government organisations expressed by 30 of 88 firms were divided into five main points (Figure 4.9).

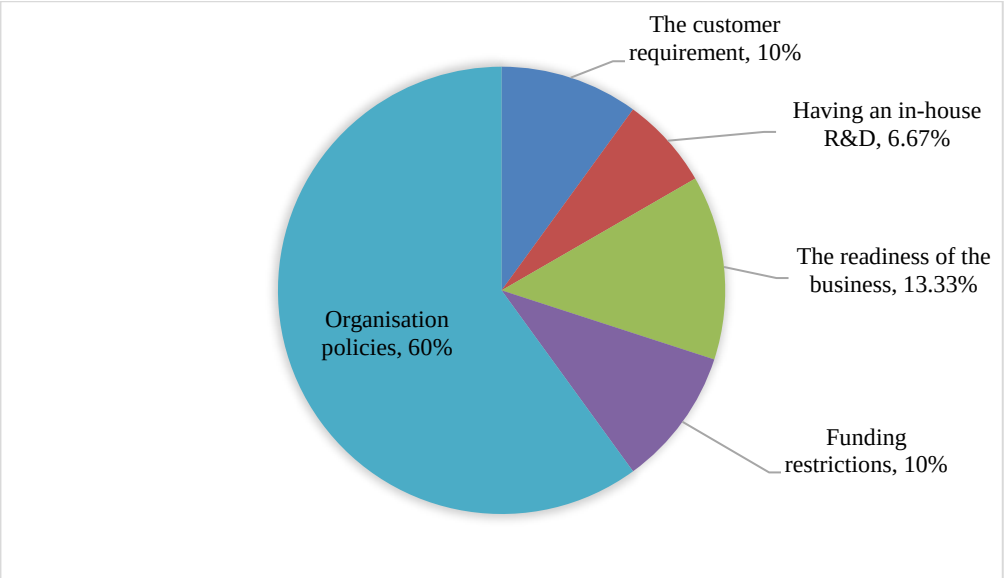


Figure 4.9: The main reasons for SMEs not engaging in R&D collaboration with government organisations in 2017 (n = 30)

Firstly, the survey data indicated that organisational policy had a significant effect on R&D collaboration with government organisations. Secondly, the readiness of SMEs proved to be an obstacle to them collaborating in a project with government organisations. Some did not have the necessary resources, such as the machinery, tools and skilled workers, to develop an R&D project in collaboration with the government units. Thirdly, government funding restrictions affected access to R&D funding. To avoid duplicated funding by government organisations, some granting agencies indicated that businesses could not receive funding if they were receiving grants from other organisations. In addition, customer requirements were indicated as being an obstacle to R&D collaboration between SMEs and government organisations. Technology in the business would change if the customer requirements were to change. Lastly, a few of the companies had in-house R&D units; thus, they did not want to cooperate with external agencies.

By contrast, the positive feedback from 30 SMEs who participated in R&D with government organisations cited five main reasons. Firstly, R&D engagement with

government organisations creates a distribution of knowledge between the SMEs and government organisations. Secondly, collaboration with government units could improve R&D by increasing the efficiency of work processes and decreasing the input cost for SMEs. In addition, collaboration with the government units helps SMEs to obtain tax reductions of up to 300%, while partnerships help to extend networking.

It could be concluded that government organisations and SMEs are linked weakly. The interviews suggested that the quality of technology and the benefits of the R&D projects or collaborations should be reviewed carefully before entering a collaborative agreement with external agencies (see the Case of T1 detail). The imbalance in the levels of technology in terms of knowledge and devices between SMEs and government organisations or academic institutions has affected the speed of work, or might be a burden that increases capital funds.

Furthermore, the interviews indicated that some of the government's or universities' technologies did not match or lagged behind the SMEs' requirements (see Appendix IX). Moreover, most of these technologies are not ready for commercial use because researchers have developed their knowledge in the laboratory, which is completely different from the operational area. Most government and university-based technology or knowledge are part of the macro picture of businesses, as they are not ready for application, are expensive, and require a lengthy period of development before being ready for commercial applications.

Moreover, organisational policy seems to be a major obstacle to strengthening the partnership between SMEs and government organisations. In addition, there is an aftereffect of less collaboration with external agencies, either government organisations or academic institutions, because business policies did not prioritise R&D to drive the business.

Current research has indicated that the most powerful factors in strengthening SMEs are accessibility to knowledge and innovation available via business cooperation (Basile, 2012; Wang and Wu, 2012). In addition, the process of R&D collaboration amongst businesses has the benefits of knowledge transfer, know-how sharing and so forth, which creates an ecosystem called 'open innovation' (Chesbrough *et al*., 2014).

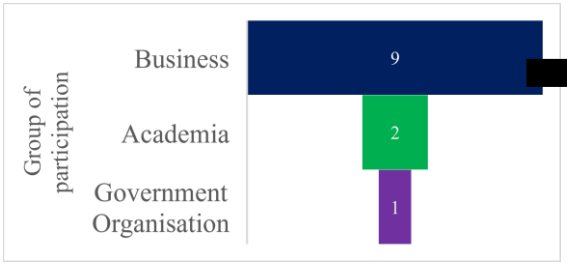
Therefore, the opportunity to improve the competitiveness of SMEs might be related to the number collaborations they have with other organisations (Mancinelli and Mazzanti, 2009).

However, this research found that the target group for R&D collaboration with SMEs was the private sector rather than government organisations or universities due to their organisational policies. Nevertheless, R&D activities in SMEs in the seafood sector continued during 2013–2017, while interactions with external R&D units increased to a lesser extent in 2017 (Figure 4.7). This implies that SMEs in the seafood sector can engage in R&D activities in various ways.

As mentioned above, the demand side influences the R&D engagement of Thai SMEs in the seafood industry. Although the rate of participation with external agencies such as universities and government units is not high, R&D expenditure in Thai SMEs in the seafood industry continues to increase. Thus, it seems Thai SMEs in the seafood industry understand the positive effect of R&D investment and have the ability to conduct R&D and innovation activities on their own. Thus, the possibility is that this group will constantly engage in R&D because it produces satisfactory outcomes. The next section compares the market performances of the Without R&D engagement group and the With R&D engagement group to clarify the role of R&D activities in the performances of the businesses.

4.5 The interview results

The sample interviews in this research have been divided into three groups, namely businesses, government organisations and academic institutions. The main interview questions are provided in Box 3.1. Furthermore, to clarify the interviewees' answers, the researcher asked additional questions within the scope of the main structure of the original question. There were 12 interviewees in total, composed of nine business people, two members of academic institutions and one member of a government organisation. Their details are shown anonymously in Figure 4.10.



Group of participants	Case code	Participant descriptors
Business	B01	Director of Innovation group
Business	B02	Business Manager
Business	B03	Industrial Manager
Business	B04	Engineer and Business partner
Business	B05	Industrial Manager
Business	B06	Engineer and Accountant
Business	B07	Business Manager
Business	B08	Business Manager
Business	B09	Industrial Manager
Academia	U01	Executive Director
Academia	U02	Executive Director
Government organisation	G01	The director of a Non-Profit organisation

Figure 4.10: The total number and anonymous summary of research group participants

The detailed summary of the individual interviews is provided in Appendix IX. A SWOT analysis was used to analyse the results of the interviews. The summary of the interview results for Thai SMEs in the seafood industry in the context of the R&D is presented in Table 4.2.

Table 4.2: The summary of the results of the interviews of Thai SMEs in the seafood industry concerning R&D in Thai SMEs in the seafood industry via a SWOT analysis

Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
S1) Thai SMEs in the seafood business can invest in machines and tools to support the R&D process; however, most R&D in the sector are simple methods that create minor changes, such as packaging, flavour. **S2)** The Thai SMEs in the seafood industry can produce high-quality products following international export measure conditions. **S3)** Thai SMEs in the seafood industry have both budgets and experts' readiness to organize the training programmes. **S4)** The business owners understand the role of R&D to	**W1)** SMEs in the Thai seafood industry did not have money and workers to do R&D. **W2)** The R&D project contributed by the government to increase the R&D investment in Thai SMEs in the seafood sector did not match the users' requirements. **W3)** The customer requirement has a significant effect on the R&D activities in Thai SMEs in the seafood industry. Meanwhile, the customers remain in the same group and require minor innovative products. Thus, the seafood products in Thailand have a low level of development; in other words, the R&D in	**O1)** The government of Thailand has established measures to activate R&D expenditures in Thai SMEs, such as tax exemptions. **O2)** Customers require high product standards that indirectly force Thai SMEs in the seafood industry to focus more on R&D to provide a high-quality standard to their customers. **O3)** Networking with academic institutions and government organisations could fulfil the lack of resources in SMEs and extend the scope of an innovative process to cover the whole business. **O4)** Foreign investors are interested in using Thai SMEs in the seafood business	**T1)** Thailand faced trade barriers from international trading partners, e.g., illegal, unreported and unregulated fishing, the quality standard, Agile Dumpling. That makes Thai producers, particularly SMEs, lose their focus on R&D to solve the problems they face. **T2)** Thai SMEs in the seafood industry are being the nominees of foreign investors or LEs frequently. SMEs' resources have been applied to process innovative products at those companies with no transference of the knowledge or technology to SMEs. **T3)** The Thai education system that produces workers does not match the business requirements. Most newly

Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
increase the efficiency of the business and determine R&D to be one of the policy drivers in SMEs.	Thai SMEs in the seafood industry did not develop as much. **W4)** Thai SMEs in the seafood industry did not understand the patent mechanisms to protect their benefits. **W5)** The different levels of education of workers affect the knowledge-sharing process. Some workers in Thai SMEs in the seafood industry have a low level of knowledge that creates a gap in communication during work processes. This also might be a problem during product or process development within the academic research unit. **W6)** Some Thai SMEs have a limited area to install machines in their businesses. Thus, the company has decided to reduce investments in machines and tools.	as the production line's base. That is why increasing R&D expenditures of the nation and workers can learn the R&D processes on the job.	graduated workers cannot work because they cannot connect classroom knowledge to real-life work. **T4)** The worker system in Thai SMEs in the seafood industry has been influenced by neighbouring countries. Because the minimum wage of Thai labour, around 100 Baht in 2013, increased to at least 300 Baht in 2017, some Thai employees in SMEs were replaced by an alien labour force that earns lower wages. Although the Thai government later solved this problem by adjusting all wages of labour to the same rate, Thai SMEs lost the know-how to develop the product or process of work to those alien labourers already working. **T5)** Some SMEs failed to create a linkage with universities, as some R&D projects on which SMEs co-work with

Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
			universities have high prices and are not ready to use in the business. Furthermore, university experts cannot take care of the R&D project because passing on the knowledge of R&D projects to the company is not their priority and will not promote them to have a higher academic level. Thus, the mechanism to access a university-linked R&D project is difficult for SMEs; it requires a high budget and a long period to drive an R&D project. **T6)** There is a discrepancy in the ratio of level of education to salary rate. A newly graduated student, particularly one at a high degree level, will not work at the starting salary of 15,000 Baht. This affects SMEs in the seafood business that cannot find skilled employees.

The main strengths of R&D in the Thai SMEs in the seafood industry have been summarised according to four points. The Thai SMEs in the seafood and fishery industries have the ability to invest in R&D on machine and tools and employment (S1 and S3, Table 4.2), and the key factors in driving R&D in these groups are the business owners and government regulations (S2 and S4, Table 4.2). Business owners who understand the role of R&D in the business' development include R&D in their policies and plans to improve the efficiency of the business.

Leydesdorff (2010) stated that management policy was key to the survival of firms; if businesses do not have a strong structure, the other components of the main structure will not be established or might collapse. In other words, if R&D is not one of the business policies, the activities related to R&D will not receive sufficient budget or employees to operate effectively.

The weaknesses of the Thai SMEs in the seafood industry in the context of R&D were identified based on the interview data, and were categorised as six points. Although the Thai SMEs in the seafood and fishery industries have the ability to invest in R&D, most SMEs remain faced with financial constraints, and limited resources, which have affected the R&D expenditure of these businesses (see W1 and W6, Table 4.2). Moreover, R&D trends in Thai SMEs in the seafood industry have only experienced minor improvement because consumer behaviour has changed very little (see W3, Table 4.2). In other words, dramatic changes to products might cause the business to risk market failure. Therefore, the result of R&D investments may only be reflected in minor changes to products or process, such as packaging development, flavour improvement, and so on (Early, 1997; Intarakumnerd *et al.*, 2011).

Thus, collaboration via networking will be an activating factor for R&D engagement in Thai SMEs in the seafood and fishery sectors, and will provide a competitive advantage due to the economic growth of the businesses (Ranga and Etzkowitz, 2013). Hou and Mohnen (2013) stated that cooperation amongst the main stakeholders in the triple-helix model not only increased the R&D activities in businesses, but also increase the number of product innovators in China. The main role of external organisations for SMEs is as consultants (Kim *et al*., 2012). Furthermore, the main activities during collaborations between universities and companies are obtaining

grants to support R&D projects and organising training programmes for businesses (Kim *et al*., 2012).

Even though cooperation between universities and the industry to improve the efficiency of products or process via technology and innovation are critical is for Thai enterprises (Brimble and Doner, 2007), the industrial manager indicated that the R&D collaborations with the government or universities did not satisfy SME's requirement (see W2, Table 4.2). In addition, the knowledge gap regarding communication between the businesses and consultants from the academic arena is an obstacle to R&D project development (see W5, Table 4.2).

In this regard, Tanticharoen *et al.* (2008) stated that the lack of communication between technology developers and users was the main obstacle to technological development. In addition, concerns about company secrets was an impediment to knowledge sharing between partners (Tanticharoen *et al.*, 2008). Thus, most empirical studies of the case of Thailand have attempted to find intermediaries to communicate amongst participants in other sectors. Therefore, it is necessary to strengthen the sector via both internal and external R&D - inside knowledge is the result of knowledge sharing between businesses, while outside knowledge is derived from academia or government organisations. Nonetheless, Thai SMEs in the seafood industry still experience the obstacles of limited knowledge or liquidity in their businesses, although some R&D activities exist in these businesses due to government regulations (see W2, Table 4.2).

Although the Director of the Food Innovation Centre indicated that SMEs in the seafood industry did not understand the process or benefits of patent registration (see W4, Table 4.2), the overall trend in patent registration in the seafood and fishery industry has increased dramatically over the past 20 years (Intellectual Design Group Company Limited, 2018). From 1997 to 2010, the rate in patent applications in the seafood and fishery sectors was consistent at fewer than 1,000 patents; however, rate almost doubled from the previous year in 2007. The number of patent applications in the seafood and fishery sectors increased to over 2,000 and remained the same during 2011 – 2018 (Intellectual Design Group Company Limited, 2018).

From the points of views of the interviewees in this thesis, the threat analysis could be summarised as six points. Although seafood and fishery exports have had a positive impact on the economy, the seafood industry has faced many challenges, with both internal and external factors having arrested the growth of the Thai seafood market (see T1, Table 4.2). Thai producers of seafood products have experienced anti-dumping and countervailing duties from importing countries. Furthermore, the Thai seafood industry has encountered trade tariff barriers in terms of high quality control and traceability (Sowcharoensuk, 2019).

Labour is one of the necessary factors for driving the seafood and fishery industries. However, most new graduates do not have work experience, and are unable apply to apply their academic knowledge to their work (see T3, Table 4.2). In addition, the minimum wage rate might be an obstacle to recruiting new staff, particularly workers with postgraduate degrees (see T6, Table 4.2). This has resulted in an increase in the number of foreign workers who are prepared to work for lower wages than are Thai workers (see T4, Table 4.2), which may also be the reason for knowledge leaking from Thailand to competitive countries via overseas workers.

Initially, R&D projects in the Thai food business in 1990 were only conducted by universities (Intarakumnerd *et al*., 2002). The research in that period entailed basic research to establish R&D in the food business and to maintain the food supply of the nation (Intarakumnerd *et al*., 2002). Thus, R&D budget allocated by the government was limited to university grants. The cooperation between universities and the industry to improve the efficiency of products or processes via technology and innovation were critical for Thai enterprises (Brimble and Doner, 2007).

However, the analysis of the interviews revealed that SMEs rarely implemented the R&D projects initiated by universities due to the knowledge gap. Businesses were unable to use the microscale results obtained in R&D laboratories in practice because the results were different on the macro scale of industry (see T5, Table 4.2). Moreover, collaboration in R&D project with universities was quite expensive, and did not guarantee a result. Thus, SMEs decided to buy completed R&D work and apply it in their business rather than develop R&D project with universities (see T5, Table 4.2).

The analysis of opportunities for Thai SMEs in the seafood industry based on the interview result could be divided into four points. The synopsis of two of the points related to SMEs' opportunities is linked to the triple-helix mechanism to support business development (see O1 and O3, Table 4.2).

In addition, the market requirement was the most powerful factor in increasing the R&D activities of Thai SMEs in the seafood industry (see O2, Table 4.2) because R&D has proved to increase the quality of products. In this regard, The Intellectual Design Group Company Limited (2018) stated that R&D in the seafood sector remained focused on process and product development to secure its market position in terms of maintaining its previous market and finding new local and international markets to access.

Quality standards are key to market penetration, particularly for export markets. Many partnership countries have applied quality standards as a non-tariff barrier to Thai seafood products. Thus, R&D has been used as an advanced tool to increase the quality standards to meet the export conditions and to support the continuous market growth of the sector. Furthermore, R&D has been included in packaging development to maintain the freshness and purify of the products, and has been applied as a tool to control prices in the market.

Moreover, international trade and foreign investment are important ways of the national economy to recover, particularly in the case of the Thai economy, which experienced a lack of liquidity that affected the overall GDP.

The Thai seafood and fishery industries are amongst the world's main seafood exporters, which could motivate foreign investment in the sector. Foreign investors target Thai SMEs and exploit their weaknesses in terms of limited money for collaboration. Thai SMEs in the seafood industry have experienced the same situation as other sectors in that foreign investors have expressed interest in investing in their businesses (see T2 and O4, Table 4.2). Nonetheless, this is an excellent opportunity to capitalise on overseas trends.

4.6 Case study analysis

In this section presented the result of four SME cases within the seafood industry: two cases related to traditional products and two cases related to value-added products. The two cases that produced traditional products were the dehydrated shrimp business and the jellyfish business. Meanwhile, the two cases that produced value-added products were the fried-shrimp head business and the crispy anchovy business. Interviews were used to garner insights into how these businesses operated, with each interview lasting from one to two hours. Moreover, the traditional product interviews took place in local factories, which allowed the researcher to observe the line production processes. However, the two companies producing value-added products did not permit access to their factories because they wanted to keep certain business practices secret. In a similar spirit, the audio and pictorial records of these interviews and visits could not be published in this thesis in order to protect business privacy and confidentiality.

This section examines the lessons learnt by the business owners via data and insights from research materials, such as interviews, annual reports, grey literature, websites, social media, and related documents. The individual cases will be explained separately, as each business in turn will be examined in terms of their general information, market context, organisational management, business limitations and problems, and the role of R&D in the business. The secondary data from the published and unpublished documents will be used to compare and contrast in-depth results from the general cases and to compare these businesses with other cases found in the literature review.

The aim of this research is to explore the role of R&D effect on the Thai SMEs in the seafood business development. Also, networking might provide key support for R&D activities in this group. Therefore, the structure of the analytical method used for the case studies has been divided into four main substructures, namely:

1) Business profiles
2) R&D aims and activities
3) The role of R&D in business development in terms of market and product performances
4) The role of networking in R&D development with regard to academia, government organisations and other businesses

Owing to the different groups used in the case studies, namely, two traditional product cases and two value-added product cases, the data will be compared across both within and between groups.

4.6.1 The business profiles for the four case studies

The four case studies examined in this research consist of two traditional product cases and two value-added product cases. Two case studies involving traditional production, which means that the applied technology may simply change the original product slightly, are used in this research: a dehydrated shrimp business and a processed jellyfish business. The cases cover small-sized businesses located in Ranong province in the southern part of Thailand. The code for this group is "T".

Meanwhile, the other two cases are value-added product businesses, meaning that they increase the value of seafood products by using middle to high technology to create new products. The case studies used to explore value-added businesses consist of a fried shrimp head snack company located in the central part of Thailand and a crispy anchovy company located in the eastern part of Thailand. The code for this group is "V".

An overview of these four case studies is presented in Table 4.3.

Table 4.3: Summaries of the four case studies

Firm profile	**Traditional product cases**		**Value-added product cases**	
Case code	Case T1	Case T2	Case V1	Case V2
The main product of the business	Dehydrated shrimp	Processed jellyfish	Fried-shrimp head snack	Crispy anchovy snack
The participants	Owner	Owner	Owner	Owner
Age of the business (years)	50	1.3	6	7
Size of the business	Small	Small	Small	Small
The total number of employees (persons)	10	70	15	10

Firm profile	Traditional product cases		Value-added product cases	
Capital fund (millions of baht)	3,000,000	Less than 50,000,000	5,000,000	7,000,000
Organisational management system	Family business	Joint venture with the foreign investor	Family business	Individual owner
Obstacles/ limitations	• Lack of raw material • Fluctuations in price	• Lack of raw material • Fluctuations in product price	• Copied products • Lack of high-quality raw material	• Cannot control the quality of the product • Cannot enter new markets
Business progress	• The business owner adjusted some lines of production to produce the preserved food	• Continues to enter the export market	• Continuous growth but the owner does not want to jump into running a large enterprise	• No focus on R&D because the business owner has business and stakeholder problems • The business will be closing down

Note: The data collection period was 19th September 2018 – 4th February 2019

Brief business profiles are presented below.

Case T1: Dehydrated shrimp company

"Knowledge and networking will lead to sustainable business growth."
The owner of the Case T1 business
21st December 2018

This case covers a small enterprise that was established in 1969 in the Ranong Province in the south of Thailand. Fifteen to 20 employees are required to run the business, most of whom are Burmese because over the last 50 years, Thai labour laws have permitted lower wages to be paid to Burmese workers. The capital structure of the business consists of seventy percent of its funds go towards natural resources, 20% goes to wages and electrical services, and 10% is used toward other expenses. Working at its optimal efficiency, the business is able to produce 1,000 kilograms of dehydrated shrimp from 10,000 kilograms of fresh shrimp per day. The price varies from 600–800 baht per kilogram and depends on the size of the shrimp.

The business has faced various challenges in its attempts to create continuous growth. The high level of market competition and trade barriers have forced them to conform to quality standards and made traceability compulsory. Also, since Thailand received the yellow card caution, almost half of its fishing boats have been prohibited from fishing by the Thai government (Phanwichatikul, 2019). This situation has changed market mechanisms dramatically because while interest in the product remained the same, product availability was reduced. Thus, the prices of the resources increased, which, in turn, affected the capital funds of the business. In other words, the yellow card caution lowered the capital funds of the business. Therefore, the business owner declined export market orders because they could not guarantee that orders would be met under the terms of the new trade agreement and instead chose to focus more on the domestic market. Thus, they looked into ways to improve efficiency by reducing waste and increasing added value. To aid in this goal, the business owner attended business classes that helped them to acquire market knowledge and helped to lay the groundwork for a network of valuable contacts across the past five years (2013-2017).

Furthermore, the Ministry of Labour statute increased the minimum wage from 52 baht in 1981 to 310 baht in 2019, affecting the capital funds of the business directly. In addition, the business's limited funds posed a risk of obstructing the flow of work, especially with regard to attempts to establish innovative machines and tools with unknown value. Therefore, to ensure sustainable growth, the business devised strategies related to reducing uncontrolled input factors, such as the cost of labour and the cost of natural resources. Additionally, the quality of the product had to be brought up to a certain standard. Thus, to control the depletion of the capital fund, the business owner decided to reduce the labour force from 15-20 employees to 10 employees per day, replacing the dismissed workers with more efficient and less costly machines and tools.

Case T2: Processed jellyfish company

"R&D investment is a risk, but it is a necessary tool to get into the wider market"
The business owner of the Case T1 company
14th November 2018

The second traditional product case focuses on a small jellyfish business. The business is situated in the Ranong Province in the south of Thailand. The capital fund of the company is less than 50 million baht and it employs 70 employees, 20 of whom work in the office and 50 of whom work in the factory. The educational profile of the business shows that one employee holds a master's degree, two hold bachelor's degrees, 17 graduated from vocational courses, and the remaining employees are Burmese workers without higher educations.

Initially, the business owner worked as a broker, or middleman, between the primary seller and Mahachai Market in Samut Sakhon, which is located in the central part of Thailand and boasts the largest fresh seafood market in the country, for more than three years. This position helped the business owner to acquire a broad picture of the jellyfish business, including a sense of who the main players in the market were and an understanding of the various mechanisms by which the product is produced.

The owner worked in the jellyfish business in this area for approximately three months before moving to the Ranong Province, where it proved easier to secure cheap labour, lower the costs of operation, and the natural resources required to succeed in the market.

The average capital fund was 15-25% of the total sales per year, but in the peak sales periods, the average capital rose to 34-40% of the total sales per year. The capital fund has been divided into two pots: the main pot covers investments in materials and appropriates approximately 80% of the funds, while the minor pot covers investments in employees and public utilities and appropriates approximately 20% of the funds.

There were three types of final products:

1) Whole jellyfish: this product is produced by simply cleaning the jellyfish with water before selling it. The price of this type of product is 80 baht per kilogram.

2) Jellyfish parts and salted jellyfish: jellyfish are cut into parts that are separated before cleaning. The price of this type of product is 120 baht per kilogram. The shelf life of these products is approximately one year.

3) Washed jellyfish legs. The price of this type of product is 70 baht per kilogram. The shelf life of this product is approximately three months.

Case V1: Fried-shrimp head snack company

"Knowledge sharing to the public may increase the risk of business"
The business owner of the Case V1 business
9th November 2018

The business was established in the past four years in order to answer the motivational question: 'How can waste be used to add value?' The business owner started the business in 2013 with a capital fund of 700,000 baht. The staff of the business consists of 20 employees, five of whom graduated with diplomas and work in the marketing unit, and 15 of whom hold unspecified degrees that qualify them to work on the production line.

The organisational management of the business was modelled on the traditional family business framework, as is usually seen in small and medium-sized businesses, but the strategy used to drive the business and shape its policies was quite different from that of typical SMEs in that it involved the use of creative and innovative methods. After launching their product in the local market in 2015, the business owner decided to register for a television programme competition that aimed to encourage SME businesses in Thailand with prizes of 1 million baht. The competition provided feedback and commentary from experts in various fields. Ultimately, the business won the competition in 2015, giving them the money required to extend their business. Also, the competition provided the business with free promotions by connecting with a large TV audience, thus laying the groundwork for the business to develop its product and compete in various innovative programmes.

The business enjoyed continuous growth due to its consistent employment rate and its application of R&D machines and tools to reduce the time needed for certain processes and reduce the risk of injury. The growth rate of the business changed dramatically

from 350,000 baht per month to 130 million baht per month in just five years. Interestingly, 50% of the revenue was the result effective IT use, with the business using technology to communicate more effectively with customers and to market products more effectively on social media.

Case V2: Crispy anchovy snack company

"Who you know is more important than know-how"
The business owner of the Case V2 business
24th October 2018

The crispy anchovy business was situated in the Eastern Province of Thailand. The capital fund of the company was under 50 million baht, and they employed four workers on a permanent basis. The business modeled its strategy on the fried seaweed business model, which enabled it to experience dramatic growth from a small enterprise to a large enterprise in a short period. Initially, the business used fruit and seafood materials from the local area in order to produce the original product. However, the limited-time access to fruit materials interrupted the continuous business flow. Thus, the business line was changed to focus exclusively on fish material.

The driving motivation of this value-added product case was to form a network of useful contacts and alliances based on the principle of 'It's who you know, not what you know'. A strong knowledge network helps a business keep abreast of new developments and changes in government regulations. Furthermore, a network draws in specialist expertise from a variety of different fields. However, the primary problem for the business was its difficulty in maintaining high-quality control, a shortcoming that harmed its involvement in certain areas of the foreign market. In addition, its market strategy failed to reach a sufficient number of customers. Meanwhile, R&D was used to support the downstream production line through the packing process, qualitative testing, and so on.

In the next part, the R&D aims, the role of R&D in business development, and the role of networking in supporting R&D activities will be analysed for these businesses.

4.6.2 The purposes of R&D engagement

The main R&D aim for the case studies was to receive quality guarantees from the government. The other purposes of R&D engagement varied across the businesses. The R&D aims of the four case studies are summarized in Box 4.1

Box 4.1: The key interview details that emerged for 'the aim of R&D engagement' in the four case studies of SMEs in the seafood industry in Thailand

T1- R&D applied in the business to reduce the uncontrolled factors, such as the wages of employees, the price of natural resources.; also, R&D is used to raise the quality and accuracy of the product.

T2- R&D investment was applied to achieve quality control and extend the shelf-life of the products.

V1- R&D investment helps the business enter the niche market; also, R&D investment returns can be the source of funding for sustainable growth.

V2- R&D was applied for packaging and qualitative testing purposes only.

Key:

T1: Business Owner
T2: Business Owner
V1: Business Owner
V2: Business Owner

The business owner in Case T1 indicated that the business' R&D engagement had begun in the last five years. However, most R&D investments were directed toward machines and tools (costing approximately 3–4 million baht), instead of highly skilled workers. The reasoning was that machines could be operated easily and therefore did not require highly skilled workers with high salaries to operate them.

Nevertheless, the skills and knowledge of the employees still needed to be improved – a difficult task given that all the employees were employed on a part-time basis only. In order to solve this problem, the business owner decided to take training courses and then share any knowledge they acquired with their employees. In addition, the business

owner used these opportunities to update the business' understanding of market trends, regulations, and methods for entering new markets.

Then, the business owner gradually adjusted the protocols on the production line for workers operating in high-risk areas with machines and tools. These adjustments helped to reduce the product cycles, control the quality of the products, reduce the risk of accidents in the industrial area, and control the amount of capital expended per crop.

Thus, the R&D activities were used to raise the quality and accuracy of the product and to reduce the risks from uncontrolled factors, such as fluctuations in the price of labour and increases in price for in natural resources.

On the contrary, in Case T2, the business did not set out to engage in R&D. However, external environmental factors intervened and made R&D engagement a necessity; indeed, the needs of the export market and the high demand of customers forced the business to invest in R&D in order to increase product standards. Thus, the demands of the market were the key factor that forced the business owner to change the organisational management system from a traditional system focused on labour-intensive work processes to an innovation system that engaged in R&D activities.

The company's machine and tool investments helped to improve the quality of the product so that it could meet customer requirements. The machines and tools reduced the time needed for processes, increased product accuracy, and reduced the amount of labour needed. The machines and tools sped production up three times compared to manual labour. In other words, the machines and tools not only raised product standards, they also reduced the time, labour, and risk involved in the process.

Meanwhile, the original idea for Case V1 came from the question: 'How can waste be used as a valuable product?' The business enjoyed continuous growth owing to its consistent employment rate and its application of R&D machines and tools to reduce the time needed for certain processes and reduce the risk of injury. Interestingly, 50% of the revenue came as a consequence of effective IT use, with the business using technology to communicate more effectively with customers and to market products more effectively on social media.

The weak linkage with R&D activities in Case V2 resulted in the company's inability to control the quality of their product. R&D was used to support downstream activities, such as the packing process, qualitative testing, and so on. Thus, the business faced difficulties in maintaining high quality control, a shortcoming that harmed its involvement in certain areas of the foreign market.

All in all, government enforcement affected the R&D investments of Thai SMEs in the seafood business a great deal. Figure 4.11 presents a summary of the purposes of R&D engagement for the four case studies used in this research. Some companies considered the requirements they needed to meet to expand their accessibility to local and international markets. Meanwhile, the natural resource supply and limited input factors, such as money and the total amount of workers, may have induced businesses to focus on R&D investments in order to increase efficiency through reducing waste, creating value with the waste, and so on, thus moving on to produce value-added products for increased profits from the same input factors. However, these products had to meet the government's quality control standards before they could be sold.

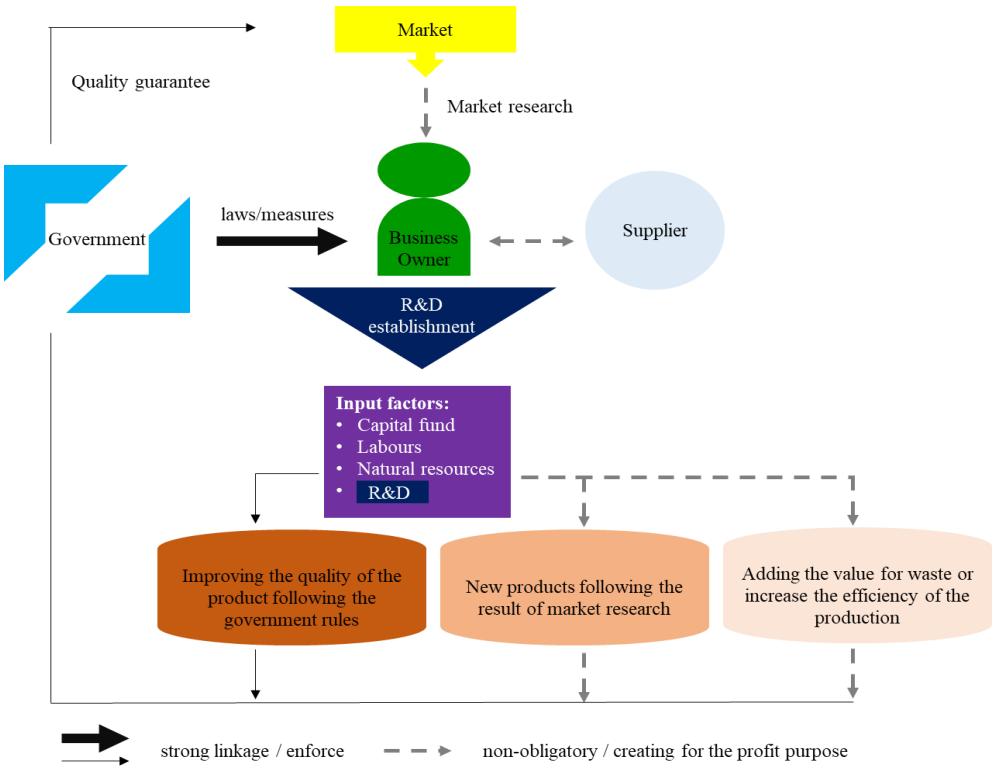


Figure 4.11: A summary of the aims of R&D engagement for the four case studies from the Thai seafood industry

The Thai government has set rules, or measures, to control product quality to meet international standards and protect the rights of consumers. All of the products in the market have to pass the quality guarantee. If the business owner ignores these rules, they may be restricted to a tiny market area or unable to sell their products. Thus, business must follow the rules and linkages with government organisations, particularly those involved in quality control, as will be discussed in the next section.

4.6.3 The role of R&D in business development

R&D affected business development, both in terms of market performance and product performance, in the four case studies. Box 4.2 presents the key interview responses regarding the role of R&D in business development in terms of market performance and product performance.

Box 4.2: Summary of the interview details that emerged concerning the role of R&D in business development in the four case studies of Thai SMEs in the seafood industry in Thailand

T1- Although R&D is the tool used to develop the new lines of development, e.g. value-added products, reduce waste in the production line, its contribution to knowledge is important in sustaining business growth.

T2- R&D helps to create new lines of products and expand the market area abroad.

V1- R&D affected new lines of products and dramatically increases total sales.

V2- The ready-to-use technology applied to create modern packaging affects the market performance of the business and allows dramatic growth in a short period. The business lacked market research and did not have their own R&D knowledge. That is the reason way the business faced a difficult time and the decision was made to close the business.

Key:

T1: Business Owner
T2: Business Owner
V1: Business Owner
V2: Business Owner

R&D activities affected product development in case T1. In the last three years, the product ratio shifted from 100% traditional product to 60% traditional product and 40% value-added product. The value-added product built on the traditional product by

mixing chili sauce and dehydrated shrimp. The price of the value-added product was 550 baht per kilogram. Even if the price per gram of the chilli sauce was lower than that of the traditional product, the chili sauce did not use 100% dehydrated shrimp, as it also included local herbs and other ingredients. Furthermore, the chili sauce helped the business to maintain their income during periods where they lacked access to the natural resources necessary to produce dehydrated shrimp on a mass scale, thereby reducing waste.

In the case of T2, R&D was used to develop the product for export. The total company revenue was approximately 200 billion baht per year, with 70 billion baht coming from the domestic market and 130 billion baht from abroad. Thirty percent of the export revenue came from Japan, and 70% came from South Korea.

Furthermore, R&D was used to create a new product line. Due to the short shelf life of the original product, the business owner decided to create a new line of ready-to-eat products by working together with the National Food Institution of Thailand. The product had a mark-up of around 200-300% of its original value and had a longer shelf life than the original product. The local market increased, and the new products sold faster there than in the export market.

In the case of V1, R&D activities help to increase production efficiency by controlling product quality, extending the shelf lives of products, and creating a new flavour line. Also, R&D activities increased profits dramatically.

A scalping strategy was employed to select the best-quality material for production. The quality control process began at the shrimp farm and ended with the packing process. The raw material came from a certified farm. The original product, namely the fried-shrimp head snack, came in a variety of flavours, including Tom-Yum, green curry, and Pad Thai. Then the chilli paste product was developed to manage the excess waste from the production line. According to the business owner, the product had to meet certain health standards. Thus, the materials and ingredients conformed to health regulations, such as maintaining low sodium levels and high calcium levels.

R&D helped production increase from 2,000–3,000 packages per day to 10,000–20,000 packages per day, depending on customer requirements. Furthermore, R&D helped to maximise the strengths of the business by improving the drying and storage processes to extend the shelf life of the original product to up to a year, a feat that competitors could not manage.

In Case V1, the business's goal was to increase turnover from 350,000 baht per month to 1 million baht per month. The strategy of the business in the first and second year was modelled on the pull strategy and consisted of three key steps: 1) trialling the product and managing the sale promotions, 2) producing a variety of flavours, and 3) registering exhibit booths at the international and local exhibition levels. The third step came about because the business had problems with copied products. Thus, it was essential to save time and manpower by connecting with customers at exhibitions and by using online marketing. Online marketing was conducted on blogs and apps like Facebook and Line[13]. Meanwhile, direct communication was made with customers through exhibit booths, where the products could be screened and selected by potential foreign investors. Also, co-branding with an international brand helped to reduce the risk of becoming involved with an unprofessional dealer. In the past five years, the business had enjoyed continuous growth, expanding from sales of 350,000 baht per month in 2012 to 130 million baht per month in 2016.

The business then enjoyed a continuous increase in sales to more than 10 million baht per month and it had the potential to evolve into a large enterprise in under four years. However, the business owner wanted to maintain the business's status as an SME because they did not want to bear investment risks and could not benefit from government support. Thus, the business owner decided not to transform the business into a large enterprise.

[13] Line application is the freeware application that was original subsidise by a Tokyo-based subsidiary by a South Korean internet search engine namely Naver Corporation. The line is the communicated application on the smartphone and computer. Line user can share texts, pictures, audio; recently, line application had developed to provide digital finance service and entertainment services.

In the case of V2, the business needed to create modern packaging in order to make a strong impression on the customers. However, the business did not apply a modern touch when creating its packaging, opting to reject R&D opportunities in this area and instead relying on ready-made packaging. Thus, they lacked marketing knowledge, which created an obstacle to developing their product and process. Furthermore, cooperation with One Tambon One Product (OTOP) without consideration for quality control negatively impacted the consistency of the taste and quality of the product. In addition, they lacked an optimal business plan and effective marketing strategy.

The business owner thus faced difficulties in running the business. Any R&D investments at this stage would most likely have had to be done in conjunction with market research. However, the business owner was considering closing down the business to reduce the loss in capital and focusing on profitable product lines.

In sum, R&D impacted both market performance and product performance in the four case studies on Thai SMEs in the seafood industry. Table 4.44 presents the details of the interview responses regarding the role of R&D in terms of market performance and product performance for these four case studies.

Table 4.4: The interview details regarding the role of R&D in the business performances of the four case studies involving Thai SMEs in the seafood industry

Code case	T1	T2	V1	V2
R&D on product performance	• Creating a new line of the value-added product and changing the ratio of the overall product from 100% traditional product to 60% traditional product and 40% value-added product • Reducing the production period to reduce costs	• Increasing the shelf life of a product • Creating a new line of products	• Scaling up the product from 2,000–3,000 packages per day to 10,000–20,000 packages per day • Extending the shelf life of the product up to a year • Creating a new line of products	• Creating a modern design of the packaging that attracts the customer • Extending the shelf life of products • Creating a new line of products

Code case	T1	T2	V1	V2
R&D on market performance	• Increasing the value of the product, leading to more profit for the business per unit compared to the original product	• Increasing the value of the innovative product by around 200–300% of the original product's value	• Increasing turnover from the target 350,000 baht per month to 10 million baht per month	• Increasing the outcome of the business from around 300,000 baht per month to more than 10 million baht per month

The main role of R&D in product performance was extending the shelf lives of products and creating new lines of products. Furthermore, R&D helped add value to production line waste and scale up products, leading to reductions in cost.

R&D impacted product development through new flavours, new packaging, primary value-added products, and so forth. These improved products met market requirements and changed profits dramatically, particularly in the case of V1 and T2. However, the change seen by Case T1, although positive, fluctuated according to market requirements.

Case V2 applied ready-to-use technology to create modern packaging that attracted customers in the first product launch period. However, they lacked their own R&D knowledge and did not continue to develop their products. As a result, there was a dramatic decrease in outcomes to the point that the business considered exiting the market.

4.6.4 The role of networking in R&D engagement in businesses

Thai SMEs in the seafood industry must create linkages with government organisations to receive quality standard guarantees. These businesses engage with other businesses or associations to receive updates regarding news, regulations, and so forth, not for R&D contributions. Meanwhile, academia has weak linkages with this group due to high costs and long R&D project periods compared with the conditions under which the group works with government organisations and other businesses.

The details regarding the external organisations that support R&D engagement in the four Thai SMEs involved in this research are summarised in Box 4.3.

In Case T1, the business strategy was based on the triple helix network model, which lays the foundation for the government, academic institutions, and businesses to work together. Normally, a business owner would become a member of a local association in order to receive updated news, statutes, and knowledge. However, in this case, the limited knowledge of the local association members forced the business owner to seek help from an academic figure. Then they registered for a training course provided by government organisations and the local university and used this opportunity to acquire needed skills.

In the case of T2, the limited knowledge and skills bank of the business's workers affected its R&D engagement. Thus, R&D linkages with external organisations were created with government organisations because the business owner did not wish to work with an academic institution due to a lack of trust in process by which the product would be produced within such a partnership. According to the business owner, in order to work with a university, the business must show evidence that it has a substantial capital fund whilst also proving that any financial investments will not be used purely for commercial gain. Furthermore, the systematic production used by the company did not require the sort of sophisticated technology that an academic institution could help to support. Therefore, it was decided that the target partners should be government organisations at the local level and local associations.

Correspondingly, in the case of V1, the business owner intended to protect the secrets related to how their product was developed, but the company depended on connections with universities, farmers, and other businesses to improve the overall efficiency of the product. Thus, certain information had to be shared with the business's knowledge network. Unfortunately, the business faced copycat issues, but the business owner used this crisis to become a co-branding business partner. This experience made the business owner wary of sharing knowledge with the public, and they no longer wanted to create a network with other businesses if it could be avoided.

Box 4.3: The key interview details concerning the role of networking in R&D engagement in the four case studies of Thai SMEs in the seafood industry in Thailand

T1- Working with government organisations and academia is the best way to fill knowledge gaps through training courses to improve the efficiency of the business, particularly product and process development.

T2- Suspicions regarding the business benefit are key in a decision not to create linkages with the universities.

V1- The business creates a linkage with the government organisation because the government laws force them to pass the quality guarantee, while the business owner did not intend to work with the universities to keep business secrets. Co-branding with other businesses solved the copied product problem, but it made the business owner worry about revealing information to the public.

V2- Creating a network is more important than R&D investment. Networking might help the business owner find a special channel through which to acquire privileges from the government organisations or academia that bring small risks to the business. On the contrary, the business might face a high risk from an R&D investment failure or unpredictable result.

Key:

T1: Business Owner
T2: Business Owner
V1: Business Owner
V2: Business Owner

Also, the business owner did not want to work with a government organisation or an academic institution to create sophisticated technology for the business. Indeed, the R&D used in the production process came primarily from learning from observations of the production line. Nevertheless, government regulations required that the business pass certain guarantees in order to ensure the quality of the product before launching it on the market. Thus, the business had to engage with a government unit.

Meanwhile, in the case of V2, networking was a higher priority than R&D investment. The driving motivation of Case V2 was to form a network of useful contacts and alliances based on the principle of: 'It's who you know, not what you know'. A strong knowledge network helped the business to keep abreast of developments and government regulations. Furthermore, the network drew on specialist expertise from a variety of different fields.

All four case studies in this research engaged with external organisations with various goals. In three case studies, namely Case T1, Case T2, and Case V2, the business owners wanted to participate in networks to strengthen their businesses. To the contrary, Case V1 wanted to create linkages with external organisations to achieve a quality guarantee. Figure 4.12 shows a summary of the networking done to support the R&D activities of the four case studies of Thai SMEs in the seafood business.

All four case studies created a linkage with a government organisation to obtain a quality guarantee. Furthermore, due to the limited knowledge of their workers, Cases T1 and T2 created linkages with government organisations via training programmes, R&D projects, and so forth to acquire the knowledge needed to improve their products. However, in the case of V2, the aim was to engage with government organisations to obtain privileges, such as free areas for exhibitions, notice of upcoming updates in regulations, and so on. They had no R&D focus when engaging with these organisations.

Meanwhile, in order to keep Case V2's business secrets, the business owner developed its products with in-house R&D and engaged with government organisations for quality guarantee purposes only.

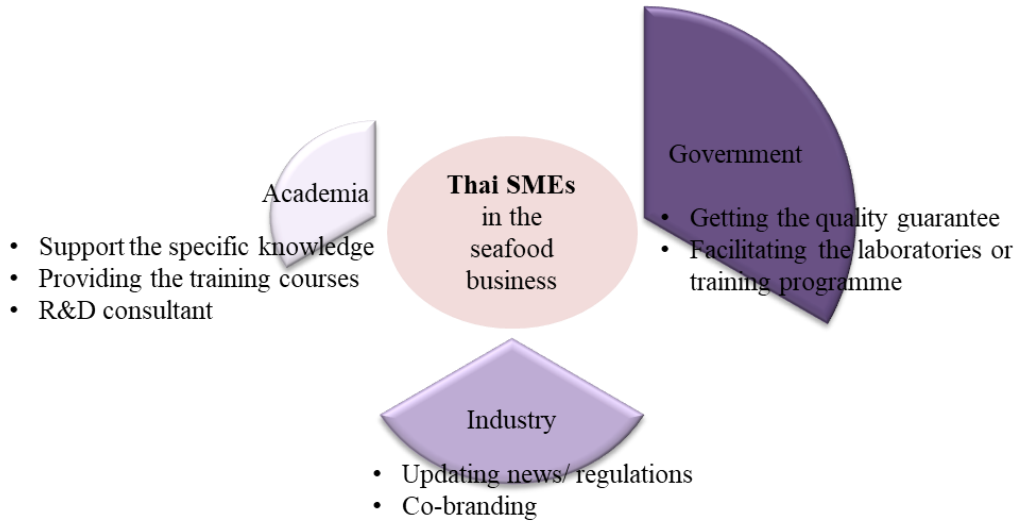


Figure 4.12: Summary of the networking done by the four case studies from the Thai seafood industry

However, the aim in engaging with the other businesses or associations in all case studies was to receive updated news, regulations from the government, and so forth, not R&D help. All the owners agreed that sharing knowledge or technology with the public carried risks in terms of copied technology or products in a highly competitive market.

For a business to maintain its status as an SME, it must acquiesce to limits to its growth, such as in labour and costs. Therefore, the government uses the SME support strategy to solve SMEs' weaknesses. However, this economic policy has affected the top competitors in the domestic market, pressuring them to increase their efficiency. Meanwhile, to some extent, the businesses had survived in the market by copying products and developing them further. Thus, the businesses did not want to acquire business partners and risk giving away their secrets and thus experience less progress in R&D than they otherwise would have.

Meanwhile, academia is not a main target for collaboration in the opinion of the four case studies in this research. Running R&D projects with a university consumes more time and money compared with working with government organisations or other businesses. In addition, university laboratories operate on a small scale that is far from the macro scale employed by businesses. There may be a long period required in which to install and adjust technologies, machines, and so on. from the micro scale to the macro scale.

In sum, there has been much research into the impact of R&D engagement on SMEs (World Bank, 2018b; McGuirk, Lenihan and Hart, 2015; Acs, Audretsch and Feldman, 1994). However, Community Innovation System (2012) reported that SMEs employ alternative methods to become innovative in their approaches. In this research, the analysis of two case studies showed that the Thai SMEs in the seafood industry have the capacity to engage in their own forms of R&D.

The reason for R&D was different for each business. In the dried shrimp business, the owner used first-hand, on-the-job experiences to make adjustments to business processes. Meanwhile, the jellyfish business owner was forced by government

regulations regarding traceability and foreign investment to improve business practices via R&D.

In addition, both T1 case and T2 case did not want to increase their workforce or invest in employees with science or engineering backgrounds, as such shifts would be too costly. Instead, to save on employment costs, the business owners hired Burmese and poorly educated workers. Thus, a weakness in these businesses was that they lacked expert employees capable of bringing specialist knowledge to bear on business practices, so a business partner had to be brought in to fill in these gaps.

Partnering with a government organisation and an academic institution were the two options available to the business. However, from their point of view, the local academic institution’s knowledge was not particularly useful, it wasted valuable time in the trial process, and it required too great an investment. Thus, they chose a government organisation in Bangkok to be their business partner. The cooperation between the business and the partner brought benefits, such as a scrupulous training programme, quality control testing, and positive associations.

Table 4.5 showed the summary of R&D in four case studies in this thesis could be reflective of the R&D development model explained in Section 2.1.

Customer requirements lead the direction of a business, rather than trends in technology. The business owner sets the business's direction based on the trends in the market and then steps back to consider what they have, especially R&D. Government organisations are the main players in driving all four cases in this study, while the demand-pull or customer requirement raises the main ideas for R&D development in all four cases. Regularly, government organisations are involved as regulators and ensuring quality guarantees in the seafood industry in Thailand. Meanwhile, further government organisations provide, e.g. financial support, skilled expertise, training programmes, to support business development, though their level of involvement varies according to different businesses' needs.

In cases T1 and T2, the businesses want to access a new market area but do not have the skills or knowledge to operate in this new area of work by themselves. In this regard, government organisations could support the knowledge gain and upskilling of workers. Also, government organisations could contribute as service providers in terms of supplying analytical tools that reduce the monetary burden on the two companies in the initial stage of accessing that new market area.

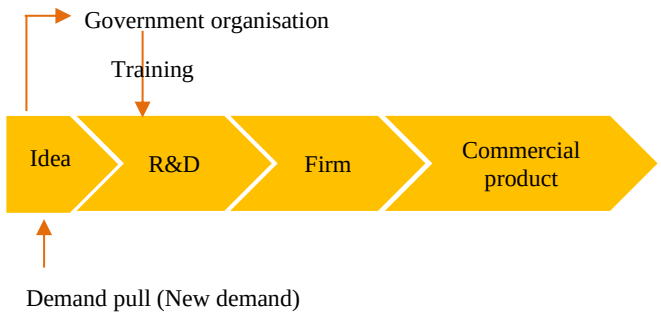
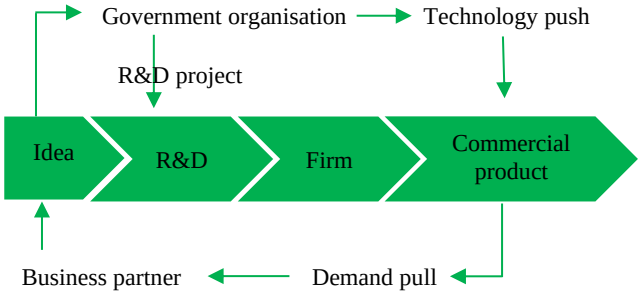
These businesses' drive to access a new market is the result of customer requirements in both local and international markets. To increase their access to the new market or expand their business to reach customers abroad, creative ideas are necessary. Also, R&D activities are essential tools for realising a business owner's ideas in the manufacturing process and bringing those to customers in a limited timeframe.

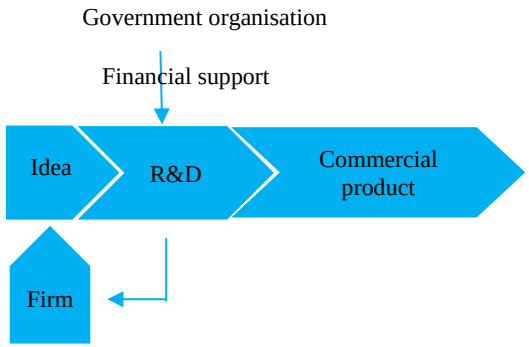
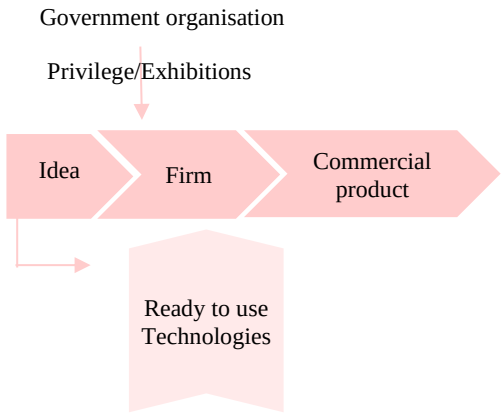
The trend of technology pushes the T2 company to face new challenges and develop. Customers' requirements have forced them to increase their production efficiency, to match a broad range of needs in an international market. Technologies push the direction of business development, based on R&D, to move far from their initial plans when the business was first started.

In contrast, R&D development in V1 casework in the close system through government financial support. However, since the business owner's vision is to access the global market, quality guarantee and financial support remain necessary for increasing the scale of production.

In the case of the V2 company, the company cannot synchronise the business idea with the market trend using R&D tools. The point of development is that the business owner drives the business with an idea but lose R&D development and drove the business with the commercial technology. Further, they cannot see the market trend; thus, the business can profit quickly but is not sustainable in terms of competition if the business cannot create a unique product or find a market area in which to survive.

Table 4.5: Summary of the R&D model used to develop the four case studies in this thesis

Case studies	Main actors or Key drivers of change	A summary of the seafood case study	The brief business-driven model
T1	Competitors	The business owner got the idea to create a new line for a product, while decreasing the total amount of natural resources that they need to feed into the production line. However, the business owner did not have enough knowledge to improve the products and processes by themselves. Thus, government organisations the main stakeholders, as they may supply R&D knowledge to Case T1. They can develop the business's processes/tools to reduce the time required for the production process and generate the new product line, supporting the business to bring this to the market.	
T2	International customers' requirement	High demand from customers abroad has affected company T2 in that it must get a quality standard guarantee before exporting its products. For this reason, foreign business partners have forced the Thai partner to invest in R&D infrastructure and tools. Furthermore, to extend the reach of the business to the ready-to-eat market, company T2 has decided to work with a government organisation's experts to engage in product-related R&D.	

Case studies	Main actors or Key drivers of change	A summary of the seafood case study	The brief business-driven model
V1	Business owner	Company V1 carries out R&D in an in-house unit. The business owner wants to add value by using surplus seafood products or waste, like the heads of shrimp. Thus, an idea and preliminary R&D process have come about from the business owner. To get the capital funding to expand the business's scale, the business owner has decided to submit their product to a government organisation-run competition.	
V2	Business owner	The business owner got the idea of running this business using low-value material, such as seaweed, coming from a large-sized company. They want to add value to local material, such as tiny fish. However, they do not want to operate all production lines. They decided to order local producers' requirements. Furthermore, they brought a packaging machine and tools from abroad to create innovative packaging that might increase customer attraction. As such, company V2 employed R&D in an indirect way. However, company V2 cannot maintain the quality of its products and cannot increase the scale of the total sales generated from its products.	

4.7 The effect of R&D on business development

The effect of R&D on business development has been studied according to two aspects, namely market performance and product performance (based mainly on survey results but interview comments also considered). The impact of R&D on market performance in terms of total sales and the export revenue of SMEs is discussed in Section 4.7.1. The role of R&D in product performance in terms of product development, the obstacles to applying R&D in the product development process and the role of networking in supporting the product development in Thai SMEs in this research are analysed in Section 4.7.2.

4.7.1 The market performances of the businesses

Empirical studies have indicated that, to enhance the sustainability of the business in a knowledge-based society, R&D is an essential factor in driving the growth of the industry, maintaining competitiveness in both local and international markets (Neito and Santamaria, 2010; Feng *et al*., 2017), and establishing new products on the market (Ghazalian, 2012). In other words, R&D is a crucial factor in increasing the competitiveness that contributes to marketing performance of firms. Market-based performance is part of the measurement of the success of a product. Most of the market-based indicators focus on the total sales of products, penetration rate, market share, and so forth (Molina-Castillo and Munuera-Aleman, 2009). The market performance used to explore the role of R&D in business development is expressed in terms of the total sales, including export revenue and domestic revenue.

A significant amount of research has shown the significant and positive correlation of R&D expenditure, the income of a business and export revenue. Therefore, the comparison of market performance consists of the comparison of total sales, which is the accumulated value of export income and domestic income, and the export revenue of two groups of SMEs, namely the With R&D group and the Without R&D group.

The Without R&D group consisted of businesses that stated they did not have R&D activity in their companies when answering the questionnaire, while the With R&D

group consisted of businesses stated they did have R&D activities in their businesses when responding to the questionnaire. However, some of the participants in the With R&D group did not indicate the details of their R&D expenditure in their answers; this group has been called the None group.

The data pertaining to the market performance of the business were obtained via a questionnaire, interviews and secondary data. To investigate the trend of R&D investment and its outcome, the market performance over five years (2013–2017) was analysed.

4.7.1.1 Total sales

Total sales refer to the accumulated income of the business, including local and export income. The highest total sales in the Without R&D group within the range of 1-250 million baht increased continuously over five years (2013-2017). By contrast, for the With R&D group in the same category, the trends in total sales were the opposite. The With R&D group with a total income within the range of 1-250 million baht showed a continuous decrease over five years (2013-2017) (see Table VIII.7, Appendix VIII).

In 2013, both groups of SMEs fell within the range 1–250 million baht. The With R&D group had a higher percentage than the Without R&D group in all categories except for the range of 1–250 million baht. Although the highest percentage of the total sales in the With R&D group in the range 1-250 million baht was around 1.7 times higher than it was for the Without R&D group, the value could be replaced via the high range of total income. As can be seen in Figure 4.13, the total sales in the range of more than 2,000 million baht for the Without R&D group were almost 2.5 times higher than they were for the With R&D group. Thus, it can be assumed that the SMEs in the Without R&D group could have a higher total value than the With R&D group.

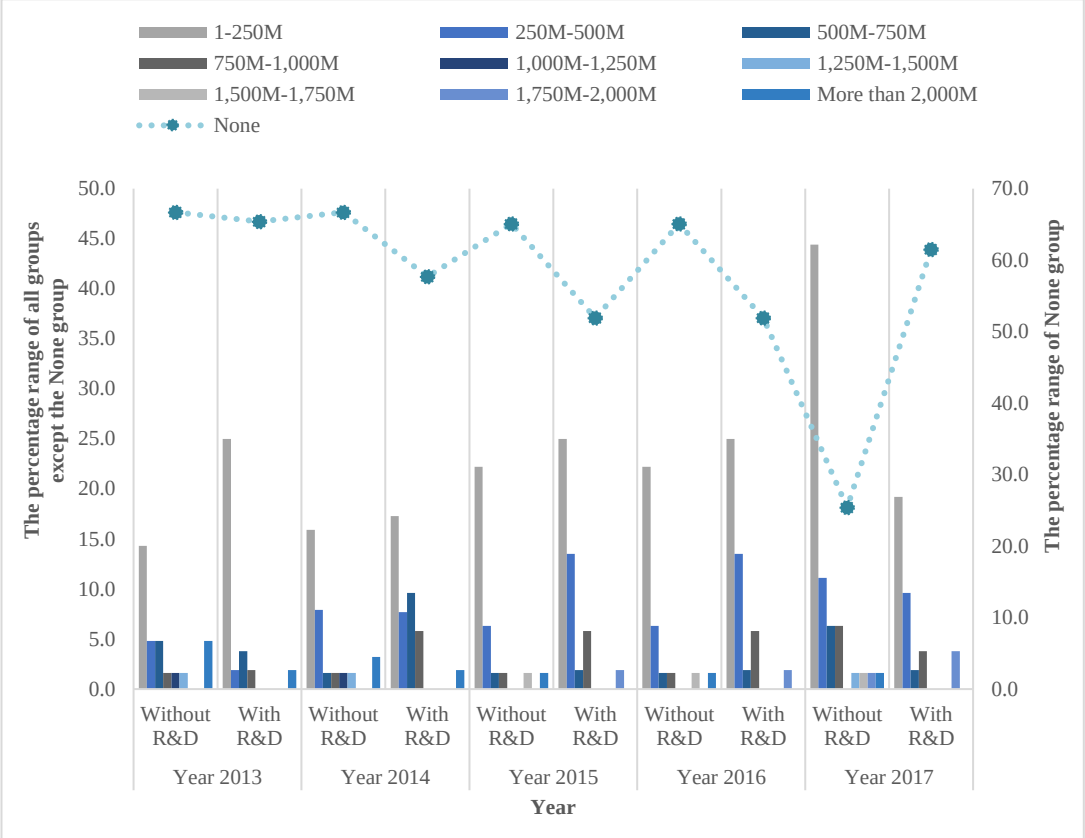


Figure 4.13: Total sales structure of Thai SMEs in the seafood industry during 2013–2017

Notes:

1) M means million Thai baht
2) None is the participants in the With R&D group did not indicate the details of their R&D expenditure in their answers
3) The total amount of sample is 115 SMEs in the seafood industry in Thailand
4) The total number of sample in the Without R&D group is 63 SMEs in the seafood business in Thailand
5) The total number of sample in the With R&D group is 52 SMEs in the seafood business in Thailand
6) The period of data collection is 19th September 2018 – 4th February 2019

On the other hand, in 2014, the total revenue of the With R&D group across all ranges, except for the ranges of 250 -500 million baht and more than 2,000 million baht, was greater than was that of the Without R&D group. The main range for both groups was 1–250 million baht, but the With R&D group had a higher percentage than did the Without R&D group.

In 2015, the total revenue of the groups decreased from 2014, but the performance of the With R&D group in terms of the percentage of total revenue was slightly higher than was that of the Without R&D group across all ranges of the total sales. The results presented in Figure 4.13 show that the With R&D group had a higher total income than did the Without R&D group across all income ranges in this year. However, the statistical analysis indicated that R&D did not affect the total income at the 95% significance level.

The trend of total income for the With R&D group remained positive in 2016. The total sales value in the With R&D group had a higher percentage than was the case for the Without R&D group, except in the range of 1,500 – 1,750 million baht - the With R&D group did not have data in this range. However, the statistical analysis indicated that R&D did not affect the total income value at the 95% significance level.

Conversely, in 2017, the Without R&D group had a greater percentage of the total sales across all ranges except for the 1,750–2,000 million baht range. Furthermore, the highest percentage of total sales of the Without R&D group in the range of 1-250 million baht was around 2.3 times higher than it was in the With R&D group. The macro picture is shown in Figure 4.13; in terms of the total sales in 2017, the Without R&D group performed better than did the With R&D group. The statistical analysis indicated that R&D affect the total income value at the 95% significance level.

4.7.1.2 Export revenue

The export revenue of Thai SMEs in the seafood industry fluctuated during 2013–2017. Export revenue indicated a growing trend from 2013 to 2014, which decreased slightly in 2015. The percentage of export revenue then increased from 2016 to 2017. However, the export revenue profiles of the participants in this research in the With R&D group indicated a better performance than they did for the Without R&D group during 2013–2016; this result was the opposite in 2017. However, the statistical analysis indicated that R&D expenditure did not affect the value of export revenue across the five years of the survey by a 95% significance level (see Table VIII.8, Appendix VIII).

The Without R&D group was the leading group with regard to the export revenue structure during 2013–2017. Furthermore, the highest total export revenue of the Without R&D group within the range of 1-250 million baht experienced a continuous increased over five years (2013-2017). By contrast, the With R&D in the same income range experienced the opposite trend in total export revenue, as this group's export revenue experienced a continuous decrease over five years (2013-2017).

In 2013, both groups of SMEs fell within the range 1–250 million baht. The With R&D group had a higher percentage than did the Without R&D group in all export revenue ranges except for the range of 500–750 million baht. Although the highest percentage of export revenue in the With R&D group that fell within the range of 1-250 million baht was around 1.8 times higher than it was for the Without R&D group, the value could be replaced by the high range of export income, because the maximum level of export revenue in the Without R&D group was more than 2,500 million baht and the With R&D group did not have data to analyse. However, the overall export revenue of both groups is regarded as a low level of export income (Figure 4.14).

In 2014, the export income of both the Without R&D group and the With R&D group was at a low level. The highest percentage of export revenue fell within the range of 1-250 million baht (Figure 4.14). Although the highest percentage of export revenue for the With R&D group fell within the range of 1-250 million baht, and was approximately 5% higher than that of the Without R&D group, the maximum value of export revenue fell within the range of more than 2,500 million baht (3.2%), whereas the With R&D group did not have data for the same range. Therefore, it cannot be concluded that the With R&D group had a higher performance in terms of export income in comparison to the Without R&D group. This is because the low total percentage in the Without R&D group could be replaced by the high value of export income, which was in the range of more than 2,500 million baht.

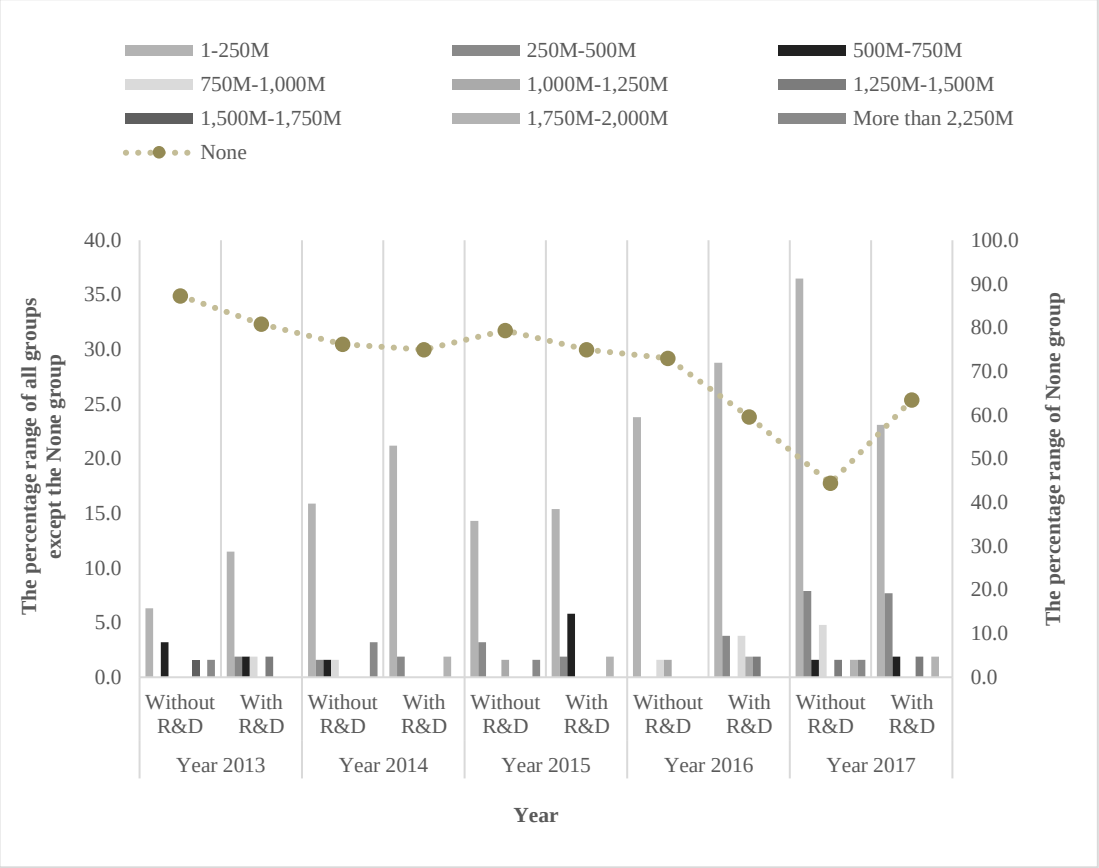


Figure 4.14: The export income of Thai SMEs in the seafood industry during 2013–2017

Notes:

1) M means million Thai baht
2) None is the participants in the With R&D group did not indicate the details of their R&D expenditure in their answers
3) The total amount of sample is 115 SMEs in the seafood industry in Thailand
4) The total number of sample in the Without R&D group is 63 SMEs in the seafood business in Thailand
5) The total number of sample in the With R&D group is 52 SMEs in the seafood business in Thailand
6) The period of data collection is 19th September 2018 – 4th February 2019

In 2015, the export revenue of the participants decreased from 2014, but the performance of the With R&D group in terms of export revenue was slightly higher than was that of the Without R&D group. However, the concentration of export revenue ranges was higher than was the export income in 2014.

The trends in export income for the With R&D group were positive in 2016. The export value for the With R&D group had a higher percentage than was the case for the Without R&D group for all the ranges of export income. However, the statistical analysis indicated that R&D did not affect the export income value at the 95% significance level.

By contrast, the export revenue of the Without R&D group showed a positive result in comparison to the With R&D group in 2017 due to the main range of export revenue in 2017 being in the range of 1-250 million baht and 250-500 million baht, respectively. The export revenue of the Without R&D group in the range of 1-250 million baht was approximately 2.3 times higher than it was for the With R&D group. Moreover, the export revenue in the range of 250-500 million baht was higher than it was for the With R&D group, but there was only a slight difference in the percentages of the two groups.

The other export ranges of both groups had similar percentages, except in the range of 750-1,000 million baht; the Without R&D group had 4.8%, while the With R&D group did not have data to analyse. Hence, the export revenue in 2017 implied that the Without R&D group had a good performance in export activities in comparison to the With R&D group. However, the statistical analysis indicated that R&D did not affect the export income value at the 95% significance level.

The trends in export revenue in 2017 in this research followed trends in national income of Thailand in 2017 (Figure 4.14; Office of The National Economic and Social Development Council, 2019). The national income of Thailand in the 2017 report indicated that the GDP increased by 4% from 2016. Moreover, one of the main reasons for the increase in GDP was the increase in the total export activity. Furthermore, worldwide requirements for Thai seafood products increased by 5.6% in 2017 (Office of The National Economic and Social Development Council, 2019).

The total R&D expenditure of Thailand in 2017 and the R&D expenditure in the food and beverage sector increased continuously from 2013-2017; however, the R&D expenditure of the seafood and fishery sectors in Thailand decreased gradually from 2016 (see Table VIII.4, Appendix VIII).

Thus, the increase in export revenue in the seafood industry in 2017 might be related to the increase in demand on the world market. Moreover, the high demand for seafood products may have caused a loss of focus on R&D activities, and accelerated the process of delivering export products. Thus, the amount of export products of the Without R&D group was greater than they for the With R&D group in 2017.

It is well known that SMEs play a major role in driving the macroeconomy of a nation, particularly in times of recession, because their flexibility enables them to adapt to changing circumstances. The drive for competition and market growth has prompted most SMEs to focus more on innovations that would contribute to the price and quality improvement of products. Especially in 'Entrepreneurial Economy' from the late 1970s to today, concentration on the economy of scale has been reduced, and the role of innovation in SMEs has increased (Sedej and Justinek, 2012).

Therefore, to increase their competitiveness, SMEs have adjusted their role not only as knowledge exploiters, but also circulate the knowledge in the innovation system and engage in the commercialisation of knowledge (Sedej and Justinek, 2012). Typically, SMEs could have a comparative innovative advantage over LEs because of their flexibility, which is an advantage when it is necessary to adjust to changing circumstances in the business environment. In addition, the limited transaction costs of coordinating, managing and controlling activities with other parties would give SMEs an advantage over LEs (Neito and Santamaria, 2010). However, unlike LEs, SMEs are at a disadvantage in terms of engaging competitively in innovation due to shortfalls in supportive factors such as skilled labour, R&D facilities and equipment.

Nonetheless, The National Science Technology and Innovation Policy Office (2016a) reported the continuous growth of R&D expenditure in Thai businesses, including SMEs. Thailand thrives on agriculture-based industrial activities; in this regard, the food industry, which is part of the agricultural value chain, had the highest R&D expenditure in 2016 (National Science Technology and Innovation Policy Office, 2016a). One of the interesting sectors in the agricultural business is the seafood sector, in which Thailand is one of the world's leading producers.

The ages of Thai SMEs in the seafood business that participated in this research ranged from 1–60 years. The most of the SMEs were in the range 11–40 years, while the highest percentage of the age range was 11–20 years. Of note, R&D engagement was rare or was not found in the youngest age group (1–10 years) and the oldest age group (51–60 years).

The distribution of the capital funds of SMEs in the seafood industry was in the range of one to more than 1,200 million to 2,600 million baht. However, the With R&D group had a higher average capital fund range than did the Without R&D group.

Furthermore, the distribution of employment in the two groups differed from the main employment range. Most of the Without R&D group had employees in the range of 1–100 people, while the With R&D group has the highest percentage of employment in the range of 251–500 people. Therefore, it is apparent from the business profiles that Thai SMEs in the seafood business will engage in R&D activities when they have the readiness to do so or stability in terms of the capital funds and employment.

The second section studied the R&D behaviour of Thai SMEs in the seafood business in terms of R&D expenditure and R&D networking. The survey data indicated that the R&D participants in this research only included 52 of 115 firms. However, the R&D expenditure in the same group exhibited continuous and positive investment over the five years of the study period (2013–2017). Furthermore, R&D employment remained at the same rate during the first three years of the study (2013–2015) before gradually decreasing from 2016 to 2017. By contrast, investment in machinery and tools had a high density of investment in 2015 and a high value of an investment in 2017. Moreover, most SMEs in the same group invested in machinery and tools in the range of 1–500,000 baht.

Therefore, it can be argued that the R&D activities in Thai SMEs in the seafood business might create slight changes in their products or processes that do not require expensive machinery and tools. In addition, R&D employment has fluctuated in terms of the total number of employees per year; however, the employment value has increased over five years (2013–2017). Thus, it can be assumed that SMEs in the Thai seafood sector paid more attention to high-skilled workers.

The participants in R&D networking covered in this research were small in number as a proportion of the total number in the sector. Moreover, with regard to collaboration, it was found that most SMEs engaged in R&D networking with private sector agencies and their customers rather than with government units or universities.

As Thai SMEs in the seafood industry have experienced financial constraints and have limited resources to establish R&D activities in their companies, SMEs need to reduce the risk of R&D investment failure by developing product ideas with their customers. They also work with other private companies in the form of suppliers or partners.

R&D investment has been shown to have a positive effect on the outcomes of Thai SMEs in the seafood industry. These positive effects on Thai SMEs are reflected in increased market performance in terms of the total sales and export income. This was not the case for SMEs in the seafood sector that did not engage in R&D. As can be seen, the total sales and export income of SMEs in the With R&D group were higher than were the corresponding incomes in the Without R&D group.

Overall, the factors that impact on the efficiency of Thai seafood businesses are capital funds, the employment of skilled labour and R&D investment. Of these, the R&D factor is crucial for SMEs to achieve quality and competitiveness, which was reflected in the continuous growth of the total sales and export income of SMEs that engaged in R&D activities. However, SMEs in this sector have limited R&D access and limited involvement in R&D networking.

4.7.2 Product performance

The product performance in the Thai SMEs in the seafood industry was assessed using the results of the interviews in Section 4.4. To clarify the results of the study, secondary data were used to explain the unclear findings in this section. The effects of R&D on the product performance of the Thai SMEs in the seafood industry in this thesis could be summarised as four points, which are the role of R&D in product development, the effect of R&D on product performance, the barriers to implementing R&D in product development and the role of networking to support R&D for product development, which will be discussed in detail below.

4.7.2.1 The role of R&D in product efficiency in the Thai seafood industry

R&D is crucial for creating an innovative product or process as Suwanrangsi (1997b) stated that R&D had been applied to improve the quality of products in the Thai seafood sector since the early 1990s (Suwanrangsi, 1997b). The interview results showed that R&D was a significant factor in increasing the efficiency of products or creating an innovative product or process.

Unfortunately, the information about product development in this research did not indicate the details of product or process development clearly due to the limitations of service employment contracts or contracts of sale between SMEs and their contracting partners. However, product development in the Thai seafood industry could be represented by the patent registrations reported by Intellectual Design Group Company Limited (2018). In 1997 - 2010, the trend in applying for patents in the seafood and fishery sectors was consistent at below 1,000 patents, but twice as many patent applications were received in 2007 compared to 2006 (Figure 4.16).

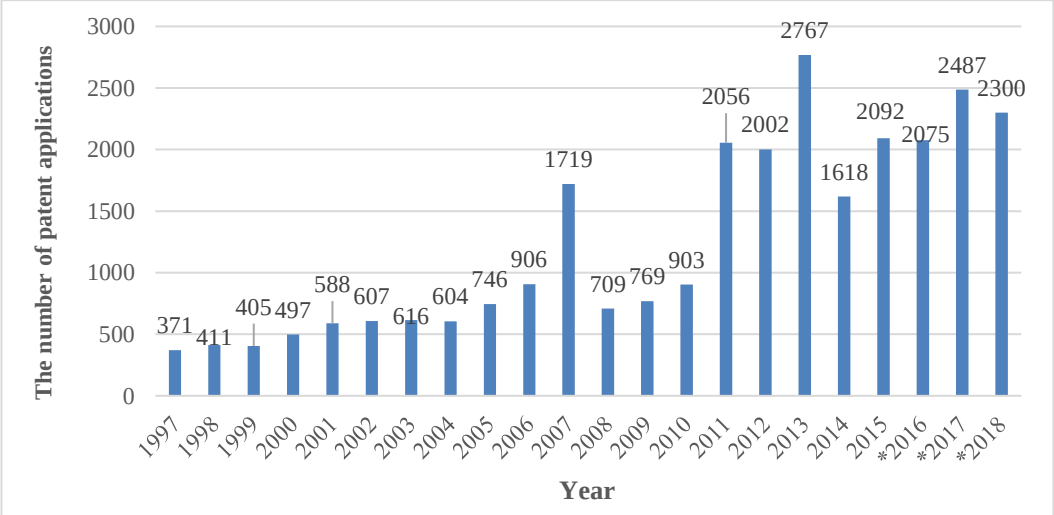


Figure 4.15: The number of patent applications in the seafood and fishery sectors in Thailand during 1997-2018 (Intellectual Design Group Company Limited, 2018)

Note:

*: The number of patent applications during 2016 to 2018 are the estimated value

The trend in applying for patents in the seafood and fishery sectors then increased to over 2,000 patents, and remained the same during 2011 – 2018 (Figure 4.16; Intellectual Design Group Company Limited, 2018).

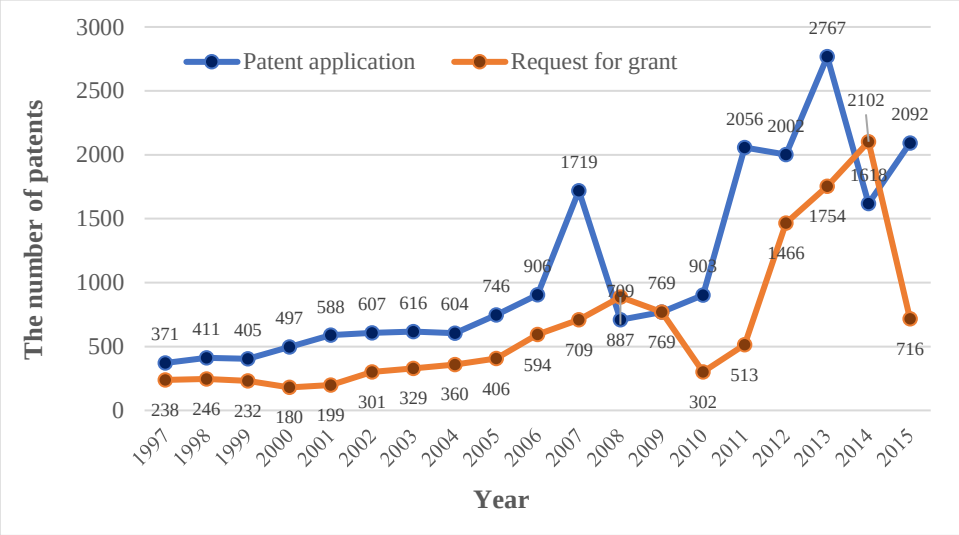


Figure 4.16: The trend in patents in the seafood and fishery sectors in Thailand during 1997 – 2015 (Intellectual Design Group Company Limited, 2018)

However, Figure 4.16 indicates that the number of requests for the granting of patents was around 0.6% higher than was the number of patent applications in 2015 (Intellectual Design Group Company Limited, 2018).

The number of patent applications in the seafood and fishery sectors implies that producers in the sectors began implementing R&D officially in their businesses in 1997, and that this increased dramatically in 2011.

Furthermore, the trend in R&D development remains focused on product and process development, increasing product nutrition, and packaging. As Chulalongkorn University Intellectual Property Institute (2017) reported, the percentages of patent applications related to processed food [14] were as follows: 21% was for food preservation and food processing, 13% for developing food additives and related

[14] Data as of the 20th of August 2017.

processes, 8% for process development and product development, and 6% for packaging and related processing.

According to the patent survey by the Intellectual Design Group Company Limited (2018), it could be assumed that R&D in the seafood sector remains focused on process and product development to secure its market position in terms of maintaining its previous markets and finding new avenues to access the local and international market places. However, quality standards are key to market penetration, particularly for export markets. In addition, many partnership countries have applied quality standards as a non-tariff barrier to Thai seafood products. Thus, R&D has been used as an advanced tool to increase the quality standards to meet the export conditions and to support the continuous market growth of the sector. Furthermore, R&D has been included in packaging development to maintain the freshness and hygiene of the products, and is applied as a tool to control the price in the market.

4.7.2.2 The effect of R&D on product development

R&D cannot create a dramatic change in the products of Thai SMEs in the seafood industry because the demand-pull in terms of R&D has been slow.

Seafood products are high in protein and are a source of vitamins, which are sensitive to high temperatures (Food and Agricultural Organization of the United Nations, 2010). Thus, the most important aspect of seafood products is freshness. Maintaining freshness and nutrition in the products after harvesting then from the sea remains a critical challenge for Thai SMEs. Thus, some producers have chosen primary processing to produce their products. In addition, consumers are familiar with the existing products on the market. Moreover, most Thai SMEs in this sector have had lengthy contact with their partners, most of whom require the same products (see Appendix IX).

However, the main products of the sample in this research were frozen product, chilli paste, dried seafood products, fried products and fermented products. These products use primary technology in the processing process. Furthermore, the period of product development is six months to two years depending on the complexity of the product

and the readiness of the business (see Appendix IX). This indicates that Thai SMEs in the seafood industry are still at an early stage of product development. In addition, seafood sector products have a minor impact on the economy (National Food Institute, 2015).

It seems that both the demand-pull effect and the technology-push effect result in the limited product development in Thai SMEs. As customers are familiar with the existing products, the market cannot drive Thai SMEs to increase the innovative products via R&D. On the contrary, the existing seafood products on the market meet the customers' requirements.

4.7.2.3 The barriers to implementing R&D for product development

The barriers to implementing R&D for product development in Thai SMEs in the seafood industry consist of both internal and external factors. The main internal obstacle is that Thai SMEs in the seafood industry lack the motivation to engage in R&D, while such motivation may be driven by market mechanisms as an external disturbance factor. Moreover, SMEs' limited resources continue to be a barrier to product development via R&D.

As shown in Section 4.7.2.2, the demand-pull affects R&D engagement in Thai SMEs positively; however, one cannot deny the fact that the limited resources of Thai SMEs might decrease the R&D engagement of these groups (Neito and Santamaria, 2010). This might be the reason for the emphasis on R&D in these groups as something they need to do regularly to maintain the total sales and ensure the survival of the business.

The results of the interviews indicated that the aim of R&D investment was to increase product performance in Thai SMEs in the seafood industry and to achieve the quality standards that meet government regulations and in response customers' requirements (see the Case T1, the Case V2 and Appendix IX).

Thai SMEs in the seafood sector use R&D to develop products or to solve existing problems, and do not understand the macro picture or have action plans to apply R&D to expand the efficiency of their work.

4.7.2.4 The role of networking in supporting R&D for product development

The goal of creating external collaboration for Thai SMEs in the seafood industry is to receive approval from government organisations; they are unable to perform some aspects of their work or to solve a specific problem.

Thai products must meet the national standards of quality control that protect consumers' rights and to expand the export seafood market. The Thai government announced a list of central laboratories to guarantee the quality standards of the producers. Thus, the main aim of Thai SMEs when collaborating with government organisations is to guarantee their standards. If they ignore the regulated standards, they would not be able to sell their products or might face other punishments such as fines or having their companies closed.

Moreover, the primary motivation of Thai SMEs in the seafood industry for contacting universities is to solving specific problems in their businesses (see Appendix IX). The private sector makes a small contribution to increasing the product performance because of the high competition in the market. The profits derived from Thai seafood products are tiny (see Appendix IX). Although Thai SMEs register as members of various associations, the communication with these associations is aimed at circulating news updates and regulations, and conferring to negotiate cross-claims with the government.

Thus, Thai SMEs in the seafood industry have the ability to develop their product performance by themselves. Suwanrangsi (1997b) argued that the application of technology to increase the value of products was established in the businesses via joint ventures or in-house R&D. However, Thai SMEs have the ability to apply primary technology in the processing of their seafood products. The limited resources of SMEs in terms of budget and labour, as well as the market mechanism, are the main obstacles to product development for this group. Furthermore, the collaboration of Thai SMEs in the seafood industry does not aim to create permanent knowledge networks permanently, but collaboration for specific purposes. Thus, the trend of product development in Thai SMEs in the seafood industry is moving ahead without direction.

4.8 Conclusion

The goal of this research was to describe the role of R&D in the business development of Thai SMEs in the seafood and fishery industry. However, the firms employed more than one factor to drive their businesses. Thus, in order to identify the role of R&D in business development, this research compared the efficiency of two groups of SMEs in the seafood sector, which were SMEs that engaged in R&D activities and SMEs that did not. The results of this thesis can be summarised according to four points, which are the characteristics of Thai SMEs in the seafood industry, the R&D behaviour of this group, the role of networking in supporting the R&D activity of the Thai SMEs in this industry, the effect of R&D on the Thai SMEs' development in the seafood and fishery sectors.

The first section presented the characteristics of Thai SMEs in the seafood and fishery industries. This section also presented the firms' capacity in terms of capital funds and labour, which were the main input factors when comparing two groups, the With R&D group and the Without R&D group, of Thai SMEs in the seafood industry.

The age profile of the firm: The R&D engagement of Thai SMEs in the seafood industry decreased as they aged, except in the early stages of a firm (1-10 years). Thus implies that SMEs have limited capacity to implement R&D in their businesses in the early stages, as capital funds, labour and other basic production input factors are necessary in the initial stage.

The overview of the capital funds of firms: The capital funds of Thai SMEs in the seafood industry were distributed over a low range (1-200 million baht). This might be because a characteristic of SMEs was the limited the amount of capital funds or the total amount of labour (see Section 2.4.1: The SME landscape).

Total headcount of employees: The distribution of the total amount of labour in Thai SMEs in the seafood industry in SMEs Without R&D was 1-100 people, while the highest percentage of the total employment in the SMEs With R&D was in the range of 251-500 people. It seems that business development may be reliant on labour-intensive activities. However, when businesses age or open new sections such as R&D

units, the existing labourers are unable to expand the scope of their work to cover the new areas, which may result in the recruitment of skilled workers to perform the tasks.

The second section discussed the R&D investment of this group. R&D expenditure was divided into two parts, namely R&D investment in machinery and tools, and R&D expenditure on employment. This section only discussed the With R&D group.

Total R&D expenditure: The R&D expenditure of Thai SMEs in the seafood industry fluctuated during 2013-2017. The R&D expenditure experienced a continuous increase from 2013-2016, followed by a slight decrease in 2017. However, even the highest percentage of R&D investment by this group during 2015-2017 was low (500,000 – 1 million baht). The purpose of R&D investment in Thai SMEs in the seafood industry was divided into two aspects, which were R&D expenditure on employment and the R&D expenditure on machinery and tools.

R&D expenditure on employment: The R&D investment in employment by the Thai SMEs in the seafood industry was contrasted with the total R&D expenditure. The R&D investment in workers was relatively high in 2013, 2015 and 2016, and then decreased dramatically in 2017. Furthermore, the main range of R&D investment in employment was 350,000-700,000 baht.

The R&D expenditure on machinery and tools was highest in 2015, whereas the other four years showed dwindling R&D investment in machinery and tools. Furthermore, the value of R&D investment for this purpose remained in the low range (1-500,000 baht).

Although the amount of R&D expenditure on employment was not high, there was continuous investment during 2013-2017. Moreover, the investment in machinery and tools was low, except in 2015 when the Thai government launched measures to support SMEs, particularly tax exemptions for imported machinery and tools (Thailand Board of Investment, 2014). In other words, Thai SMEs in the seafood industry does not have the ability to make massive investments in machinery and tools every year. In addition, the lifespan of machinery and tools might be more than ten years. Moreover, the price of machinery and tools is quite high compared to wages for labourers. Thus, Thai

SMEs in the seafood industry might not invest in machinery and tools because they want to maintain the liquidity of their businesses by limiting the scale of work and relying on human labour. In other words, new products or new processes in Thai SMEs in the seafood industry do not require new machinery and tools, as they can adjust their existing tools to provide an innovative approach or use a partner's facilities to create innovative products.

In the third section presented the role of networking on R&D development in the Thai SMEs in the seafood business. Many publications have revealed the ability of networking to support business growth, with different results across the businesses. Government regulations and stakeholders have become involved in innovative organisational management in Thai SMEs in the seafood industries. However, most of the Thai SMEs did not collaborate with external organisations due to the policy of the company.

The fourth section presented the effect of R&D investment on market performance by comparing the total sales and the export revenue during 2013-2017 for the two groups. Product performance was studied by analysing the data from the interviews and four case studies without a comparison between the two groups. The market performance in terms of total sales and the export revenue of SMEs who had R&D in their businesses was greater than it was for SMEs that did not engage R&D during 2013-2016, but the statistical analysis did not confirm the different results between the two groups across the five years of study. Furthermore, the results of the interviews revealed that R&D played a significant role in the development of new products and innovative process in Thai SMEs in the seafood industry. In this regard, Early's (1997) empirical study indicated that the innovation generated by R&D activities could eventually create new products or processes. Furthermore, innovation decreased the time needed to improve the new product or process (Schiller and Diez, 2007). However, the changes to products and processes were minor, such as new flavours and packaging, which fluctuate according to customers' requirements.

In this regard, the Chulalongkorn University Intellectual Property Institute (2017) reported that the percentages of patent applications related to processed food[15] were as follows: 21% was for food preservation and food processing, 13% for developing food additives and related processes, 8% for process development and product development, and 6% for packaging and related processing.

During 2013-2017, the Thai seafood and fishery industry encountered many challenges in terms of both internal and external barriers that directly affected the R&D decisions of Thai SMEs in this sector, such as the dramatic changes in the minimum wage, the IUU problem, and so on. Thus, the Thai SMEs in the seafood sector had to secure the liquidity of their companies and decrease investments in new projects, particularly with regard to projects with unpredictable outcomes and unnecessary costs such as R&D projects, to maintain the survival of the company.

Therefore, the main focus of R&D activities in the Thai SMEs in the seafood industry is on increasing the quality of their products following the Thai government's regulations. SMEs need to establish the business' status on government records until there are ready to move to a higher level. The fluctuating R&D investment of Thai SMEs in the seafood industry during 2013-2017 might have been because they limited their investment to sustaining the necessary routine work of the business and decreased investment in high-risk projects. With regard to the demand for Thai seafood products aboard, consumers require traceability, and information about the source, quality and safety of the products they chose to consume (Bhatt *et al.*, 2017). Thus, government measures to instigate or support the R&D investment in the Thai SMEs (such as tax exemptions for importing machinery and tools from abroad, organising R&D training programmes, and so forth) have been implemented to increase the quality of Thai products to meet the accepted international standards that will be discussed more details in Section 5.2 and Section 5.3.

[15] Data as of the 20th of August 2017.

Chapter 5

Conclusions and Recommendations

This thesis aimed to investigate the impact of research and development (R&D) on the seafood industry in Thailand in terms of product and market performance. It also investigated the role of networking among the government, academic institutions and other businesses to support the R&D engagement mechanism in Small and Medium Enterprises (SMEs) in Thailand's seafood and fishery sectors.

Both qualitative and quantitative data were used in this research. Firstly, a questionnaire was sent to 237 Thai SMEs in the seafood industry via mail and e-mail. That those 115 SMEs responded to the questionnaire were then invited to participate in interviews. Nine companies consented to participating in face-to-face interviews. In addition to these industry representatives, three staff members from a government organisation, along with researchers and university lecturers, were invited to participate in face-to-face interviews. Also, four SMEs; two traditional product producer companies and two value-added product producer companies agreed to be the case studies in this thesis.

These results shed light on the R&D process and its role in business development for this industry, contributing insights that may inform policy initiatives and future plans for supporting R&D expenditures. Since the research also examined interactions with external organisations to achieve the purposes of R&D, these results may further improve the patterns of collaboration between SMEs and external organisations to increase efficiency.

This chapter presents the conclusions and recommendations from this research. Section 5.1 presents a summary of key findings. It is followed by recommendations for future research and future practise, which are provided in Sections 5.2 and 5.3,

respectively. The policy recommendations are discussed in Section 5.4. Lastly, Section 5.5 offers concluding remarks.

5.1 Summary of key findings

This thesis finds that R&D affects the development of Thai SMEs in the seafood industry in terms of market performance and product performance. R&D cannot drive the efficiency of a business alone, but it is a necessary support factor and an essential point of product development that can increase a business' income.

The analytical survey data in this thesis indicate that the R&D investment of Thai SMEs in the seafood industry is extremely low compared with their total capital funds. One reason for this low level of R&D expenditures is that R&D activities are conducted informally or on an in-house basis. Furthermore, idea generation for developing R&D activities in these businesses stems from consumer requirements. Moreover, some Thai SMEs in the seafood business may undervalue the benefits of R&D and, thus, eschew the risks associated with R&D investment.

With these factors in mind, the best way to improve the efficiency of SME performance via R&D is to increase R&D awareness, especially regarding the outcome of R&D on business development in Thai SMEs in the seafood industry. Such an increase in awareness may increase the rate of R&D expenditure in Thai SMEs in the seafood and fishery industry. Especially in the early stages, however, more than awareness is required. In addition, improving the readiness of Thai SMEs to utilise R&D knowledge is necessary to understand the R&D mechanism, create knowledge, promote innovation, and achieve sustainable growth.

Networking is another factor that can enhance R&D activities. Networking can overcome budgetary, knowledge, and R&D workforce limitations. It is in private sector organisations' interests to support R&D activities among Thai SMEs in the seafood industry because such activities promote overall growth in the field. Meanwhile, government organisations must support the optimal measures, fair laws, and free facilities that increase access to affordable R&D services. Finally, academia should provide advanced R&D knowledge and techniques. At the helm of these

networking efforts, the private sector must create an overarching R&D roadmap, sharing R&D facilities and distributing benefits across the industry.

Hou and Mohnen (2013) state that cooperation between the main stakeholders in government organisations, academic institutions, and businesses increases businesses' R&D activities and thus the product innovators per employee in China. As a result, the triple helix model acts as a cogwheel that pushes enterprises to become more efficient and adapt to the knowledge-based economy, which in turn, supports the nation's sustainable economic development.

Almost all relationships between the three actors in the model are based on consulting (88%) (Kim *et al.*, 2012). The major interactions between universities and industry players take the form of research grants or contracts (59%) or training programs (38%) (Kim *et al.*, 2012). As such, universities play the role of 'entrepreneurial mediators' in the triple helix model (Kim *et al.*, 2012).

Knowledge exchange networking activates a dynamic circulation of information in the business community and promotes greater awareness of the importance of R&D. Furthermore, knowledge exchange is the first step towards learning and innovating (Kuhne *et al.*, 2013).

In general, cooperation between universities and the industry to improve products' or processes' efficiency by means of technology and innovation is critical for Thai enterprises (Brimble and Doner, 2007). However, misunderstandings or miscommunication because of a knowledge gap presents an issue in this regard, along with information security concerns (Tanticharoen *et al.*, 2008). Many empirical studies in Thailand's case are attempting to identify appropriate intermediaries that can communicate between the participants, thus supporting the two to work together across a variety of sectors. So, enterprises in Thailand can be strengthened by greater awareness of the need for R&D or innovation, by knowledge sharing between businesses, and by cooperation with academic institutions and government organisations.

Nonetheless, SMEs still faced the main problem of grasping knowledge as a result of insufficient expertise and financial resources. Indeed, most SMEs are focused on the domestic market and hold close relationships with specific partners. As a result of their weak networking , SMEs cannot push themselves to jump into an international market (Johanson and Vahlne, 2009).

To overcome the existing hurdle, it is important to foster a suitable environment where information flows and businesses achieve an advanced innovative transformation stage. Building relationships between firms of different sizes, in particular, increases the beneficial economy and supports knowledge circulation between partners (Kuhne *et al.*, 2013).

Networking is key to increasing R&D awareness and activates the flow of information, which develops into knowledge and innovation. Moreover, networking increase the complexity of an innovation process, leading to greater dependency on interaction for innovation within networks. Furthermore, cooperation between networks offers opportunities for new or alternative relationships, links, or markets, and allows businesses access to new or complementary competencies and technologies. In particular, managed and joined networking activities have been found to increase innovation among SMEs. Generally, SMEs' cooperation with customers, supplies, competitors, government organisations, and research units achieves more successful innovation. Without this, a massive gap can be noted regarding businesses' capacity for innovation (Chen *et al*., 2017).

The development of in-house R&D helps firms to catch up with the technology frontier, and firms can then transfer novelty research between themselves and thus support the development of partners. If firms are to strive for industry leadership, in-house development within a business is essential (Bougrain and Haudeville, 2002). In-house R&D, more so than the purchase of technology, increases the numbers of product innovators and new products per employee in a business, as has been the case among SMEs in China in recent years (Hou and Mohnen, 2013).

Investigation of R&D activities in terms of R&D expenditures of SMEs in the fishery industry in Thailand reveals that there are two main aspects of R&D investment in Thai SMEs: R&D investment in employment and R&D expenditure on machinery and tools. The average R&D investment in employment is lower than the average R&D investment in machinery and tools; conversely, the expenditure on employment was found more frequently than the expenditure on machinery and tools.

The seafood industry in Thailand is a labour-intensive industry; thus, the main resource for operating a business is the workers. The purpose of installing machinery and tools in seafood businesses is not to replace these workers but to enhance workplace safety by completing tasks that might otherwise injure workers.

The decision to invest in machinery and tools is also based on consumer requirements related to the payback plan. Furthermore, governmental policy support, in the form of tax exemptions, for example, drives R&D investment in machinery and tools in Thai seafood industry SMEs. Because SMEs have limited resources to operate their businesses, they must ensure their survival via stable organisational management that pays attention, in particular, to the liquidity of the business.

Exploration of the effect of R&D on the development of production activities in Thai seafood and fishery SMEs reveals that R&D expenditure has a positive relationship with market performance. This research demonstrates that SMEs that engaged in R&D activities saw a higher percentage of total sales than did SMEs that were not involved in R&D. Furthermore, R&D promotes expansion of Thai seafood SMEs into international markets. Thus, the percentage of export revenue for SMEs engaged in R&D activities was higher than it was for SMEs that did not participate in R&D activities.

Because the demand-pull effect is insufficient to drive technological development, however, R&D produces only a slight increase in the product performance of this group. SMEs' limited resources in terms of money and workers provide another possible explanation for the limited change in product development.

Considering the importance of R&D to the growth of the seafood industry in Thailand, this thesis aimed, further, to identify factors that promote R&D development and technological learning. It revealed networking as a principal factor in this regard. The aim of R&D collaboration with other business is to receive updates about news, laws and business benefits. Moreover, collaboration with governmental organisations aims to obtain privileges, such as tax exemptions, while guaranteeing that food standards comply with the quality laws of various nations. Finally, university collaborations aim to exploit expert knowledge to solve specific problems.

In the Thai seafood industry, government organisations play a key role as both the regulator and the main supporter—via financing and facilities—of R&D activities among SMEs. Meanwhile, academic organisations and experts serve as content supporters and knowledge contributors. In contrast, the private sector does not actively support R&D activities of industry competitors. However, they remain the indirect R&D catalyst in this group because, to increase their own area of market access, it is necessary to increase their product performance in terms of quality, innovation, and other factors so that they are at least equivalent to their competitors. This positions business competitors as indirect R&D activators. Still, active collaboration with external organisations remains low in this sector.

The results of four case studies—two from traditional product producers and two from value-added product producers—confirm that neither R&D nor networking could, by itself, drive a successful business. Rather, Thai SMEs require both factors to achieve their goals. In terms of networking, these four case studies also illustrate different purposes for creating linkages with external organisations.

Three case studies (T1, T2 and V1) applied R&D to develop their businesses and saw positive results in terms of both product performance and market performance. As these cases show, R&D can lower the cost of products, reduce waste, extend the shelf-life of products, and enable products to meet international quality standards. Each of these factors, in turn, leads to market expansion at the local and global level.

On the contrary, the business strategy in the fourth case (V2) prioritised networking over R&D. In fact, it failed to devote any significant efforts and resources to R&D,

opting, instead, to rely on ready-to-use technologies and machines from abroad. In the early stages, this strategy appeared fruitful because available technologies made packaging more attractive. However, other businesses found it relatively easy to copy these results by purchasing the same machines. In time, therefore, the businesses that first utilised readily available technologies and initially reaped significant benefits saw a significant reduction in those benefits. Within three years, their total sale and export revenues decreased dramatically.

Although the purpose of engaging with external organisations in each of the four cases might differ, all case studies share a common finding: Thai government efforts to enforce quality standards and laws improve quality across Thai SMEs in the seafood industry. On the contrary, academia ranked as the last option for R&D projects in all four case studies. Several factors explain this finding, including the high cost of the project, the long period of study, and the prevailing lack of trust regarding the benefits of R&D projects. In this research, the strongest link between academia and Thai seafood SMEs appears to be in terms of knowledge contribution through training programmes or expert consultants with specific knowledge of advanced techniques.

All four case studies also defined the private sector as business competitors and avoided direct collaboration. Thus, the main role of the private sector in all four case studies involved providing updates on news, laws and other measures from the government. Still, current findings do not preclude business competitors from changing their priorities and recognising the opportunity for partnerships as trade policies and agreements evolve. Indeed, this happened in the case of V1, where a business competitor became a business partner in the face of a copied product problem.

This research provides academic contributions in the area of R&D and innovation in the SME seafood industry in Thailand. Existing studies have focused primarily on the role of R&D in high-performance industries, which have the capacity to improve their businesses internally via R&D. Scholars have also explored innovations, such as high-end technology adopted by industries and large-sized enterprises in developed countries.

The current research aimed to study the role of R&D in the seafood industry in Thailand in terms of product and market performance. It looked, in particular, at SMEs, which constitute the majority of Thai businesses. The results of this thesis might generate awareness among Thai seafood SMEs, which in turn, could encourage them to focus more on R&D. Moreover, this thesis aimed to explore the role of networking among the government, academic institutions, and other businesses to support the R&D engagement mechanism in Thai SMEs in the seafood and fishery sectors. The results of this thesis could provide a foundation for collaboration between SMEs with limited technology and government and related organisations or national leaders to determine the best way to support R&D in this group and increase R&D activities in similar sectors.

Three main knowledge contributions emerge from this thesis:

a) The conceptual framework—drawn from Rothwell (1992), Trott (2005) and Saigosoom (2012) and tested in this research—reveals a unique pattern of R&D among Thai SMEs in the seafood sector. This result can provide guidelines for the study of R&D activities in similar sectors (such as the agricultural sector or the low-technology sector) or in contexts similar to Thai SMEs in other developing countries. The qualitative results of Intarakumnerd *et al*.'s macro innovation model in Thai seafood industry (2015), and Saigosoom's (2012) study of R&D in Thai SMEs in the food industry support this thesis's findings regarding R&D behaviour of Thai SMEs in the seafood industry. The quantitative data in this research could fill the gap in the existing research on this topic and initiate the creation of government policies to support R&D investment of Thai SMEs, particularly in the seafood and fishery industries.
b) The effect of R&D on business development described in previous research can be categorised as the effect on product performance, market performance and organisational management performance (Turnbull *et al*., 2019). Detailed quantitative outcomes in terms of total sales and export revenue could be applied to create an economic model to determine the optimal R&D investment to benefit Thai SMEs in the seafood industry.

c) This research offers a method for increasing R&D participation of Thai SMEs in the seafood industry by applying the principle of driving innovation via Leydesdorff and Etzkowitz's triple-helix model (1996; Etzkowitz & Leydesdorff, 2000). The results of the research provide significant justification for the triple-helix, which enables three partners—namely the government, universities and businesses—to collaborate on R&D engagement among Thai SMEs in the seafood industry. This finding is consistent with previously published research (see Kim *et al*., 2012; Hou & Mohnen, 2013) that attempted to explain this collaborative model and its effects. Adding value to the existing research, this thesis describes the main organisations and different purposes of R&D collaborations for Thai SMEs in the seafood industry.

5.2 Recommendations for future research

Empirical studies indicate that R&D affects the economic growth of businesses in terms of SMEs' market performance, production performance and organisational management performance. The scope of this thesis includes market performance and some aspects of product performance. Thus, future research could also study the effects of R&D on production performance and organisational management performance to ascertain the full effect of R&D on business efficiency, which could lead to the creation of an appropriate technological roadmap for improving the product and market performance of Thai SMEs in the seafood industry.

Moreover, the present research studies the production aspect; however, trends in technology in the Thai seafood sector might vary according to the demand-pull effect or customers' requirements. Thus, future research could further investigate the role of the demand side in the evolution of R&D trends for Thai SMEs in the seafood industry. Additional studies on the impact of R&D on product development could also explore, in detail, ways to create the necessary technological platform to increase the product quality performance of Thai SMEs in the seafood sector.

Interestingly, some Thai SMEs were able to accommodate R&D activities within their businesses, but the structure of R&D in those businesses did not clearly allow R&D

activities to progress. Thus, future research must explore organisational management, including the visions of chief executive officers. The results might yield understanding of the motivations R&D users have for investing in R&D—insights that would strengthen policy development to support R&D investment, particularly in Thai SMEs.

Networking is an additional factor with the potential to support the growth of SMEs; however, the scope of external networking is mainly limited to government organisations. In addition, the effects of collaborative networking are unclear; thus, future research could explore the scope of external organisations that interact with SMEs and study the impacts of collaboration with the goal of creating stronger networking links.

The characteristic of SMEs might affect the R&D engagement of the Thai SMEs in the seafood industry. Therefore, future research could analyse the correlation between the age of the businesses, the budget of the businesses, and the total number of employees, and the correlation of those factors to the R&D participation that might varies across the different level of its.

Furthermore, the limited data collection period affects the total number of questionnaire respondents having 115 SMEs, 12 interviewees, and four case studies. It is a small number compared with the total number of SMEs in the agricultural, forest and fishery sector, with around 42,000 companies included all businesses (see 3.3.1.1). Furthermore, the result in the external collaboration only 27 firms responded in this thesis. Thus, this thesis might reflect the trend of R&D in the Thai SMEs in the seafood and fishery industry. Thus, future research might increase the target population's scope to increase the total amount of respondents. In addition, the less amount of SMEs who participated with the external organisation cannot assume the macro picture of the collaboration between SMEs and government organisations and academic institutions. This thesis's result may reflect the trend of external organisations that SMEs decided to work with and its reason. Also, the external organization that SMEs might participate with could expand the units to cover the academic institutions and research units that might show the ratio of collaboration between partners clearly.

Significantly, the case studies used in this research lack an example of innovation. Therefore, in the future, more investigation is needed into businesses that have applied R&D to create innovative products. Such research may offer insights into the path SMEs in the seafood industry follow toward innovation. Also, the failure found in the case of V2, which lacked its own R&D knowledge base, offers a cautionary example for other businesses that continue to overlook participation in R&D; V2's progress should be monitored, and it must explore optimal models for R&D and suitable networking plans in order to develop a recovery business plan.

5.3 Recommendations for future practice

The results of this thesis confirm that R&D has a positive impact on the business performance of Thai SMEs, particularly in the seafood industry. Thus, this research provides a baseline for creating R&D budget plans while offering guidelines for the construction of an R&D roadmap for Thai SMEs in the seafood industry. In addition, the results of this research could be developed into guidelines for an R&D survey in the agricultural sector or the food industry, each of which is responsible for major contributions to Thai export products. Because the sustainability of these businesses has a significant impact on Thai national income, policymakers, industry leaders, and academic experts would do well to gather and analyse these results to generate a national R&D platform.

Furthermore, the results of interviews reveal that networking is one of the factors that support effective R&D engagement among Thai SMEs in the seafood industry. Therefore, government organisations that devise and enforce laws and regulations could adjust their efforts to create opportunities for *all* parties—in the government, academia, and the private sector—to work together to maximise mutual benefits. Further supporting these efforts, the results of this thesis could be used to rectify inefficient patterns and policies in government units and universities to improve their work with SMEs. By establishing incentives or better appropriating benefits, the Thai government could also encourage workers to make R&D contributions.

In addition, the Thai government could promote network collaboration by prioritising copyright protection of innovation. A serious penalty for piracy could make private sector actors feel more secure in sharing their knowledge with the public and collaborating with partners in academic and government organisations. With adequate protections, the resulting knowledge-sharing society would, moreover, produce innovation not only in the Thai seafood industry. Rather, it would make innovation the norm across Thailand.

The low questionnaire response rate in this research highlights problems with R&D data management in Thailand at the business and national levels. The survey method and data management from this thesis could yield ideas for adjusting R&D survey data collection strategies in Thailand so that they are more effective in both quality and quantity. The Thai government could, for example, create a national one-point data service to store significant data. This service might help to reduce the duration of the analytical process and confirm the accuracy of data showing the benefits of R&D activities.

5.4 The policy-driven recommendations

A summary of the Thai SMEs in the seafood industry included in this thesis is shown in Figure 5.1.

Most of the ideas for developing Thai SMEs in the seafood and fishery industry are motivated by customer requirements or demand-pull. At the same time, trade barriers such as limiting characteristics or the number of products to export challenge the Thai producers to develop their products to meet those conditions or to maintain the market share held by the industry. Furthermore, limited access to the natural resources that are primary products of the production process adjusts the direction or affects the policies that drive the businesses in the industry.

Thus, R&D is involved in Thai SMEs' development in the seafood and fishery industry. The specific character of Thai SMEs (see 2.4.2) is that they often possess limited capital funds or workers to run the businesses; many can carry out simply R&D on their processes, machinery and tools, resulting in only minor changes to their

products. On the contrary, SMEs in this thesis who decide to collaborate with external organisations, the government, academic institutions, or other businesses might expand their development scope to have a moderated-to-advanced product or develop their processes.

The main reason for Thai SMEs to work with external organisations is that they want to improve their products or produce new ones with extended shelf lives and high quality, following international standards to expand their market to be global in its reach. Businesses also want to convert waste into products, to reduce their routine expenses. Mid-to-advanced technology is required to improve processes' efficiency or launch a new line of products. SMEs alone do not want to invest in machines and tools in a trial stage or primary stage as they cannot predict the actual turnover from the new product line. Thus, collaborating with external organisations who can support the supply or purchase of such machinery and tools, provide expertise on the production process, e.g. help with money in some way, presents an excellent way in which SMEs can access the mid-to-advanced technology that they seek.

Product development affects the market expansion of Thai SMEs in the seafood industry. Minimally improved products often remain in the same area of the market, particularly the local market, or slightly extend their reach in regards to the market area. Conversely, moderately or majorly changed products can increase the business's access to a new market area, which might be a high-value or niche market. Also, the capacity to manage waste from the production process or reuse waste to generate resulting value presents an opportunity.

The impact of SMEs in terms of their economic and social contribution is reviewed in Chapter 2. However, policies to strengthen SMEs do not have the same power as LE-driven policies, in particular, in terms of their R&D function. Due to the different characteristics of SMEs, with limited budgets and workers, especially skilled workers, they do not have the readiness to make macro-investments or to accept the worst-case scenarios that come with the risks associated with investing.

The following policy-driven recommendations based on the results of this thesis are aimed at increasing the opportunities for R&D engagement among Thai SMEs in the seafood industry.

Supporting market research: The Thai government should provide both local and international market research so that Thai SMEs in the seafood industry can better understand customer requirements and thus plan their strategies, accordingly. The government might alternatively offer an R&D investment incentive for Thai SMEs in the seafood industry; some SMEs have not wanted to invest in R&D as they have been worried about new products' turnover affecting the business's liquidity.

Creating an R&D platform for SMEs: To drive Thai SMEs' development in the seafood sector, an R&D platform could provide them with direction, stakeholders, and methods for generating business achievements such as increased total sales, e.g. reduced routine costs, by means of R&D. Also, this R&D platform might encourage the government and universities to support the budgets, facilities, and infrastructure of local businesses. SMEs who have limited budgets and workers to develop by means of R&D might take a collaborative opportunity to further their enterprise, using R&D to their benefit and strengthening the Thai economy, as a result.

Supporting talent mobility: The specific characteristic of SMEs, in terms of capital and their workforce, might present business development obstacles to advanced technology. Therefore, the government should put measures in place or write laws to support workers' mobilisation between government organisations, universities, and businesses. The effect of such talent mobility would be to reduce the distances between those three. Government organisations and universities may then better see the need for research and understand the scope of the area of research on customers' needs from SMEs. Meanwhile, SMEs might learn from the experts in the government and at universities and thus improve their performance as a result of collaboration.

Open knowledge sharing: Knowledge exchange is a bridge for creating an 'open innovation' by sharing knowledge via partnerships to create new economic landscapes in the knowledge-economy decade (Kuhne *et al*., 2013). Specifically, Open Innovation's goal is to catalyse internal innovation processes via knowledge

circulation of both inflow and outflow sources, and enhance the market by external innovation (Bayona-Saez *et al*., 2017). Thus, to strengthen the business's competitiveness, it is necessary to develop an inflow of business knowledge by collaborating with external knowledge that supports other knowledge or information areas (Nikolic *et al*., 2015). Thus, the circulation of knowledge might foster a learning ecosystem and an innovative means of transferring academic knowledge to businesses, as well as a stock of knowledge from government organisations via public communications

Promoting awareness of the circular economy: A lack of natural resources drives high competition between businesses to find those materials and process them into products that increase those resources' values. Such high demand implies that SMEs might run their production lines with limited resources and higher capital. Thus, the government should raise awareness of how to create zero waste from businesses and create value from what would have been waste by transforming it into a new line of products. However, processes to create value from waste or reduce the waste generated from the production line require R&D. Thus, the circular economy should support R&D, e.g. increasing its ease of access, reducing the price of R&D.

The policy implications of the results of this thesis could heighten R&D awareness and promote the creation of an innovative learning system for Thai SMEs in the seafood industry, leading to an increase in R&D expenditure and greater performance in terms of the products offered by and the markets accessible to this group.

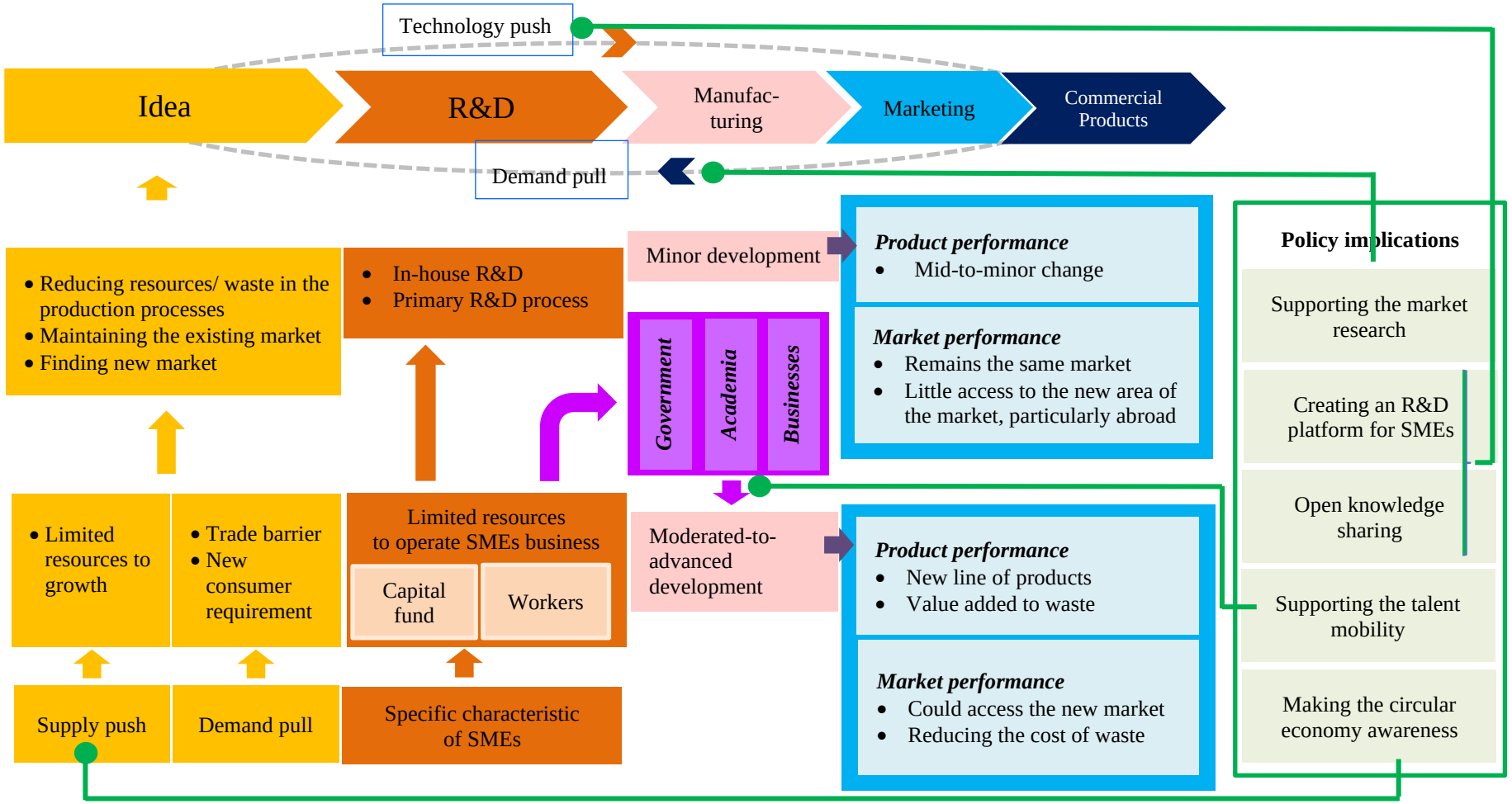


Figure 5.1: Summary of the Thai SMEs in the seafood industry included in this thesis and related policy recommendations

5.5 Concluding remarks

Maintaining a healthy business survival rate under current conditions, which are defined by the demand for high-quality products and indefinitely limited resources, require innovative business strategies.

R&D is an essential input element and a key factor in significantly improving business efficiency. However, the level of investment in R&D remains low, particularly in SMEs and particularly in developing countries. The readiness of businesses in terms of liquidity, awareness, and know-how is offered as an explanation for the low level of R&D investment by this group. The unpredictable results of R&D expenditures also affect current levels of R&D. Thus, to create innovations that bring unique products to the market and increase profits, it is necessary to strengthen the normal input factors—capital fund and staffing—while also raising awareness of R&D, particularly in SMEs and developing countries.

Working with a network can reduce the influence of limiting factors and increase a business's R&D activities. The patterns of network relationships may vary according to particular business features, such as size, sector and country of operation.

The three main actors in R&D activity are government organisations, academic institutions and private companies. These principal players increase the overall level of R&D activity. Generally, the role of government organisations is related to measures and laws. Academic institutions contribute knowledge and play the role of consultants for specific projects or areas of work. Finally, in the private sector, even business competitors can act as business partners and share resources.

While focusing on the case of Thai SMEs in the seafood industry, this research reveals the role of R&D in increasing business efficiency in terms of market performance and innovative products. The study also illustrates the efficacy of collaboration among external agencies to achieve R&D goals. By inspiring future research to bolster the trend of R&D investment among SMEs in the food business and other sectors that

complement the seafood industry, the results of this thesis could make the national macroeconomy sustainable.

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Appendices

Appendix I: Participant Information Sheet and Consent Form

Participant Information Sheet for firms in the seafood business and related organisations which involved in the responsiveness of SMEs to the research and development (R&D) interventions

Name of department: Civil and Environmental Engineering
Title of the study: How responsive are small and medium enterprises (SMEs) in the fishery and seafood sector to research and development (R&D) interventions through the Triple Helix system?

Introduction
In 2017, Thailand is the world leading exporter of seafood product under the limited use of new technologies, which has been a drag on the country's productivity and competitiveness over the years. R&D is acknowledged to be an internal factor like the former factors as capital, labour, and make the disrupt change productivity in developed countries and emerging markets. Meanwhile, the number of SMEs, who lacked the necessary resources for growth, e.g. innovation fund, high skill labour, in the sector is continuously growing and also recognised as an engine of job creation, and economic growth. Thus, to maintain the leader position of the seafood industry, it is necessary to increase the R&D interventions in Thai SMEs in the seafood business. The R&D effect on the productivity in the seafood industry does not report before. Thus, this study would like to reflex the effect of R&D on seafood business productivity. Furthermore, to raise the R&D activity in SMEs in the sector this study will find optimal supportive factors and players to establish the R&D activity of them. This research is part of the thesis of Sithon Kulradathon, PhD student who has got the Scholarship from The Royal Thai government, at the Department of Civil and Environmental Engineering, University of Strathclyde, U.K.

What is the purpose of this investigation?
The purpose of this study would like to clarify the role of R&D in the productivity of seafood business, especially in Thai SMEs. Furthermore, this study will seek the optimal player and factors to support the R&D activities in the seafood business.

Do you have to take part?
This research aims to raise the efficiency of seafood industry to be the leader position of the exporter in the world. The investigator needs your information to make this

study successful. The participation is voluntary to give necessary information in this study to make the clear picture of seafood sector development and free to withdraw at any time, without giving a reason.

What will you do in the project?
This study requires both quantitative and qualitative data. The participants in this study will be obtained through questionnaire administration. Also, an in-depth investigation and meeting observation are required, a few firms will be selected as case studies, which will be conducted through a combination of interviews and use of archival data that are both published and unpublished. The period of data collection will be completed in three months (during July – September 2018). The result of this research will complete in the last year of 2019.

Why have you been invited to take part?
This research requires the response from 100-120 voluntary to give their information. You have been invited because you have experience in the seafood industry in Thailand, you have the experience to apply R&D in your business, and have an export activity that helps to tell what are factors to raise their efficiency to expand the market.

What are the potential risks to you in taking part?
The investigator cannot assume that the result of this research can help to raise the SMEs efficiency by R&D better than the routine work of SMEs. But you could be encouraged new knowledge/factor to improve the productivity in the seafood industry for a future case.

What happens to the information in the project?
Your information will be kept confidential. It not will be shared with your employee and the third party who is not involved in this research. In order to protect your privacy and confidential, your information will be kept separately from your personal identification information. The researcher will assign your data by case number, and also we will keep your data separately from any documents that link to your personal information.

The University of Strathclyde is registered with the Information Commissioner's Office who implements the Data Protection Act 1998. All personal data on participants will be processed by the provisions of the Data Protection Act 1998.

Thank you for reading this information – please ask any questions if you are unsure about what is written here.

What happens next?
If you are happy to give your information, please sign the consent form that shows the detail in the below to make sure that you have read and understood the information of this research and answer any queries with your satisfaction. Then, you will go to complete a questionnaire which we estimate will take you 30 minutes. Also, we hope you to agree to a follow-up interview to find out more about your approach. In the analytical process, the researcher will look at it in an aggregate form. Your data will be combined with other participants so we can look at patterns across a large group of people. This research may publish this study in terms of journal articles, books, or presentation at the conference. The investigator will analyse your answer with other firms and present it in the picture of the seafood industry of Thailand. On the contrary, if you are not suitable to give your information to fulfil this project, you can ignore our question. Thank you for your attention and hope to have your corporation in the future.

Researcher contact details:
If you wish to find more about this research contact Sithon Kulradathon, The Department of Civil and Environmental Engineering, James Weir Building, Level5, 75 Montrose Street, Glasgow, Scotland, The United Kingdom, G1 1XJ, Telephone number (UK): +44(0)1415483275 e-mail: sithon.kulradathon@strath.ac.uk.

Chief Investigator details:
The chief investigator of this project is Dr.Girma Zawdie, Senior Lecturer, The Department of Civil and Environmental Engineering, James Weir Building, Level5, 75 Montrose Sreet, Glasgow, Scotland, The United Kingdom, G1 1XJ, Telephone number: +44(0)1415483275, e-mail: g.zawdie@strath.ac.uk.

This investigation was granted ethical approval by the University of Strathclyde Ethics Committee.

If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Secretary to the University Ethics Committee
Research & Knowledge Exchange Services
University of Strathclyde
Graham Hills Building
50 George Street
Glasgow
G1 1QE
Telephone: 0141 548 3707
Email: ethics@strath.ac.uk

Consent Form for the responsiveness of SMEs in the seafood sector to research and development interventions

Name of department: Civil and Environmental Engineering

Title of the study: How responsive are small and medium enterprises (SMEs) in the fishery and seafood sector to research and development (R&D) interventions through the Triple Helix system?

- I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences. If I exercise my right to withdraw and I don't want my data to be used, any data which have been collected from me will be destroyed.
- I understand that I can withdraw from the study any personal data (i.e. data which identify me personally) at any time.
- I understand that anonymised data (i.e. .data which do not identify me personally) cannot be withdrawn once they have been included in the study.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to be a participant in the project
- I consent to be audio and video recorded as part of the project

(PRINT NAME)	
Signature of Participant:	Date:

Appendix II: Questionnaire to study Research and Development and IT Use in the seafood industry in Thailand (English version)

(English translation of questionnaire in appendix III)

The significance of the questionnaire

This questionnaire is aimed to elicit data that would provide the empirical basis of a study being conducted by a student at the Department of Civil and Environmental Engineering, University of Strathclyde, U.K. The objective of this study is to examine the extent of IT use and access to Research and Development (R&D) activities across SMEs in the seafood industry; and the existential factors that promote and inhibit such activities. Please take a few minutes to fill out this questionnaire. Please ✓ in the table or box and fill the number/detail on the space provided. Your answers will be kept confidential. Thank you for your participation. For more information please contact Sithon Kulradathon via mobile number 0877859229 or e-mail address: sithon.kulradathon@strath.ac.uk

Part 1: General Information

1.1	Name of company:	……	
1.2	Age of company (year):	……	
1.3	Size of firm	Employment	Capital value
		○ 10-49 employees or fewer employees	○ turnover not exceeding EUR 10 million
		○ 50-249 employees or fewer employees	○ turnover ceiling not exceeding EUR 50 million
		○ 250 or more than employees	○ turnover ceiling exceeding EUR 50 million or more than
1.4	Employment details	Total Number of employees	……
		With Bachelor's degree	……
		With Master's degree	……
		With PhD	……
		Others	……
1.5	Do you publish annual reports	○ Yes ○ No	
1.6	Are these reports available on the company's website	○ Yes ○ No	

1.7 What is the nature of products of your company? And what is the share of each product line in the company total output?

Line of Product	2013		2014		2015		2016		2017	
	Value (Baht)	Share (%)	Value (Baht)	Share (%)	Value (Baht)	Share (%)	Value (Baht)	Share (%)	Value (Baht)	Share (%)
○ Shrimp										
○ Canned Tuna										
○ Frozen squid										
○ Frozen Fish Fillet										
○ Frozen Fish										
○ Canned Sardine										
○ Dried Fish										
○ Mollusc										
○ Pet Food										
○ Other (Please specify……										

Part 2: The Evidence of R&D and IT activity

2.1 Has your company had any engagement in R&D activities and IT use during the period of 2013 to 2017?

○ Yes ○ No

2.2 Please indicate details of the inputs of your company for the period 2013 –2017?

Inputs	2013	2014	2015	2016	2017
Total Capital Investment (include loan, equity) (Baht)					
Total Workers (does not include R&D and IT) (Baht)					
Total R&D expenditure (Baht)					
Total R&D employment (Baht)					
Total IT investment for device and software (Baht)					
Total IT employment (Baht)					
Other (Please specify)……..……					

2.3 Please rate areas of R&D and IT activities that your company has engaged in during the periods 2013 – 2017?

Partners	Never	Rarely	Sometimes	Very Often	Always
R&D personnel employment					
R&D personnel development					
IT personnel employment					
IT personnel development					
Machines and tools					
Infrastructure (Building, Land)					
IT (Devices, Software development)					
Others (Please specify)…….……					

2.4 How often has your company secured funding for R&D and IT from various sources services during 2013 – 2017?

		Never	Rarely	Sometimes	Very Often	Always
In-house investment	R&D					
	IT					
International investors	R&D					
	IT					
Local investors	R&D					
	IT					
Academic projects	R&D					
	IT					
Government funding	R&D					
	IT					
Others…….	R&D					
Others…….	IT					

2.5 Levels of qualification of R&D and IT employees in your company during the period 2013 – 2017?

Level of qualification	2013		2014		2015		2016		2017	
	R&D	IT	R&D	IT	R&D	IT	R&D	IT	R&D	IT
Total employees (person)										
Bachelor's degree (person)										
Master's degree (person)										
PhD (person)										
Others……										

2.6 How did your company's R&D and IT activities help enhance its performance during the period 2013-2017?

Goal	Key Performance Indicators	2013	2014	2015	2016	2017
Process Development	The number of total new process per year					
	The average of the production cycle in the total product (date)					
	The average of the total number of product per the production cycle					
Product Development	The number of totally new product per year					
	The number of total product per year					
	The average production price per each					
Marketing Performance - Total Sales (Baht)						
The average price of the product per each (Baht)						
Existing customer	Total number of an existing customer					

Expanding market sales	Export market (Total cost (Baht))					
	Local market (Total cost (Baht))					
The average time to sell your production (day)						
Other (Please specify)……..						

2.7 If your company has not engaged in R&D activities and IT use over the period 2013-2017, what are the main reasons for this?

……

……

……

……

Part 3: The process of production

3.1 Which of the following would increase the production efficiency of your business, and how?

Factors	Not at all helpful	Slightly helpful	Somewhat helpful	Very helpful	Extremely helpful	How? (Please specify)
Increasing Capital Investment						…… …… ……
Increasing Number of workers						…… …… ……
Increasing Resources (Land, Machines, Tools, Raw material)						…… …… ……
Engaging in Research and Development activities						…… …… ……
Increasing IT employees and facilities						

Others (Please specify)…… ……..						……..…… ……..…. ……..

Part 4: Marketing

4.1 What percentages of your products are normally earmarked for:

○ Export market ……..(%)

○ Local market ……..(%)

4.2 Marketing performance

Goal	Key Indicator Performance	2013	2014	2015	2016	2017
Sales/ Revenue	Total sales (Baht)					
Existing customer	Total number of an existing customer					
Market sales	Export market (Total cost (Baht))					
	Local market (Total cost (Baht))					

4.3 What are the factors that contributed to increases in the sales and revenue in your business from 2013 to 2017?

Factors	Not at all helpful	Slightly helpful	Somewhat helpful	Very helpful	Extremely helpful
Increasing the total amount of products					
Expansions of company (Land, Resources, Labour, Business partner)					
Improvement of quality of the product					
Entering new markets					
Creating an attractive product/ Niche product					
Others (Please specify)……					

Part 5: Engagement in cooperative and collaborative activities

5.1 How frequently does your company work with external partners?

Partners	Never	Rarely	Sometimes	Very Often	Always
Government units					
Academic institutions					
Large companies					
Other SMEs					
Knowledge network/Consortium					
Societal associations					
Others (Please specify)……					

5.2 What are the purposes of creating schemes for network collaboration?

Purpose	Not Important	Somewhat Important	Important	Very Important	Extremely Important
Improving your product efficiency					
Sharing resources					
Sharing knowledge					
Reducing risk and capital fund					
Making business-friendly strategies					
Reducing time to the market					
Do not know/ have experiences					
Regulation					
Increasing R&D efficiency					
Others (Please specify)……..…					

5.3 What are the reasons for your company not engaging with other partners?

Reasons	Not at all Significant	Slightly Significant	Moderately Significant	Very Significant	Extremely Significant
The company has enough facilities to improve itself					
Keeping the secret of businesses					
Do not have trust in sharing knowledge/information					
Have the different areas of interest with partners					
The uncertainty of business benefit due to collaboration					
The ambiguity of long-term achievable goal					
Others (Please specify)…….					

Part 6: Following up

6.1 Are you available for short following up interviewee of this research? ○ Yes ○ No

6.2 Any other comments?

……

……

……

……

……

……

……

……

➢ Thank you for your cooperation and support. We will keep your information confidential ≺

Appendix III: Questionnaire to study Research and Development and IT Use in the seafood industry in Thailand (Thai version)

Case Number.....

แบบสอบถามสำหรับการศึกษาผลของการใช้การวิจัยและพัฒนา (R&D) และการใช้เทคโนโลยีสารสนเทศ (IT) ในอุตสาหกรรมอาหารทะเลในประเทศไทย

ที่มาและความสำคัญ

แบบสอบถามนี้เป็นส่วนหนึ่งในงานวิจัยของนักศึกษาในระดับปริญญาเอก ณ the Department of Civil and Environmental Engineering, University of Strathclyde ประเทศสหราชอาณาจักร โดยมีวัตถุประสงค์เพื่อศึกษาบทบาทของเทคโนโลยีสารสนเทศและการวิจัยและพัฒนาเพื่อการพัฒนาอุตสาหกรรมอาหารทะเลไทย โดยเฉพาะในวิสาหกิจขนาดกลางและขนาดย่อม รวมถึงวิเคราะห์ปัจจัยที่ก่อให้เกิดการกระตุ้นและการยับยั้งปัจจัยดังกล่าวข้างต้นในการดำเนินธุรกิจอาหารทะเล โปรดสละเวลาของท่านในการตอบแบบสอบถาม โดยกรุณาทำเครื่องหมาย ✓ในตารางหรือ O และระบุจำนวน/รายละเอียดในช่องว่าง คณะผู้วิจัยจะปกปิดข้อมูลของท่านเป็นความลับ ทางคณะผู้วิจัยขอขอบคุณล่วงหน้าในความร่วมมือมา ณ โอกาสนี้ หากต้องการสอบถามข้อมูลเพิ่มเติม กรุณาติดต่อ ศิธร กุลรดาธร ทางโทรศัพท์มือถือ หมายเลข 0959399140 หรือ ทาง e-mail: sithon.kulradathon@strath.ac.uk

ส่วนที่ 1: ข้อมูลทั่วไป

1.1	ชื่อบริษัท:	.....	
1.2	อายุของบริษัท (ปี):	.....	
1.3	ขนาดของบริษัท	จำนวนลูกจ้าง	งบลงทุน
		O 10-49 คน หรือน้อยกว่า	O เงินทุน ไม่เกิน 50 ล้านบาท
		O 50-249 คน หรือน้อยกว่า	O เงินทุนมากกว่า 50-200 ล้านบาท
		O 250 คน หรือมากกว่า	O เงินทุนมากกว่า 200 ล้านบาท
1.4	รายละเอียดการจ้างงาน	จำนวนลูกจ้างทั้งหมด (คน)	.....
		จำนวนลูกจ้างระดับปริญญาตรี (คน)	.....
		จำนวนลูกจ้างระดับปริญญาโท (คน)	.....
		จำนวนลูกจ้างระดับปริญญาเอก (คน)	.....
		จำนวนลูกจ้างในวุฒิการศึกษาอื่นๆ (คน)	.....
1.5	บริษัทของคุณได้มีการเผยแพร่รายงานประจำปีต่อสาธารณะหรือไม่	O มี	O ไม่มี
1.6	รายงานประจำปีและเอกสารอื่นๆ ที่เกี่ยวข้องมีการเผยแพร่ผ่านเวปไซต์ของบริษัทหรือไม่	O มี	O ไม่มี

1.7 สินค้าหลักของบริษัทคุณประกอบด้วยอะไรบ้าง และคิดเป็นสัดส่วนเท่าไหร่เมื่อเทียบกับผลผลิตโดยรวมของบริษัท

ประเภทผลิตภัณฑ์	พ.ศ. 2556		พ.ศ. 2557		พ.ศ. 2558		พ.ศ. 2559		พ.ศ. 2560	
	มูลค่า (บาท)	สัดส่วน (%)	มูลค่า (บาท)	สัดส่วน (%)	มูลค่า (บาท)	สัดส่วน (%)	มูลค่า (บาท)	สัดส่วน (%)	มูลค่า (บาท)	สัดส่วน (%)
○ กุ้ง										
○ ทูน่ากระป๋อง										
○ ปลาหมึกแช่แข็ง										
○ เนื้อปลาแช่แข็ง										
○ ปลาแช่เข็ง										
○ ปลาซาร์ดีนกระป๋อง										
○ ปลาตากแห้ง										
○ หอย										
○ อาหารสัตว์										
○ อื่นๆ (โปรดระบุ)										

ส่วนที่ 2: สถานการณ์ด้านการวิจัยและพัฒนาและการใช้เทคโนโลยีสารสนเทศ

2.1 บริษัทของคุณมีกิจกรรมการวิจัยและพัฒนาและการใช้เทคโนโลยีสารสนเทศในช่วงระหว่าง พ.ศ. 2556 – 2560 หรือไม่

○ มี ○ ไม่มี

2.2 กรุณาระบุรายละเอียดของต้นทุนที่ใช้ในการพัฒนาบริษัทของคุณ ระหว่าง พ.ศ. 2556 – 2560

ต้นทุน	พ.ศ. 2556	พ.ศ. 2557	พ.ศ. 2558	พ.ศ. 2559	พ.ศ. 2560
งบลงทุนทั้งหมด (รวม การกู้ยืม, หุ้น) (บาท)					
จำนวนการจ้างงานทั้งหมด (ไม่รวมบุคลากรด้านการวิจัยและพัฒนาและเทคโนโลยีสารสนเทศ (บาท)					
งบลงทุนด้านการวิจัยและพัฒนาทั้งหมดไม่รวมบุคลากรด้านการวิจัยและพัฒนา (บาท)					
จำนวนการจ้างงานเฉพาะบุคลากรด้านการวิจัยและพัฒนา (บาท)					
งบลงทุนด้านเทคโนโลยีสารสนเทศเฉพาะอุปกรณ์และซอฟท์แวร์ (บาท)					
จำนวนการจ้างงานเฉพาะบุคลากรด้านเทคโนโลยีสารสนเทศ (บาท)					
อื่นๆ (โปรดระบุ)					

2.3 โปรดลำดับความสำคัญของแนวทางการทำวิจัยและพัฒนาและการใช้เทคโนโลยีสารสนเทศในบริษัทของคุณในช่วงระหว่าง พ.ศ. 2556 – 2560

แนวทาง	ไม่เคย	นานๆ ครั้ง	บางครั้ง	บ่อยครั้ง	สม่ำเสมอ
มุ่งเน้นการจ้างบุคลากรเพื่อการวิจัยและพัฒนา					
มุ่งเน้นการพัฒนาบุคลากรด้านการวิจัยและพัฒนาที่มีอยู่					
มุ่งเน้นการจ้างบุคลากรเพื่องานด้านเทคโนโลยีสารสนเทศ					
มุ่งเน้นการพัฒนาบุคลากรด้านเทคโนโลยีสารสนเทศที่มีอยู่					
จัดซื้อเครื่องมือและอุปกรณ์					
ปลูกสร้าง/ต่อเติมโครงสร้างพื้นฐาน (อาคารและที่ดิน)					
จัดซื้อเทคโนโลยีสารสนเทศ (อุปกรณ์, การพัฒนาซอฟท์แวร์)					
อื่นๆ (โปรดระบุ)					

2.4 โปรดลำดับความถี่ของเงินทุนที่บริษัทได้รับเพื่อการทำวิจัยและพัฒนาและการพัฒนาเทคโนโลยีสารสนเทศ ระหว่าง พ.ศ. 2556 – 2560

แหล่งเงินทุน		ไม่เคย	นานๆ ครั้ง	บางครั้ง	บ่อยครั้ง	สม่ำเสมอ
การลงทุนภายในบริษัท	R&D					
	IT					
นักลงทุนชาวต่างชาติ	R&D					
	IT					
นักลงทุนภายในประเทศ	R&D					
	IT					
โครงการวิจัยของสถาบันการศึกษา	R&D					
	IT					
เงินทุนจากรัฐบาล	R&D					
	IT					
อื่นๆ.....	R&D					
อื่นๆ.....	IT					

2.5 โปรดระบุจำนวนการจ้างงานทั้งหมดและจำนวนการจ้างงานจำแนกตามระดับการศึกษาในบริษัทของคุณระหว่าง พ.ศ. 2556 - 2560

ระดับการศึกษา	พ.ศ. 2556		พ.ศ. 2557		พ.ศ. 2558		พ.ศ. 2559		พ.ศ. 2560	
	R&D	IT	R&D	IT	R&D	IT	R&D	IT	R&D	IT
จำนวนการจ้างงานทั้งหมด (คน)										
จำนวนการจ้างงานในระดับปริญญาตรี (คน)										
จำนวนการจ้างงานในระดับปริญญาโท (คน)										
จำนวนการจ้างงานในระดับปริญญาเอก (คน)										
อื่นๆ.....										

2.6 การทำวิจัยและพัฒนาและการใช้เทคโนโลยีสารสนเทศช่วยให้เกิดการยกระดับศักยภาพของบริษัทคุณในช่วง พ.ศ. 2556 – 2560 อย่างไร

เป้าหมาย	ปัจจัยบ่งชี้ศักยภาพ	พ.ศ. 2556	พ.ศ. 2557	พ.ศ. 2558	พ.ศ. 2559	พ.ศ. 2560
การพัฒนากระบวนการ	เกิดการพัฒนากระบวนการใหม่ในกระบวนการผลิต (จำนวนกระบวนการใหม่/ ปี)					
	ค่าเฉลี่ยจำนวนวันที่ใช้ในกระบวนการผลิตต่อรอบการผลิต (วัน/ปี)					
	ค่าเฉลี่ยผลผลิตทั้งหมดต่อรอบการผลิต (จำนวนผลผลิต/รอบ/ปี)					
การพัฒนาผลิตภัณฑ์	เกิดการพัฒนาผลิตภัณฑ์ใหม่ (จำนวนผลิตภัณฑ์ใหม่/ ปี)					
	จำนวนผลผลิตทั้งหมด/ ปี					
	ค่าเฉลี่ยราคาสินค้า (บาท/ ชิ้น)					
ศักยภาพด้านการตลาด – ยอดขายทั้งหมด (บาท/ปี)						
ค่าเฉลี่ยราคาสินค้าต่อชิ้น (บาท/ ปี)						
จำนวนลูกค้า	จำนวนลูกค้าทั้งหมดของบริษัท (ราย/ ปี)					
การขยายตลาด	รายได้จากตลาดต่างประเทศ (บาท/ ปี)					
	รายได้จากตลาดภายในประเทศ (บาท/ ปี)					
ค่าเฉลี่ยระยะเวลาในการขายผลผลิตต่อรอบการผลิต (วัน)						
อื่นๆ (โปรดระบุ)						

2.7 กรณีที่บริษัทของคุณไม่มีการทำวิจัยและพัฒนาและไม่มีการใช้เทคโนโลยีสารสนเทศระหว่าง พ.ศ. 2556 – 2560 โปรดระบุเหตุผล

.....

.....

.....

ส่วนที่ 3: กระบวนการผลิต

3.1 ปัจจัยอะไรที่ทำให้เกิดการเพิ่มศักยภาพผลผลิตในบริษัทของคุณ และอย่างไร

ปัจจัย	ไม่มีประโยชน์	มีประโยชน์บ้าง	ค่อนข้างมีประโยชน์	มีประโยชน์มาก	มีประโยชน์มากที่สุด	อย่างไร (โปรดระบุ)
การเพิ่มขึ้นของเงินทุน						....
การเพิ่มขึ้นของแรงงาน						....
การเพิ่มขึ้นของทรัพยากรในการทำงาน (ที่ดิน, เครื่องจักร, เครื่องมือ, วัตถุดิบ)						....
การใช้ประโยชน์จากการวิจัยและพัฒนา						....
การเพิ่มขึ้นของเจ้าหน้าที่และเครื่องมือด้านเทคโนโลยีสารสนเทศ						....
อื่นๆ (โปรดระบุ)						....

ส่วนที่ 4: ด้านการตลาด

4.1 โปรดระบุสัดส่วนยอดขายของบริษัทเมื่อเปรียบเทียบระหว่างการส่งออกไปต่างประเทศ และการจำหน่ายภายในประเทศ

- ○ การส่งออกไปต่างประเทศ .....(%)
- ○ การจำหน่ายภายในประเทศ .....(%)

4.2 โปรดระบุศักยภาพด้านการตลาดของบริษัท

เป้าหมาย	ตัวบ่งชี้ศักยภาพ	พ.ศ. 2556	พ.ศ. 2557	พ.ศ. 2558	พ.ศ. 2559	พ.ศ. 2560
ยอดขาย / รายได้	ยอดขายทั้งหมด (บาท)					
จำนวนลูกค้า	จำนวนลูกค้าทั้งหมด (ราย)					
ยอดขายในตลาดต่างๆ	การส่งออก (บาท)					
	การจำหน่ายสินค้าภายในประเทศ (บาท)					

4.3 อะไรคือปัจจัยในการเพิ่มยอดขายและรายได้ให้บริษัทของคุณระหว่าง พ.ศ. 2556 – 2560

ปัจจัย	ไม่มีประโยชน์	มีประโยชน์บ้าง	ค่อนข้างมีประโยชน์	มีประโยชน์มาก	มีประโยชน์มากที่สุด
การเพิ่มขึ้นของจำนวนผลผลิต					
การขยายตัวของบริษัท (การเพิ่มพื้นที่, การเพิ่มทรัพยากร, การเพิ่มแรงงาน, การพัฒนาความร่วมมือกับเครือข่าย)					
การพัฒนาคุณภาพของผลิตภัณฑ์					
การเข้าสู่ตลาดใหม่					
ความคิดสร้างสรรค์ของผลิตภัณฑ์/ ผลิตภัณฑ์เป็นที่ต้องการของตลาดหรือเป็นผลิตภัณฑ์ที่หาได้ยากในตลาด					
อื่นๆ (โปรดระบุ).....					

ส่วนที่ 5: ความร่วมมือกับหน่วยงานภายนอก

5.1 โปรดระบุความถี่ในการดำเนินงานร่วมกับหน่วยงานภายนอกเพื่อการพัฒนาบริษัทของคุณ

หน่วยงาน	นานๆ ครั้ง	บางครั้ง	บ่อยครั้ง	สม่ำเสมอ	ไม่เคย
หน่วยงานภาครัฐ					
สถาบันการศึกษา					
วิสาหกิจขนาดใหญ่					
วิสาหกิจขนาดกลางและขนาดย่อมอื่นๆ					
เครือข่ายสนับสนุนด้านความรู้/ สหภาพ/ สมาคม					
สมาคมทางสังคมต่างๆ					
อื่นๆ (โปรดระบุ)					

5.2 โปรดระบุความสำคัญของการพัฒนาความร่วมมือในลักษณะเครือข่ายเพื่อการพัฒนาธุรกิจ

วัตถุประสงค์	ไม่สำคัญ	ค่อนข้างสำคัญ	สำคัญ	สำคัญมาก	สำคัญที่สุด
เพื่อพัฒนาศักยภาพของผลผลิต					
แบ่งปันทรัพยากร					
แบ่งปันองค์ความรู้					
ลดความเสี่ยงและเพิ่มเงินทุน					
สร้างพันธมิตรทางธุรกิจ					
ลดระยะเวลาในการเข้าสู่ตลาด					
ต้องการบุคลากรที่มีประสบการณ์ มาร่วมดำเนินงาน					
ดำเนินการตามกฎ ระเบียบ ข้อบังคับ					
เพื่อเพิ่มศักยภาพด้านการวิจัยและพัฒนา					
อื่นๆ (โปรดระบุ)					

5.3 อะไรคือเหตุผลที่บริษัทของคุณตัดสินใจไม่ทำงานร่วมกับเครือข่าย

เหตุผล	ไม่สำคัญเลย	สำคัญเล็กน้อย	สำคัญ	สำคัญมาก	สำคัญที่สุด
บริษัทมีสิ่งอำนวยความสะดวกมากเพียงพอในการพัฒนาตนเอง					
เพื่อรักษาความลับของทางบริษัท					
ไม่มีความเชื่อมั่นในการแบ่งปันองค์ความรู้หรือข้อมูลของบริษัทให้กับหน่วยงานเครือข่าย					
ไม่มีจุดสนใจร่วมในการพัฒนางานร่วมกับเครือข่าย					
ไม่มีความมั่นใจว่าจะสามารถสร้างผลประโยชน์ให้กับบริษัทได้จากการทำงานร่วมกับหน่วยงานเครือข่าย					
มองไม่เห็นความสำเร็จจากการทำงานร่วมกับเครือข่ายในระยะยาว					
อื่นๆ (โปรดระบุ)					

Case Number.....

ส่วนที่ 6 : การติดตามผล

6.1 บริษัทของคุณสะดวกให้ผู้วิจัยเข้าพบเพื่อสัมภาษณ์ข้อมูลเพิ่มเติมหรือไม่ ○ สะดวก ○ ไม่สะดวก

6.2 ข้อเสนอแนะเพิ่มเติม

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➢ ขอบคุณสำหรับความร่วมมือในการตอบแบบสอบถาม คณะผู้วิจัยจะเก็บข้อมูลของท่านเป็นความลับ ➢

Appendix IV: Covering letter to invite participants for the research (Thai version)

สำนักงานคณะกรรมการนโยบายวิทยาศาสตร์ เทคโนโลยีและนวัตกรรมแห่งชาติ
319 อาคารจัตุรัสจามจุรี ชั้น 14 ถนนพญาไท
แขวงปทุมวัน เขตปทุมวัน กรุงเทพมหานคร 10330
National Science Technology and Innovation Policy Office
319 Chamchuri Square Building 14th Fl., Phayathai Rd.,
Patumwan, Bangkok 10330 Thailand

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ที่ วท 6001/ว1509

2 ตุลาคม 2561

เรื่อง ขอความอนุเคราะห์ตอบแบบสอบถาม

เรียน

สิ่งที่ส่งมาด้วย 1) เอกสารชี้แจงข้อมูลงานวิจัย (Participant Information Sheet)
2) ใบยินยอมเข้าร่วมงานวิจัย (Consent form)
3) แบบสอบถาม
4) ซองจดหมาย

ด้วย นางสาวศิธร กุลรดาธร ตำแหน่ง นักวิเคราะห์นโยบาย ด้านนโยบายนวัตกรรมเพื่ออุตสาหกรรมและการเชื่อมโยงนานาชาติ สำนักงานคณะกรรมการนโยบายวิทยาศาสตร์ เทคโนโลยีและนวัตกรรมแห่งชาติ (สวทน.) เป็นผู้ได้รับทุนรัฐบาลที่จัดสรรให้กระทรวงวิทยาศาสตร์และเทคโนโลยี ตามความต้องการของ สวทน. ไปศึกษาวิชา ณ ต่างประเทศ สาขาการจัดการเทคโนโลยี และขณะนี้กำลังศึกษาในระดับปริญญาเอก ณ The Department of Civil and Environmental Engineering, The University of Strathclyde ประเทศสหราชอาณาจักร ภายใต้หัวข้อการวิจัยเรื่อง The role of research and development and IT use as strategies for SME development with particular reference to the case of the fishery and seafood sector in Thailand โดยใช้แบบสอบถาม การสัมภาษณ์เชิงลึกและกรณีศึกษาเป็นเครื่องมือหลักในการศึกษาภายใต้หัวข้อวิจัยดังกล่าว

เพื่อให้การดำเนินงานวิจัยสำเร็จลุล่วงจำเป็นต้องได้รับความร่วมมือจากผู้ประกอบการในอุตสาหกรรมอาหารทะเลและสาขาที่เกี่ยวข้องในการให้ข้อมูลที่สำคัญ ในการนี้ นางสาวศิธร และคณะผู้วิจัยพิจารณาแล้วว่าหน่วยงานของท่านเป็นผู้มีบทบาทสำคัญต่อการขับเคลื่อนอุตสาหกรรมอาหารทะเลของประเทศไทย สวทน. ในฐานะต้นสังกัดของนางสาวศิธร จึงขอความอนุเคราะห์ในการให้ข้อมูลประกอบการวิจัยดังมีรายละเอียดปรากฏตามสิ่งที่ส่งมาด้วย 1 ทั้งนี้ หากท่านยินดีให้ข้อมูลในงานวิจัย กรุณาลงนามในใบยินยอมเข้าร่วมงานวิจัย Consent form (สิ่งที่ส่งมาด้วย 2) และให้ข้อมูลในแบบสอบถาม (สิ่งที่ส่งมาด้วย 3) และกรุณาส่งเอกสารดังมีรายละเอียดปรากฏตามสิ่งที่ส่งมาด้วย 1 – 3 พร้อมแนบรายงานประจำปีของบริษัท และเอกสารอื่นๆ ที่เกี่ยวข้องกับผลการดำเนินงานของบริษัทระหว่างปี พ.ศ. 2556 – 2560 ใส่ซองจดหมาย (สิ่งที่ส่งมาด้วย 4) กลับมายัง นางสาวศิธร กุลรดาธร ทางจดหมายที่สำนักงานคณะกรรมการนโยบายวิทยาศาสตร์ เทคโนโลยีและนวัตกรรมแห่งชาติ 319 อาคารจัตุรัสจามจุรี ชั้น 14 ถนนพญาไท แขวงปทุมวัน เขตปทุมวัน กรุงเทพฯ 10330 หรือทาง e-mail : sithon.kulradathon@strath.ac.uk หรือท่านสามารถให้ข้อมูลผ่านทางเว็ปไซต์ https://stratheng.eu.qualtrics.com/jfe/form/SV_6ywhVbGv3drDE8d และส่งรายงานผลการดำเนินงานและเอกสารที่เกี่ยวข้องกลับมาตามที่อยู่ข้างต้น โดยขอความกรุณาส่งกลับข้อมูลของท่านภายในวันที่ 15 พฤศจิกายน 2561 ในกรณีท่านต้องการสอบถามข้อมูลเพิ่มเติม สามารถติดต่อนางสาวศิธร กุลรดาธร ทาง e-mail: sithon.kulradathon@strath.ac.uk ซึ่งอยู่ระหว่างการเก็บข้อมูลภาคสนามในประเทศไทย ในการนี้ สวทน. ใคร่ขอบคุณท่านในความร่วมมือตอบแบบสอบถามล่วงหน้า มา ณ โอกาสนี้

ขอแสดงความนับถือ

(นายกิติพงค์ พร้อมวงค์)
เลขาธิการสำนักงานคณะกรรมการนโยบายวิทยาศาสตร์
เทคโนโลยีและนวัตกรรมแห่งชาติ

Appendix V: Covering letter to invite participants for the research (English version)

2 October 2018

Title of documentPlease answer the questionnaire research

Dear name of participants

Attached files 1) Participant Information Sheet
2) Consent form
3) Questionnaire
4) Envelope

As Miss Sithon Kulradathon, a policy analyst at The National Science Technology and Innovation Policy Office, have got the scholar from the Thai government to study in the PhD degree at the Department of Civil and Environmental Engineering, The University of Strathclyde, UK. Her working on the thesis title The role of research and development and IT use as strategies for SME development with particular reference to the case of the fishery and seafood sector in Thailand by using the questionnaire survey, interview method and the case study method to collect the data

Therefore, the significant information from the business in the seafood and fishery industry and the related sector is necessary to complete this research. Sithon and a researcher team considered that your organisation has a role in driving the seafood industry in Thailand So, STI on behalf of Sithon original affiliation would like you to participate in the research shown the details in the attached document 1. If you are willing to join this research, please sign your name on the consent form (attached document 2) and please answer the questionnaire (attached document 3). Then, please return all documents and the annual report during 2013-2017 of your company and related documents by inserting those documents into an envelope (attached document 4) and send it to Miss Sithon Kulradathon, The National Science Technology and Innovation Policy Office, Chamchuri Square 14th Floor, Phayathai Road, Pathumwan, Bangkok, 10330 or e-mail: sithon.kulradathon@strath.ac.uk or via the website: https://stratheng.eu.qualtrics.com/jfe/form/SV_6ywhVbGv3drDE8d and send the business annual report and related document to the previous address. Please complete the questionnaire and return all documents before 15th November 2018. If you need more information, please contact Miss Sithon Kulradathon via e-mail: sithon.kulradathon@strath.ac.uk. STI office would like to thank you in advance for your corporation

Sincerely,

(Kitipong Promwong, Ph.D.)
Secretary-General
The National Science Technology and Innovation Policy Office

Appendix VI: The Item Objective Congruence

The Item Objective Congruence (IOC) tool is used to find the optimal content and style for a questionnaire. Normally, the total number of experts to evaluate the IOC scores should be an odd number so that a final IOC score consensus can be reached (Radhakrishna, 2007; Sinjaru, 2017). Five experts—two science policy experts, two business owners, and one university in the field of food science—evaluated the questionnaire of this thesis.

The IOC score is 1 if the question is in accordance with the objectives of the study.

The IOC score is 0 if the question is not in accordance with the objectives.

Individual scores from the five experts were then used to calculate the average score per question with the following formulae:

$$\text{IOC} = \frac{\Sigma R}{N}$$

Formula VI 1: The formula for calculating the Item Objective Congruence

Where IOC = The Item Objective Congruence
∑R = The accumulative score
N = The total number of experts

The results show that the average IOC for both the content and the literacy style of every question in the questionnaire was in accordance with the objectives of the thesis. This supports the conclusion that the questionnaire is an acceptable tool to collect the data.

Table VI.1: The table shows the conformity score of the questionnaire contents to the research aim of five experts in the seafood industry and related fields by the Item Objective Congruence calculating

Number of Questions	The content of the questionnaire						
	E1	E2	E3	E4	E5	IOC = $\frac{\Sigma R}{N}$	Average IOC
1.1	1	1	1	1	1	[1+1+1+1+1]/5	1.00
1.2	1	1	1	1	1	[1+1+1+1+1]/5	1.00
1.3	1	1	0	0	1	[1+1+0+0+1]/5	0.60
1.4	1	1	0	0	1	[1+1+0+0+1]/5	0.60
1.5	1	0	1	0	1	[1+0+1+0+1]/5	0.60
1.6	1	0	1	0	1	[1+0+1+0+1]/5	0.60
1.7	-1	1	1	1	1	(-1)+1+1+1+1/5	0.60
2.1	1	1	0	0	1	[1+1+0+0+1]/5	0.60
2.2	1	1	1	1	1	[1+1+1+1+1]/5	1.00
2.3	1	1	1	1	1	[1+1+1+1+1]/5	1.00
2.4	1	0	1	0	1	[1+0+1+0+1]/5	0.60
2.5	1	1	0	0	1	[1+1+0+0+1]/5	0.60
2.6	1	1	1	1	1	[1+1+1+1+1]/5	1.00
2.7	1	1	0	1	1	[1+1+0+1+1]/5	0.80
3.1	1	1	1	1	1	[1+1+1+1+1]/5	1.00
4.1	1	1	1	0	0	[1+1+1+0+0]/5	0.60
4.2	1	1	1	0	0	[1+1+1+0+0]/5	0.60
4.3	1	0	1	1	1	[1+0+1+1+1]/5	0.80
5.1	1	1	0	1	1	[1+1+0+1+1]/5	0.80
5.2	1	1	0	1	1	[1+1+0+1+1]/5	0.80
5.3	1	1	1	1	0	[1+1+1+1+1]/5	0.80
6.1	1	1	1	1	1	[1+1+1+1+1]/5	1.00
6.2	1	1	1	1	1	[1+1+1+1+1]/5	1.00

Notes;

1) IOC > 0.05 means the question is in accordance with the objectives of the study
2) IOC ≤ 0.05 means the question is not in accordance with the objectives
3) Number of question is the number of the question that shows on the questionnaire (Appendix II)
4) "1" means the question is in accordance with the objectives of the study
5) "0" means not sure that the question in accordance with the objectives of the study
6) "-1" means the question is not in accordance with the objectives of the study
7) E1 means the 1st specialist
8) E2 means the 2nd specialist
9) E3 means the 3rd specialist
10) E4 means the 4th specialist
11) E5 means the 5th specialist

Table VI.2: The table shows the conformity score of the questionnaire literacy style to the research aim of five experts in the seafood industry and related fields by the Item Objective Congruence calculating

Number of Questions	The literary style of the questionnaire						
	E1	E2	E3	E4	E5	IOC = $\frac{\Sigma R}{N}$	Average IOC
1.1	1	1	1	1	1	[1+1+1+1+1]/5	1.00
1.2	1	1	1	1	1	[1+1+1+1+1]/5	1.00
1.3	1	1	1	1	1	[1+1+1+1+1]/5	1.00
1.4	1	1	1	1	1	[1+1+1+1+1]/5	1.00
1.5	1	1	1	0	0	[1+1+1+0+0]/5	0.60
1.6	1	1	1	0	0	[1+1+1+0+0]/5	0.60
1.7	1	1	1	1	1	[1+1+1+1+1]/5	1.00
2.1	1	1	0	0	1	[1+1+0+0+1]/5	0.60
2.2	1	1	1	1	1	[1+1+1+1+1]/5	1.00
2.3	1	1	1	1	1	[1+1+1+1+1]/5	1.00
2.4	1	0	1	0	1	[1+0+1+0+1]/5	0.60
2.5	1	1	0	0	1	[1+1+0+0+1]/5	0.60
2.6	1	1	1	1	1	[1+1+1+1+1]/5	1.00
2.7	1	1	0	1	1	[1+1+0+1+1]/5	0.80
3.1	1	1	1	1	1	[1+1+1+1+1]/5	1.00
4.1	1	1	1	0	0	[1+1+1+0+0]/5	0.60
4.2	1	1	1	0	0	[1+1+1+0+0]/5	0.60
4.3	1	0	1	0	1	[1+0+1+0+1]/5	0.60
5.1	1	1	0	0	1	[1+1+0+0+1]/5	0.60
5.2	1	1	0	0	1	[1+1+0+0+1]/5	0.60
5.3	1	1	1	1	0	[1+1+1+1+0]/5	0.80
6.1	1	1	1	1	1	[1+1+1+1+1]/5	1.00
6.2	1	1	1	1	1	[1+1+1+1+1]/5	1.00

Notes;

1) IOC > 0.05 means the question is in accordance with the objectives of the study
2) IOC ≤ 0.05 means the question is not in accordance with the objectives
3) Number of question is the number of the question that shows on the questionnaire (Appendix II)
4) "1" means the question is in accordance with the objectives of the study
5) "0" means not sure that the question in accordance with the objectives of the study
6) "-1" means the question is not in accordance with the objectives of the study
7) E1 means the 1st specialist
8) E2 means the 2nd specialist
9) E3 means the 3rd specialist
10) E4 means the 4th specialist
11) E5 means the 5th specialist

Appendix VII: The validity and reliability of content and literacy style in the questionnaire

During the pre-questionnaire process, validity and reliability testing of the questionnaire was investigated using 30 samples of the questionnaire. The reliability of a questionnaire can be presented as an alpha value; acceptable values fall in the range of 0.65-0.80. The Cronbach's alpha value analysis used in this research is described below. The values show that the result from 30 samples have a Cronbach's alpha value of 0.666, demonstrating this questionnaire's validity and reliability.

Table VII.1: The total number of cases to evaluate the validity and reliability of the questionnaire

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Table VII.2: The Cronbach's alpha value analysis to evaluate the validity and reliability of the questionnaire

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.666	.775	19

Appendix VIII: Statistical analysis result of survey data

This appendix presents the analytical data from the questionnaire survey in eight points; the first point reveals the business profile, which consists of age, capital funds and employment in Table VIII.1, Table VIII.2, and Table VIII.3, respectively.

Secondly, Table VIII.4 provides total analytical data regarding R&D expenditures among Thai SMEs in the seafood industry, while Table VIII.5 offers details of R&D investment in employees and Table VIII.6 reveals details of R&D investment in machines and tools.

Lastly, Table VIII.7 and Table VIII.8 present analytic data on the impact of R&D on market performance in terms of total sale and export revenue among Thai SMEs in the seafood industry.

The detail of the statistical analysis of the questionnaire showed the detail below.

Table VIII.1: The age profile of the firms, comparing the Without R&D group and the With R&D group

The age range (in years)	Without R&D		With R&D		Total	
	Count	%	Count	%	Count	%
1-10	7	11.1	1	1.9	8	7
11-20	21	33.3	22	42.3	43	37.4
21-30	18	28.6	14	26.9	32	27.8
31-40	12	19	10	19.2	22	19.1
41-50	3	4.8	5	9.6	8	7
51-60	2	3.2	0	0	2	1.7
Total	63	100	52	99.9	115	100
Chi-Square*	6.714					
df	5					
p-value (significance at 0.05 level)	0.243					

Notes:

1) * 6 cells (50.0%) have expected count less than 5. The minimum expected count is 0.90
2) % = Percentage within R&D engagement
3) The total number of firms is 115
4) This table shows the age profile of Thai SMEs in the seafood industry. Using data from 2017, it compares firms that invested in R&D and firms that did not. In both groups, most of the firms range in age from 11 to 20 years, and the percentage of firms declines as they age. However, the statistical analysis indicates that age differences do not affect the R&D participation of the businesses (p-value = 0.243) at a 95% significance level.

Table VIII.2: The capital funds of the businesses, comparing the Without R&D group and the With R&D group

Capital Fund (in million baht)	Without R&D		With R&D		Total	
	Count	%	Count	%	Count	%
1-200M	35	55.6	39	75.0	74	64.3
200M-400M	8	12.7	7	13.5	15	13.0
400M-600M	9	14.3	2	3.8	11	9.6
600M-800M	4	6.3	1	1.9	5	4.3
800M-1,000M	4	6.3	0	0.0	4	3.5
1,000M-1,2000M	2	3.2	1	1.9	3	2.6
>1,200M-2,600M	1	1.6	2	3.8	3	2.6
Total	63	100.0	52	100.0	115	100.0
Chi-Square*	10.246					
df	6					
p-value (significance at 0.05 level)	0.115					

Notes:

1) *9 cells (64.3%) have expected count less than 5. The minimum expected count is 1.36
2) M = million baht
3) % = Percentage within R&D engagement
4) The total number of firms is 115
5) This table shows the structure of capital funding among Thai SMEs in the seafood industry in 2017. A comparison of firms that invested in R&D and firms that did not reveals that most firms in both groups had capital funds ranging from 1 to 200 million baht. The With R&D group were approximately 19% greater than they were in the Without R&D group. In most categories, except for the 200 – 400 million baht category, the Without R&D group accounted for a higher percentage than did the With R&D group. There were very few companies in the 1,200 – 2,600 million baht group. The chi-square test does not show the difference in the capital funds of two groups at a 95% significance level.

Table VIII.3: The employment structure of the businesses, comparing the Without R&D group and the With R&D group

Total headcount of employees	Without R&D		With R&D		Total	
	Count	%	Count	%	Count	%
1-25	10	15.6	4	7.8	14	12.2
26-50	10	15.6	5	9.8	15	13
51-75	10	15.6	1	2	11	9.6
76-100	13	20.3	3	5.9	16	13.9
101-125	1	1.6	3	5.9	4	3.5
126-150	4	6.3	2	3.9	6	5.2
150-175	1	1.6	1	2	2	1.7
176-200	3	4.7	4	7.8	7	6.1
201-225	0	0.0	0	0	0	0
226-250	3	4.7	6	11.8	9	7.8
251-500	8	12.5	12	23.5	20	17.4
501-750	0	0.0	4	7.8	4	3.5
751-1,000	1	1.6	2	3.9	3	2.6
More than 1,000-3,000	0	0	4	7.8	4	3.5
Total	63	100.0	52	100.0	115	100.0
Chi-Square*	26.737					
df	12					
p-value (significance at 0.05 level)	0.008					

Notes:

1) 17 cells (65.4%) have expected count less than 5. The minimum expected count is 0.90
2) % = Percentage within R&D engagement
3) The total number of firms is 115
4) This table shows the structure of employment of Thai SMEs in the seafood industry in 2017. In this case, comparing firms that invested in R&D and firms that did not reveals differences in the two groups. In firms that did not invest in R&D, the total workforce ranges from one to 200 employees. Meanwhile, the largest workforce among firms that invested in R&D ranged from 251 to 500 employees. The statistical analysis indicates that differences in the size of the workforce do not affect the R&D participation of businesses (p-value = 0.008) at a 95% significance level.

Table VIII.4: Structure of R&D expenditure across SMEs in the seafood sector (2013-2017)

R&D Expenditure (in million baht)	Year 2013		Year 2014		Year 2015		Year 2016		Year 2017	
	Count	%	Count	%	Count	%	Count	%	Count	%
None	41	78.8	33	63.5	23	44.2	19	36.5	29	55.8
1-0.5M	1	1.9	3	5.8	4	7.7	6	11.5	4	7.7
0.5M-1M	2	3.8	2	3.8	9	17.3	9	17.3	6	11.5
1M-1.5M	2	3.8	5	9.6	4	7.7	4	7.7	5	9.6
1.5M-2M	1	1.9	1	1.9	3	5.8	3	5.8	2	3.8
2M-2.5M	0	0.0	0	0.0	1	1.9	5	9.6	1	1.9
2.5M-3M	3	5.8	3	5.8	2	3.8	0	0.0	1	1.9
3M-3.5M	2	3.8	1	1.9	1	1.9	2	3.8	2	3.8
3.5M-4M	0	0.0	0	0.0	1	1.9	2	3.8	1	1.9
More than 4M-20M	0	0.0	4	7.7	4	7.7	2	3.8	1	1.9
Total	52	100.0	52	100.0	52	100.0	52	100.0	52	100.0
Chi-Square	14.737[a]		27.575[b]		46.982[c]		56.071[d]		34.832[e]	
df	6		7		9		8		9	
p-value (significance at 0.05 level)	0.022		0.000		0.000		0.000		0.000	

Notes:

1) M = million baht
2) % = Percentage within R&D engagement
3) a = 12 cells (85.7%) have expected count less than 5. The minimum expected count is 0.45
4) b = 14 cells (87.5%) have expected count less than 5. The minimum expected count is 0.45
5) c = 18 cells (90.0%) have expected count less than 5. The minimum expected count is 0.45
6) d = 16 cells (88.9%) have expected count less than 5. The minimum expected count is 0.90
7) e = 18 cells (90.0%) have expected count less than 5. The minimum expected count is 0.45
8) The total number of firms is 52
9) This table shows the R&D expenditure of the Thai SMEs in the seafood company during 2013-2017. The R&D expenditure in this group increased steadily from 2013 to 2016, followed by a slight decrease in 2017. The statistical analysis indicated that the percentage of R&D investment in this group did not have a different in all range during 2014-2017, but found the difference in the year 2013.

Table VIII.5: R&D employment details in terms of salary paid for R&D employee in SMEs in the seafood sector (2013-2017)

R&D Employment (in baht)	Year 2013		Year 2014		Year 2015		Year 2016		Year 2017	
	Count	%	Count	%	Count	%	Count	%	Count	%
None	28	53.8	24	46.2	24	46.2	28	53.8	42	80.8
1-350,000	0	0	4	7.7	3	5.8	1	1.9	1	1.9
350,001-700,000	5	9.6	4	7.7	7	13.5	6	11.5	3	5.8
700,001-1,050,000	6	11.5	6	11.5	6	11.5	2	3.8	0	0
1,050,001-1,400,000	4	7.7	2	3.8	4	7.7	4	7.7	2	3.8
1,400,001-1,750,000	2	3.8	4	7.7	1	1.9	4	7.7	2	3.8
1,750,001-2,100,000	1	1.9	0	0	1	1.9	1	1.9	1	1.9
2,100,001-2,450,000	1	1.9	4	7.7	2	3.8	2	3.8	0	0
2,450,001-2,800,000	1	1.9	0	0	1	1.9	1	1.9	0	0
2,800,001-3,150,000	2	3.8	0	0	1	1.9	0	0	1	1.9
More than 3,150,000-3,750,000	2	3.8	4	7.7	2	3.8	3	5.8	0	0
Total	52	100.0	52	100.0	52	100.0	52	100.0	52	100.0
Chi-Square	36.746[a]		44.841[b]		44.841[c]		36.746[d]		13.269[e]	
df	9		7		10		9		6	
p-value (significance at 0.05 level)	0.000		0.000		0.000		0.000		0.39	

Notes:

1) M = million baht
2) % = Percentage within R&D engagement
3) a = 18 cells (90.0%) have expected count less than 5. The minimum expected count is 0.45
4) b = 14 cells (87.5%) have expected count less than 5. The minimum expected count is 0.45
5) c = 20 cells (90.9%) have expected count less than 5. The minimum expected count is 0.45
6) d = 18 cells (90.0%) have expected count less than 5. The minimum expected count is 0.90
7) e = 12 cells (85.7%) have expected count less than 5. The minimum expected count is 0.45
8) The total number of firms is 52
9) This table shows R&D expenditures on employment in terms of salary paid among Thai SMEs in the seafood industry from 2013 to 2017. During this period, R&D expenditures on employment decreased continuously. The statistical analysis finds a significant effect for the years 2013-2016 but not for the year 2017 at the 95% significance level.

Table VIII.6: Machine tools investment of SMEs in the seafood business (2013-2017)

Machine and tool investment (in million baht)	Year 2013		Year 2014		Year 2015		Year 2016		Year 2017	
	Count	%	Count	%	Count	%	Count	%	Count	%
None	47	90.4	46	88.5	38	73.1	42	80.8	46	88.5
1-0.5M	2	3.8	1	1.9	5	9.6	7	13.5	4	7.7
0.5M-1M	2	3.8	3	5.8	2	3.8	1	1.9	1	1.9
1M-1.5M	0	0	1	1.9	4	7.7	0	0	0	0
1.5M-2M	1	1.9	0	0	0	0	1	1.9	0	0
2M-2.5M	0	0	0	0	1	1.9	0	0	0	0
2.5M-3M	0	0	0	0	0	0	1	1.9	0	0
3M-3.5M	0	0	0	0	1	1.9	0	0	0	0
3.5M-4M	0	0	0	0	0	0	0	0	0	0
More than 4M-20M	0	0	1	1.9	1	1.9	0	0	1	1.9
Total	52	99.9	52	100	52	99.9	52	100	52	100
Chi-Square	6.333		7.669		19.313		13.269		7.669	
df	3		4		6		4		3	
p-value (significance at 0.05 level)	0.096		0.104		0.004		0.01		0.053	

Notes:

1) M = million baht
2) % = Percentage within R&D engagement
3) a = 6 cells (75.0%) have expected count less than 5. The minimum expected count is 0.45
4) b = 8 cells (80.0%) have expected count less than 5. The minimum expected count is 0.45
5) c = 12 cells (85.7%) have expected count less than 5. The minimum expected count is 0.45
6) d = 8 cells (80.0%) have expected count less than 5. The minimum expected count is 0.90
7) e = 6 cells (75.0%) have expected count less than 5. The minimum expected count is 0.45
8) The total number of firms is 52
9) This table shows R&D expenditures on machines and tools among Thai SMEs in the seafood industry from 2013 to 2017. As the table shows, R&D investment fluctuated over the 2013-2017 period. The highest percentage of investment on machine and tools occurred in 2015. The main investment remained within the ranges of 1-0.5 million baht (9.6%), 1-1.5 million baht (7.7%) and 0.5-1 million baht (3.8%), respectively. Furthermore, the number of SMEs that had R&D investment in machinery and tools in all value ranges had a difference at the 95% significance level. The analytical data indicated that the companies that invested in the ranges of 1 – 0.5M baht and 0.5M – 1M baht had an equal percentage (3.8%) in 2013. A smaller percentage (1.8%) fell within the range of 1.5 M – 2 M baht. By contrast, the statistical analysis revealed that the number of SMEs with R&D investment in machinery and tools in all value ranges did not show a difference at the 95% significance level

Table VIII.7: Total sales profiles of Thai SMEs in the seafood industry during 2013–2017

Total sales (baht)	Year 2013				Year 2014				Year 2015				Year 2016				Year 2017			
	Without R&D		With R&D		Without R&D		With R&D		Without R&D		With R&D		Without R&D		With R&D		Without R&D		With R&D	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
None	42	66.7	34	65.4	42	66.7	30	57.7	41	65.1	27	51.9	41	65.1	27	51.9	16	25.4	32	61.5
1–250M	9	14.3	13	25.0	10	15.9	9	17.3	14	22.2	13	25.0	14	22.2	13	25.0	28	44.4	10	19.2
250M–500M	3	4.8	1	1.9	5	7.9	4	7.7	4	6.3	7	13.5	4	6.3	7	13.5	7	11.1	5	9.6
500M–750M	3	4.8	2	3.8	1	1.6	5	9.6	1	1.6	1	1.9	1	1.6	1	1.9	4	6.3	1	1.9
750M–1,000M	1	1.6	1	1.9	1	1.6	3	5.8	1	1.6	3	5.8	1	1.6	3	5.8	4	6.3	2	3.8
1,000M–1,250M	1	1.6	0	0.0	1	1.6	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0	0.0	0	0.0
1,250M–1,500M	1	1.6	0	0.0	1	1.6	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	1	1.6	0	0.0
1,500M–1,750M	0	0.0	0	0.0	0.0	0.0	0	0.0	1	1.6	0	0.0	1	1.6	0		1	1.6	0	0.0
1,750M–2,000M	0	0.0	0	0.0	0.0	0.0	0	0.0	0		1	1.9	0		1	1.9	1	1.6	2	3.8
More than 2,000M	3	4.8	1	1.9	2	3.2	1	1.9	1	1.6	0	0.0	1	1.6	0	0.0	1	1.6	0	0.0
Total	63	100.2	52	99.9	63	100.1	52	100.0	63	100.0	52	100.0	63	100.0	52	100.0	63	99.9	52	99.8
Chi-Square	1.277[a]				4.761[b]				7.177[c]				6.747[d]				19.116[e]			
df	6				7				7				7				8			
p-value (significance at 0.05 level)	0.973				0.689				0.411				0.456				0.014			

Notes:

1) M = million baht
2) % = Percentage within R&D engagement
3) a = 11 cells (78.6%) have expected count less than 5. The minimum expected count is 0.90
4) b = 12 cells (75.0%) have expected count less than 5. The minimum expected count is 0.45
5) c = 12 cells (75.0%) have expected count less than 5. The minimum expected count is 0.45
6) d = 11 cells (68.8%) have expected count less than 5. The minimum expected count is 0.45
7) e = 12 cells (66.7%) have expected count less than 5. The minimum expected count is 0.90
8) The total amount of sample is 115 SMEs in the seafood industry in Thailand
9) The total number of sample in the Without R&D group is 63 SMEs in the seafood business in Thailand
10) The total number of sample in the With R&D group is 52 SMEs in the seafood business in Thailand
11) This table shows the total sales generated by Thai SMEs in the seafood industry from 2013 to 2017. Comparing firms that invested in R&D with firms that did not reveals a higher percentage of total sales in the R&D group than in the group without R&D. Nevertheless, the statistical analysis indicates that R&D engagement does not affect the total sales of the businesses during the five-year period from 2013 to 2017 (p-value > 0.05) at a 95% significance level.

Table VIII.8: Total export revenue of SMEs in the seafood industry in Thailand during 2013–2017

Total export revenue (baht)	Year 2013				Year 2014				Year 2015				Year 2016				Year 2017			
	Without R&D		With R&D		Without R&D		With R&D		Without R&D		With R&D		Without R&D		With R&D		Without R&D		With R&D	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
None	55	87.3	42	80.8	48	76.2	39	75.0	50	79.4	39	75.0	46	73.0	31	59.6	28	44.4	33	63.5
1–250M	4	6.3	6	11.5	10	15.9	11	21.2	9	14.3	8	15.4	15	23.8	15	28.8	23	36.5	12	23.1
250M–500M	0	0.0	1	1.9	1	1.6	1	1.9	2	3.2	1	1.9	0	0.0	2	3.8	5	7.9	4	7.7
500M–750M	2	3.2	1	1.9	1	1.6	0	0.0	0	0.0	3	5.8	0	0.0	0	0.0	1	1.6	1	1.9
750M–1,000M	0	0.0	1	1.9	1	1.6	0	0.0	0	0.0	0	0.0	1	1.6	2	3.8	3	4.8	0	0.0
1,000M–1,250M	0	0.0	0	0.0	0	0.0	0	0.0	1	1.6	0	0.0	1	1.6	1	1.9	0	0.0	0	0.0
1,250M–1,500M	0	0.0	1	1.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	1.9	1	1.6	1	1.9
1,500M–1,750M	1	1.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1,750M–2,000M	0	0.0	0	0.0	0	0.0	1	1.9	0	0.0	1	1.9	0	0.0	0	0.0	1	1.6	1	1.9
More than 2,000M	1	1.6	0	0.0	2	3.2	0	0.0	1	1.6	0.0	0.0	0	0.0	0	0.0	1	1.6	0	0.0
Total	63	100.0	0	99.9	63	100.1	52	100.0	63	100.1	52	100.0	63	100.0	52	99.8	63	100.0	52	100.0
Chi-Square	6.483[a]				4.972[b]				6.761[c]				5.251[d]				6.99[e]			
df	7				6				6				5				7			
p-value (significance at 0.05 level)	0.485				0.547				0.343				0.386				0.430			

Notes:

1) M = million baht
2) % = Percentage within R&D engagement
3) a = 13 cells (81.3%) have expected count less than 5. The minimum expected count is 0.45
4) b = 10 cells (71.4%) have expected count less than 5. The minimum expected count is 0.45
5) c = 10 cells (71.4%) have expected count less than 5. The minimum expected count is 0.45
6) d = 8 cells (66.7%) have expected count less than 5. The minimum expected count is 0.45
7) e = 12 cells (75.0%) have expected count less than 5. The minimum expected count is 0.45
8) The total amount of sample is 115 SMEs in the seafood industry in Thailand
9) The total number of sample in the Without R&D group is 63 SMEs in the seafood business in Thailand
10) The total number of sample in the With R&D group is 52 SMEs in the seafood business in Thailand
11) This table shows the total export revenues of Thai SMEs in the seafood industry from 2013 to 2017. A comparison of firms that invested in R&D and firms that did not shows higher total export revenues in the R&D group than in the group without R&D. However, the statistical analysis indicates that R&D engagement does not affect the export revenue of the businesses in the five years between 2013 and 2017 (p-value > 0.05) at a 95% significance level.

Appendix IX: Detailed summary of the interviews

Case code: B01

The business profile:
This firm has the ability to produce around 50% of the total tuna products in the world, and has the power to set the price of tuna globally. The business originated in the original equipment manufacturing (OEM) sector, and had limited ability to apply technology because the Thai seafood industry is a community-based industry. Moreover, the margins for seafood products are very low, while the amount of the total business continues to increase in the market. Thus, the price of the product is the tool for competition amongst firms. To maintain its status as a world business leader, the business decided to take over international businesses as a key tool for entering the international market and to decrease the amount of time required to create a brand.

R&D activities:
The firm has confidence in the ability of R&D to increase the efficiency of the business. The company decided to invest in R&D four years ago and to recruit R&D staff. However, there has been little progress in the development of R&D in the business. The firm has had R&D employment and work in the process of development for more than 35 years. It has applied both copy and development (C&D) and R&D to improve the efficiency of the business.

However, the development of innovation in the seafood sector has not changed dramatically in response to consumer behaviour. Furthermore, financial constraint is the main reason for less R&D investment in SMEs. However, SMEs have to engage in R&D because, if they do not, their customers may prefer to do business with companies that do invest in R&D.

Collaboration via networking:
Networking helps businesses to keep up to date with trends in R&D and to compensate for weaknesses in the business via collaboration with business partners. The firm has created some networks with external businesses. The pattern of SMEs' business collaboration involves the supplier, while LEs tend to collaborate by engaging in co-projects to develop packaging. The business data shared via networking may lead to updates in the R&D trends of other companies. However, some data must be kept secret because sharing such data will not benefit the firm.

Recommendations:
Most government policies have not supported the development of LEs. Furthermore, some government projects, such as talent mobility, do not create benefits for LEs; in fact, they might have a negative impact on LEs. Thus, LEs have chosen to spend their money on university services, which are cheaper than joining some government projects would be.

Code case: B02

The main product of this business is chilli paste that includes seafood ingredients. The product development takes around six months to two years to proceed from flavour testing, to quality testing, and market testing. Furthermore, the business owner constantly attempts to develop the product and engages in research via face-to-face consumer surveys.

R&D activities in the business:
The business arranges yearly training programmes to increase the workers' efficiency—these programmes are related to the routine work of the labourers. The content of the programmes is simple and easy to understand because most of the staff in the company are older, and some did not graduate with a high-level degree. Furthermore, some of the workers have the opportunity to take the training courses aboard when LEs have the budget for these programmes. The business also invests in machines and tools, which accounts for around 30% of the total budget per year, and technicians from the companies supplying the machines have trained the workers in the business to use them.

The benefit of R&D is enabling the company to increase its scale of production, decrease the time needed to process the product, to create new types of products, and to increase the quality of the products; for example, by extending the shelf life.

The business' income:
The income of the business has increased continuously, from less than one million baht in 2015, to13 million baht in 2016, to 65 million baht in 2017, and to 95 million baht in 2018. However, 100% of the income was derived from the local market, and the company had planned to expand the market to China in 2019.

The R&D collaboration via networking:
The collaboration with government organisations is related to standardised testing because of the law in Thailand stipulates that export products must meet the standards of a government laboratory or subsidiary unit. Furthermore, the business has collaborated with a national food institution in Thailand to apply R&D to extend the shelf life of the products through the through improved packaging.

The company has also engaged in R&D collaboration with a university to increase the efficiency of the production process. However, this collaboration did not originate within the company but was instigated by the university. Furthermore, the company has engaged in R&D collaboration with LEs because LEs have skilled workers or experts who can supply the information or knowledge to improve the business' product.

Code case: B03

Business profile:
The business was established twelve years ago with authorised capital of five million baht. The business partners comprise 70% local investors and 30% foreign investors.

R&D investment:
The business only needed one machine to process its product. The once-off investment in the machine was sufficient for the business to operate for more than ten years; moreover, the annual maintenance cost is very low at around 50,000 baht per month. Furthermore, the company employed one engineer with a bachelor's degree because the law in Thailand required the business to have one engineer to control the system in the company. With regard to the other workers, three have vocational education degrees and 30 are unskilled workers. However, the number of unskilled workers fluctuates according to demand because, if the volume of raw material is high, the work load will increase.

Code case: B04

The firm sold food and frozen food products. The business derived 95% of its income from the local market and 5% from the export market. The local seafood resources in Thailand have decreased continuously and are low in quality. Thus, Thailand has to import large amounts of tuna to produce canned tuna because the location of Thailand means that it cannot produce tuna by itself. Furthermore, the traceability of Thai products is not reliable SMEs in the seafood industry have a low level of R&D expenditure because they do not have the budget to spend on R&D. Moreover, the R&D activity in Thai SMEs in the seafood industry must involve primary products such as fried fish, and SMEs cannot produce the same products as large-sized companies that produce canned products.

The company engaged in R&D collaboration with the university because the firm did not employ an expert. Recently, the firm began to work with the university to create a process to extend the shelf life of its product.

The government needs to create an R&D structure as the backbone of the nation to drive R&D in the seafood industry. At present, the R&D expenditure or the direction of R&D in the seafood industry varies across businesses, which might lead to strong competition in the sector. In addition, the government needs to establish an action plan to encourage continuous R&D investment in the seafood industry. Furthermore, the government needs to provide incentives for businesses to engage in R&D collaboration with the university to increase the demand for R&D collaboration between the fields.

Code case: B05

The business profile:
The business was located in the southern part of Thailand. The original authorised funding for the business was 75 million baht. In the past thirty years, the main product

of the business has been marine shrimp; however, the marine shrimp and related industries have experienced a lack of natural resources in the past twenty years. Thus, in the last eight years, the main product of the business has been changed to shrimp cultivated via the aquaculture method. At the time of writing, there were 550 workers in the business, of whom 150 were Thai and 400 were Burmese. The main products of the business fall into two categories, namely products sold under the business brand, and direct-order products from the customer.

Obstacles to business growth:
In 2015, there was strong competition in the local seafood industry due to foreign investors intervening in the sector. The foreign investors aimed to use the local seafood industry as a nominee. In addition, Thailand experienced the IUU problem in the same year. These problems were the main reasons for the high price of raw materials in the seafood industry. Thus, the local seafood sector had to import raw materials from Myanmar.

The R&D activities in the business:
The business had less investment in machinery and tools due to the limited scope of the business; moreover, the company did not want to lay off workers. Thus, the company decided to reduce the investment in machinery and tools. However, the Thai government adjusted the minimum wage for labourers from around 100 baht in 2013 to 300 baht in 2017, which had a direct effect on the cash flow of the business. Thus, the business did not recruit new staff and focused on increasing the efficiency of the existing workers via a training programme to increase their skills. At the time of writing, the business had 40 people working in the maintenance unit and only one engineer to manage this unit.

Code case: B06

The business profile:
The partners in the business consist of Thai investors (51%) and Japanese investors (49%). The main product of the business can be divided into the following four types: processed squid (48.37%), value-added products (30%), pre-fried products (18.68%), bread-crumbed products (12.92%), processed fish (14.41%) and processed shrimp (5%).

In total, 749 workers were employed in the business; of these workers, nine had a master's degree, 84 had a bachelor's degree, 84 had a vocational education degree, 264 were high school graduates, and 308 had completed primary education.

R&D activities in the business:
R&D projects in the company are instigated by the CEO. There were five people in the R&D unit and 50 people in the quality control (QC) unit. Most of the innovative products were driven by customers' requirements. Thus, the R&D jobs in the business can be divided into the two aspects of producing orders based on customers' requests, and developing innovative products in consultation with the customers.

The company has implemented approximately 80 training programmes each year to develop workers' skills; these programmes vary according to the levels of the workers' knowledge and their work units each month.

R&D has helped the business to create new products; specifically, five products in the past five years, and the creation of five innovative processes in the past five years. Furthermore, R&D has helped to decrease the time needed to produce the product, to increase the total quantity of the product, and has decreased the number of workers required to perform the work. The increase in the minimum labour wage was the reason for R&D engagement in the business because, in the long term, the return on income from machinery might be greater than that on labour. However, the business did not lay off workers, but redeployed them to work in the other sections of the business.

R&D collaboration via networking:
The business did not have R&D collaboration with the university because the previous result was not good and was too expensive.

Code case: B07

The business profile:
The business partnership consists of 90% Japanese investors and 10% local investors. The main product of the business is processed salmon products that are ready to cook or ready to eat. The business products are divided into the export market (96%) and the local market (4%).

R&D activities in the business:
Ninety per cent of the R&D activities in the business are focused on the creation of new products. The R&D activities in the business can be divided into two parts, namely customers' orders and the CEO's commands. Employment in R&D increased from three people in the previous year to six people at the time of writing. However, the R&D activities in the business are simple R&D products.

R&D collaboration via networking:
Although most R&D activities in the business are simple R&D, internal R&D workers can accomplish the R&D jobs on their own. Thus, the business did not want to engage in R&D collaboration with external organisations. However, collaborations with external organisations in the form of sharing materials or knowledge can lead to updates in trends of businesses or laws.

Recently, R&D employment has focused on increasing the efficiency of existing R&D workers by enlisting them in a registered, international R&D training programme at least once a year and other internal training programmes organised at the staff members' request. However, the existing staff did not recruit new staff because newly graduated people request high salaries and do not work hard. Furthermore, people who have recently graduated cannot start to work immediately, as they require a period of adjustment that may take some time. In the meantime, machinery and tools can

increase the productivity of the business when mass orders are required for a limited period.

Recommendations:
Government policy needs to support business development on an on-going basis. However, the context of government policy is not related to businesses' requirement; thus, the government should develop government policy in conjunction with businesses to meet the users' requirements.

Code case: B08

The business profile:
The company was established in 1989. The first generation focused on the fishery process; the second generation of the business then developed the structure of the company to focus more on processed seafood products. At present, the company is run by the third generation of the family that began the business.
The main business products are surimi and related products. There are 850 workers in the business in total, of whom six have master's degrees, three have bachelor's degrees, and the remainder have vocational education degrees or lower degrees.

The business operates as an OEM business has made the brand unsustainable for the business. Thus, the company has changed its policy to produce products under the business brand rather than supplying products to order. The ratio of product sales is 40% on the local market and 60% on the overseas market. The combined income from both markets is approximately 500 – 1,000 million baht per year.

R&D activities in the business:
The research question stems from customer requirements and the CEO's instructions. The R&D unit in the business has seven to eight staff members. R&D was applied to increase the productivity of the business. The company allocates 10% of the authorised funding to R&D every year. The aim of R&D investment in the business was to create new products and to develop the efficiency of exiting products. R&D was also applied to develop the processes in the production line. Machinery and tools have been installed in the risk areas to speed up productivity, while the workers who were employed in these areas have been reallocated to perform skilled work.

Furthermore, Radio-Frequency Identification (RFID) technology has been applied to detect precision and to monitor the products along the production line. The business development department selected some of the employees to register for external training courses related to the business problem. Furthermore, the business has implemented a project to support employees who wish to improve their education by studying vocational education or for higher degrees.

The benefit of the R&D investment in the business has been two new products in the past five years. Furthermore, the business can operate five production lines simultaneously.

R&D collaboration via networking:
The business has engaged in R&D collaboration with both the university and government units. Furthermore, the business has conducted R&D collaboration with other businesses for updates on laws, news and problems in their operations.
Recommendations:
The Thai seafood business has to decrease the amount of foreign labour because this has affected the national employment rate. Moreover, the government needs to establish laws and measures to control the quality of the seafood products to create sustainable growth in the sector in the future, particularly in the international market. In addition, the government needs to manage fishing quotas to create sustainable natural resources for the sector.

Code case: B09

The business profile:
The authorised funding of the business is 75 million baht, and the business employs approximately 1,000 people in total. The main products of the business are shrimp products (50%) and frozen squid products (50%).

The R&D activities in the business:
The R&D expenditure of the business is around one million baht per year. The R&D activities have been divided into two parts, namely product development and process development, and are conducted by six staff members, which is a reduction from the previous year. Most of the R&D investment is in machinery and tools, while the training programme are not considered to be important for economic growth. However, trends in technology in the existing market have not changed excessively because the customers' requirements have not changed significantly. Thus, as the business needs to extend its market, it is necessary to develop a product with the assistance of R&D.

The business requires someone with a master's degree to support the R&D work; however, the business cannot recruit such a person because the salary it can offer is too low. Furthermore, Thai workers and those with bachelor's degrees will ignore job offers if the level of the salary is insufficient for their needs.

The benefits of R&D engagement include increasing the yield and reducing costs in the production process. Furthermore, R&D investment can increase production efficiency for the product, which will assist the business to enter the Chinese market.

R&D collaboration via networking:
The university is the main partner of the business because the business is located far from the government organisations. However, providing this service to the business is an extra duty of a lecturer at the university; thus, limited time might be an obstacle to working with the university. Moreover, the company has not sought collaboration with other businesses because it wants to keep its trade secrets.

Recommendations:
The government should reconsider the laws and measures because most of them are obstacles for the business. Furthermore, the government should negotiate new markets to decrease competition amongst businesses. Moreover, the government should support the process of by-product development to decrease the costs and increase the productivity of the business. In addition, the university's research does not match the business' requirements, and the knowledge and experience of newly graduated workers have not yet been developed; thus, the university should adjust its courses accordingly, and needs to establish translational research as an intermediary between the university and the business.

Code case: U01

The role of the university in the business' development:
Academic service has become a new task for the university in the past decade, and the university has adjusted its course offerings to match the trends in technology. A recent course focus in the food and related department is on increasing innovation in food, healthy food and functional ingredient.

The R&D activities of the business:
Businesses might have limited knowledge of developing R&D projects or ways of improving their efficiency. Thus, the university, which is the source of knowledge, could fill a business' knowledge gap. Most of the research questions of businesses, particularly SMEs, do not entail in-depth ideas; however, research questions must originate from the business. Of note, a project cannot be run by one researcher, as it is necessary to request experts in various fields to support the project.

Recently, most of the universities in Thailand have established a centre of excellence unit as the contact hub for businesses. Such centres provide lists of experts and technologies available to businesses to decrease the time needed to contact an expert or to receive input.

R&D collaboration:
The role of the university is as the mentor or speaker in a training programme. A benefit of R&D collaboration is that it will give the university a better idea of businesses' requirements. Conversely, businesses can learn from the university and be able to develop their work by themselves.

Significant results of R&D contributions:
Collaborative R&D projects between the university and the business help businesses to increasing their productivity, decrease costs, and reduce waste by recycling waste as new products.

Obstacles to R&D activities in the business:
The knowledge gap between businesses and universities is the main obstacle in transferring knowledge to the business. Moreover, the CEO's vision and business policy can be obstacles to including R&D activities in the business. A further obstacle to R&D projects might be that the business lacks ideas. In addition, a business may

not want to engage in R&D collaboration with external organisations because it wants to preserve its trade secrets. However, government projects have adjusted the rules for grants by allowing stakeholders in the project to belong to one of three groups; the business, the university, and the government unit.

Code case: U02

General Information:
SMEs are the main business in the area in which the university is located. Furthermore, as most enterprises in the same area are OEMs, this has affected local businesses as they cannot produce products under their brands, but have to produce products according to the customers' requirements. This is the reason for less development in processes and products. In addition, local businesses have less capacity to adjust when faced with challenges, and cannot apply R&D easily.

Moreover, as the local businesses in this area operate in the same sector (the seafood industry) and have the same target consumer group, companies in this area experience high competition and earn less profit from their products. Therefore, most of the businesses in this area did not want to share their data with the other business because this might affect their market advantages.

Furthermore, the local businesses have less ability to predict market trends; in other words, they did not engage in market research, which is why they have unclear policies and plans for developing their products to match the customers' requirements, both in terms of the type of product and the quality thereof.

R&D activity:
The local seafood industry has experienced challenges due to limited natural resources, the increase in the minimum wage for labour, and the yellow card issued by the IUU; these challenges have affected the capital funds of seafood businesses and the amount of labour in the market. Thus, most of the local businesses are unable to invest in R&D because they have to secure the liquidity of the business.

R&D requirements must stem from the customers' requirements. The R&D focus in a business is related to process development, product development, food safety, increasing the quality of the products, and developing ready-to-eat products. The main obstacle to R&D in the business is insufficient budget to engage in market research; thus, it cannot start an R&D project. In addition, the outcome of R&D projects in the business is kept secret because the results might affect their market advantage.

R&D collaboration via networking:
The efficiency of R&D knowledge or machines developed by the university is more suited to SMEs than to LEs. As university laboratories are the same size as SME units, SMEs can apply the universities' outcomes to their businesses, while LEs need more time to expand the knowledge from laboratory scale to the large scale. Moreover, an R&D project that entails collaboration between the university and the business to generate the ideas is more successful than is an R&D project that stems from either the university's or the business' ideas.

Most of the outcomes of collaboration between universities and businesses have not resulted in patent registration because the businesses did not understand the benefits of patents. Most of the businesses have claimed sole rights to the outcomes of collaborations, which means that researchers at the collaborating university cannot apply the knowledge in other businesses. Recently, collaborations between a university and a company have developed as having two options; the company will pay 100% of the research cost if it does not want the knowledge to be shared with other businesses, or a company will pay 20% to the university if it is willing to share the knowledge with other businesses.

Code case: G01

General information about the organisation:
The organisation is structured as a combination of a government unit, businesses and a university that work together. The goal of the organisation is to support R&D careers, particularly in the food sector. The main form of the organisation's support for business development is the organisation of training programmes, the main content of which is the quality standards for various types of exports such as GMP, HACCP and ISO22000.

The main customers of the organisation are medium and large businesses because small businesses are not aware of R&D and do not have the budget for training programmes. Thus, some SMEs continue with their routine tasks because they are unable to improve their businesses. This might affect the development of the businesses in the future, as they will be unable to compete with innovative companies. The organisation has a monitor system to follow up on the progress and improvement of the business once the training courses have been completed.

The role of the organisation in business development:
At present, the organisation's action plan remains focused on increasing innovation in businesses. Most of the SMEs registered for the organisation's training courses were unable to apply R&D efficiently or did not want to engage in R&D. However, some SMEs that engaged in R&D can now develop new products or enter new markets.
Because the private companies are members of the organisation, the content of courses and training programmes to support business development must be in accordance with the goals of these businesses. Thus, the content of the courses matches the businesses' requirements.

Obstacles to increasing the efficiency of Thai SMEs via R&D:
The knowledge gap between SMEs and instruction providers is the main obstacle to transferring knowledge to these businesses. Furthermore, most of the businesses produce products by relying on local knowledge without testing the quality using R&D techniques. Furthermore, most of the SMEs' products are primary processing products that have low value. Thus, it is difficult for the organisation to transmit understanding to producers, particularly SMEs, to assist them to improve their methods and develop products in appropriate ways.

Collaboration via networking:
Recently, the conditions for obtaining grants from government units were changed to a rule that forces businesses to work with academic institutions, which was put in place because universities have extensive knowledge, readily available facilities, and budgets that could help these businesses. Thus, the government organisation changed the rules for grants from allowing businesses to work individually to them having to work with a university in the event that they need a government grant to support their work. The role of the organisation is as an intermediary between universities and businesses, in addition to managing the training programmes.

Recommendations:
Thailand's economy is based on agriculture. work in the form of associations and the management of a proper education system are the best ways of ensuring the nation's economic growth. Furthermore, creating value from the waste resulting from the processing process is very limited in Thailand. The limited use of waste is the reason for the high cost of investment and low income of the businesses; thus, Thai SMEs in the seafood industry should develop ways of benefitting from waste. Furthermore, the Thai government could help the seafood industry by negotiating new markets to decrease the level of competition.

Appendix X: Presentation based on the thesis

Kulradathon, S. and Zawdie, G. ‘Responsiveness of SMEs in the fishery and seafood sector to R&D interventions through the Triple Helix system: What price the role of universities in Thailand?’, Presented at The 5th COSINUS International Conference, The Oxford Brookes University, Oxford, UK, January 2018.