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Innovation and Productivity in the Service Sector: The Case of Thailand

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ABSTRACT

Various literature investigates the determining factor of research and development (R&D) and the impacts of R&D on firms' innovation performance and productivity. However, most available studies focus on manufacturing firms; little is considered about firms in the service sector. The gap is more evident in the case of service firms in developing countries. This study analyzes the data from the Thailand R&D/Innovation Survey 2011–2018 and applies a structural model that describes the link between R&D expenditure, innovation output, and productivity (the CDM model). The study found a link between R&D activities, innovation output, and productivity in the service sector. The results show that firms with higher R&D intensity tend to offer superior innovation performance. Firms' characteristics and behavioral factors, such as size, openness strategy, foreign share, and exporting behavior, increase the propensity to invest in R&D activity. In addition, innovation output has a positive impact on firm productivity. This study highlights the importance of promoting R&D activities and innovation as the basis for improved productivity of service firms in Thailand and highlights some differences in R&D activities and innovations between the service sector and the manufacturing industry.

Keywords: Service sector, Innovation, R&D, Productivity, CDM model

JEL Classification: C30, L8, D24, O31

1. Introduction

Over the past decade, Thai service businesses have continued to grow and play an increasingly important role in the country's economy. The expansion of the service sector is likely to accelerate as Thailand approaches high-income status, as previously happened in other countries. Rapid urbanization has enhanced this trend (Asian Development Bank, 2012).

Thailand's service sector is an important sector of the country's economy, with a value of 10.26 trillion baht in 2019, accounting for 61% of Thailand's gross domestic product (GDP). There are more than 663,000 companies in the service industry in Thailand. The service sector uses 40 percent of the labor force and lags behind manufacturing productivity by 30 percent. Unlike many peers, Thailand's service sector share has not grown, is dominated by lower-productivity industries employing lower-skilled workers, and boasts a low share of service exports, which tend to be in traditional sectors (World Bank Group, 2016).

The lack of productivity and innovation in the service sector causes lower incomes for workers, high costs, and low quality for companies, impeding the manufacturing sector's competitiveness (Kohphaiboon, 2018). The service sector is likely to be an intermediate input for the manufacturing sector, supporting the manufacturing sector to operate more efficiently (such as transportation and financial services). Manufacturing-related services (such as design, consulting, or factory installation and machinery) are also vital because they increase competitiveness and product value-added. Domestic manufacturers can offer such services (design, waste management, and other advanced services) if they rely on imports.

An extensive literature analyzes the determinants of research and development (R&D) and the impacts of R&D on firms' innovation performance and productivity (see Crépon, Duguet, and Mairesse, 1998; Fuentes et al., 2015). Because most available studies focus on manufacturing firms, very little is known about firms in the service sector. The gap is even more noticeable in the case of service firms in developing countries.

This study aims to understand how to make the Thai service sector more productive and innovative. This study explored the linkages between R&D activities, innovation, and productivity in the service sector. In addition, we investigated innovation activities in the service sector and the differences in R&D activities and innovation between the service and manufacturing sectors.

The hypothesis of this study consists of the following: (1) There are linkages between R&D activities, innovation, and productivity in the service sector; and (2) there are differences between the service and manufacturing sectors regarding the decision to innovate and the decision to invest in innovation and learning activities.

This study uses data from the Research, Development, and Innovation (RDI) survey between 2011 and 2018. Based on Crépon, Duguet, and Mairesse (1998), this study performs a three-stage Crépon-Duguet-Mairesse (CDM) econometric model across the different sectors. The CDM model investigates the relationship between R&D, innovation, and productivity. The conclusions from the case studies will be summarized.

The remaining parts of this study are organized as follows: Section 1 presents a brief overview of recent contributions to the literature on innovation in services. Section 2 shows service innovation and productivity in the Thai service sector and explains the data from the Thailand R&D/Innovation

Survey 2011-2018 compared with the manufacturing sector in Thailand. Section 3 introduces the CDM model. Section 4 presents the results from our three-stage CDM econometric model. Finally, Section 5 concludes.

2. Literature Review

There are few studies of innovation in services (Drejer, 2004; Evangelista, 2000; Hauknes, 1996; Miles et al., 1995; Fuentes et al., 2015). One reason for the scarcity is that theoretical developments have been based primarily on the study of technological innovation in manufacturing activities (Gallouj and Weinstein, 1997; Evangelista, 2000; Drejer, 2004). The immaterial nature of services also hinders the possibilities of measuring through traditional methods R&D and productivity. Moreover, tracking improvements or changes in products or services (quality level) (Gallouj and Weinstein, 1997), Many R&D and innovation surveys were conducted in developing countries following the Olso Manual (1992, 1997, 2005, 2018). Therefore, the study of innovation in services builds on the technology-based approach, also known as the assimilation approach, and definitions used to research the manufacturing sector (technological and product innovation) (see Drejer, 2004; Tether and Howells, 2007).

Djellal and Gallouj (2000) and Tether and Miles (2000) criticize the assimilation approach, arguing that it ignores that innovation in services has specific characteristics. They suggest that, in addition to technological innovations, the definition of innovation should encompass various non-technological innovations, including organizational innovations. They stress the interactions and complementarities between these two types of innovations (Tether and Howells, 2007). Moreover, the focus of research has shifted from technology to knowledge, away from the study of individual firms, to understand value chains or networks, locating services, and manufacturing as interconnected parts in a system. This study, therefore,

2.1 The three-stage Crépon-Duguet-Mairesse (CDM) econometric model

The three-stage Crépon-Duguet-Mairesse (CDM) econometric model is used to study the main determinants of technological innovation and the impacts on the productivity of service firms. For the comprehensiveness of the analysis, we benchmarked the results of service firms with those of manufacturing firms. The question is how applicable the methodology is to studying the determinants of innovation and the impacts on productivity in service firms.

A challenge of using the CDM model in service firms is that the model tends to rely on R&D expenditures as a proxy to identify innovative firms. However, R&D may not be the preferred learning mechanism underpinning innovations (OECD, 2009). Service firms may find it challenging to track and record R&D expenditures or even consider the funds used for innovation the same way as they are understood in the manufacturing context.

R&D and innovation in the service sector are related to developing a new service concept or a significant development of a service process, which will create more value for the company and partners (through co-creation). Service innovation is a new service or solution through a unique interaction with customers, valuing new systems or business partners, increasing revenue in a new way, and an organization or service system for new technology (Den Hertog, 2010, p. 19).

Service innovation means a product, service, or process resulting from technology or systematic processes and providing better service. Service innovation is carried out in the private and government sectors. Service innovation contains technological activities for which it is not necessary to rely on R&D. These companies have the potential to change their actions in many ways, especially their relationships with customers, shipping methods, and the development of new products and services. These service innovations require new technology and the capabilities of service organizations (Miles, 2013).

3. Innovation and Productivity in the Thai Service Sector

Thailand's service sector is an important sector of the country's economy. However, most service firms in Thailand offer traditional services, which require labor, leading to limitations in upgrading innovation. In Thailand, the demand for services has also expanded, reflecting the increase in the country's living standards. The growing number of foreign tourists has also created a strong demand for these services. Firms in developed economies tend to purchase business services as intermediate inputs, such as financial services and information services, to satisfy their customers' needs and improve their products. Along with its economic development, more sophisticated business services sectors have been growing fast. However, compared to its substantial tourism sector, the sector of high-end business services in Thailand remains small (Suzuki et al., 2020).

Despite its increasing presence, the services sector's productivity shows a mixed picture. The productivity level of some service sectors, which embrace a high share of employment, such as the hospitality and restaurant industries, is lower than that of others. In contrast, high-productivity business services employ a smaller percentage of workers. Labor productivity in the Thai service sector increases slightly compared to neighboring countries in ASEAN (World Bank Group, 2016). Thailand's service sector has lower productivity than production in the manufacturing industry (Suzuki et al., 2020; Sawatpanich et al., 2018).

The reason might be a low standard in the service sector, limiting the growth of productivity. Another reason is the lack of investment, especially foreign direct investment (FDI), in the in-service industry, resulting in a lack of opportunities to upgrade technology. Lifting the productivity level of the traditional service sectors while stimulating growth in the modern service sectors is essential to improving overall productivity. This fact calls for a new policy focus to foster modern service sectors that can drive higher productivity growth in the long run in Thailand (Suzuki et al., 2020).

Thailand has more stringent market rules than ASEAN countries. The Thai government protects some service firms from market competition from foreign and domestic firms, especially professional services and other services operated by state enterprises. Low competition may not encourage the Thai service sector to carry out innovative activities. Therefore, the liberalization of the service sector and professional work opportunities are the key factors in increasing efficiency, quality, and new ideas for the service sector in Thailand (World Bank Group, 2016).

Foreign affiliates can act as suppliers of more sophisticated services to Thai manufacturing and consumers, expanding the service sectors in Thailand and thus also benefiting Thailand's domestic economy. Estimates suggest that the services provided in Thailand are significant contributors to the productivity of manufacturing.

3.1 Innovative Service Firms in Thailand

The study compared innovative and non-innovative service firms using the Chi-square test and the ANOVA F-test and using data from Thailand’s RDI surveys in 2011, 2014, 2016, 2017, and 2018 (see Table 1). The results show that the innovative service firms tend to be younger, being multinational firms with a higher percentage of exports.

Innovation activities in the service sector are aimed at developing new services. They use more external funding than in the handicraft industry. They spend more money on developing people but less on purchasing machines. Most innovations in the service sector are product innovations. The essential cooperation of innovative service firms is between local suppliers, parent companies, and foreign suppliers, while professional associations are the least important.

The innovative service firms have more employees, more technological activities, more organizational innovation and market innovation, more patents, more cooperation with public research institutes and universities, and received more innovative support measures from various public organizations such as the Office of the Board of Investment (BOI), the National Science and Technology Development Agency (NSTDA), the Office of the National Higher Education Science Research and Innovation Policy Council (NXPO), and the National Innovation Agency (NIA) than the non-innovative service firms. However, there were no statistical differences in financial variables (assets, capital, revenue, and profit), internal R&D, or technological innovation.

Compared to the innovative service firms and the innovative manufacturing firms, this study found that the most innovative service firms are Thai firms with a smaller share of export revenue and a larger share of service and trading revenue.

Compared to innovative manufacturing firms, this study found that innovative service firms have fewer employees, fewer technological activities, fewer internal R&D activities, more process innovation, more patents, and less cooperation with universities and public research institutes. They receive less support regarding innovation and productivity from the government.

Innovative service firms received less support from the BOI and NSTDA. However, the study did not find any differences between the innovative service firms and the innovative manufacturing firms in firm age, financial profile (based on assets, capital, revenue, and profit), or support measures from NXPO and NIA.

Table 1: The estimation of factors influencing innovation spending between innovative and non-innovative service firms and innovative manufacturing firms

Items	Service Firms				Innovative Firms			
	Innovative	Non-Innovative	Pr.		Services	Manufacturing	Pr.	
Firm age	21.66 years	22.25 years	0.78		21.66 years	21.43 years	0.15	
MNE ownership	10.48%	9.19%	0.10	*	10.48%	19.36%	0.00	***
Asset	2.2 billion Baht	1.8 billion Baht	0.49		2.2 billion Baht	2.4 billion Baht	0.81	
Capital	0.5 billion Baht	0.3 billion Baht	0.02	**	0.5 billion Baht	2 billion Baht	0.41	
Revenue	1.4 billion Baht	1.1 billion Baht	0.30		1.4 billion Baht	3 billion Baht	0.18	
Profit	0.14 billion Baht	0.09 billion Baht	0.03	**	0.14 billion Baht	0.18 billion Baht	0.39	
Export revenue	9.19%	7.02%	0.00	***	9.19%	29.32%	0.00	***
Revenue from parent company	6.67%	4.38%	0.00	***	6.67%	18.14%	0.00	***
Revenue from OEM	6.31%	4.72%	0.00	***	6.31%	22.02%	0.00	***
Revenue from ODM	3.61%	3.57%	0.94		3.61%	12.90%	0.00	***
Revenue from OBM	14.58%	7.85%	0.00	***	14.58%	37.50%	0.00	***
Revenue from Service	45.91%	58.82%	0.00	***	45.91%	3.14%	0.00	***
Revenue from "Bought-and-Sold" trading	12.75%	11.06%	0.03	**	12.75%	4.55%	0.00	***
Size	355 persons	254 persons	0.00	***	355 persons	479 persons	0.00	***
Technological activities	82.55%	69.24%	0.00	***	82.55%	93.80%	0.00	***

Items	Service Firms				Innovative Firms			
	Innovative	Non-Innovative	Pr.		Services	Manufacturing	Pr.	
Internal R&D expenditure	2.6 million Baht	2.4 million Baht	0.95		2.6 million Baht	6.0 million Baht	0.01	***
Product Innovation	72.83%	0.00%	0.00	***	72.83%	79.89%	0.00	***
Process Innovation	54.29%	0.00%	0.00	***	54.29%	41.91%	0.00	***
Organizational Innovation	72.03%	53.38%	0.00	***	72.03%	69.57%	0.05	*
Marketing Innovation	71.93%	43.92%	0.00	***	71.93%	69.27%	0.05	*
The importance for the cooperation with "local suppliers"	25.11%	12.74%	0.00	***	25.11%	34.30%	0.00	***
The importance for the cooperation with "foreign suppliers"	13.22%	7.46%	0.00	***	13.22%	22.97%	0.00	***
The importance for the cooperation with "parent company"	15.33%	8.27%	0.00	***	15.33%	19.83%	0.00	***
The importance for the cooperation with "private non-profit"	6.86%	3.48%	0.00	***	6.86%	7.92%	0.15	
The importance for the cooperation with "competitors"	12.07%	4.22%	0.00	***	12.07%	9.83%	0.01	***
The importance for the cooperation with "professional associations"	5.61%	3.01%	0.00	***	5.61%	8.14%	0.00	***
Patent	16.70%	7.14%	0.00	***	16.70%	21.65%	0.00	***
Collaboration with university	13.67%	5.77%	0.00	***	13.67%	18.27%	0.00	***

	Service Firms				Innovative Firms			
Items	Innovative	Non-Innovative	Pr.		Services	Manufacturing	Pr.	
Collaboration with PRI	20.77%	9.27%	0.00	***	20.77%	25.45%	0.00	***
BOI support	10.81%	7.02%	0.00	***	10.81%	18.83%	0.00	***
NSTDA support	9.38%	2.66%	0.00	***	9.38%	16.77%	0.00	***
NXPO support	1.77%	0.16%	0.00	***	1.77%	1.32%	0.16	
NIA support	3.49%	0.76%	0.00	***	3.49%	3.77%	0.59	

Source: Author’s analysis based on RDI survey 2011, 2014, 2016, 2017, and 2018
Note: *** denotes a statistically significant at a 1 percent level, ** denotes a statistically significant at a 5 percent level, * denotes a statistically significant at a 10 percent level

4. Methodology

This study refines an original version of a CDM model introduced by Crepon et al. (1998) to analyze the linkages between R&D, innovation, and productivity. First, firms will decide on the allocation of resources to activities related to R&D. Then they will choose whether to conduct R&D or not and how much money to spend on it. Investing in that will lead to knowledge production, link to product or process innovation, and enhance productivity. The refined version of the CDM model consists of three equations, including R&D, (technological) innovation, and productivity.

4.1 R&D Equations

There are two equations in this step, including R&D decision and R&D intensity equations. Firms will decide whether they should invest in R&D activities or not, and then the proportion of R&D spending. The Heckman 2-step model is applied to alleviate the selectivity bias problem in the R&D intensity equation. First, the effects of explanatory variables on R&D decisions will be estimated using the maximum likelihood method, like the probit model. The average partial effect (APE) will calculate the coefficient. The R&D decision equation can be illustrated as follows:

$$R\&DDecision = \beta_1 X_1 + \varepsilon_1 \qquad (1)$$

Where R&D Decision denotes the R&D decision of a firm. X1 denotes a set of explanatory variables consisting of labor, foreign direct investment, export, patent, and firm age. β1 denotes a set of variable coefficients. ε1 represents an error term.

Second, the impacts of factors influencing R&D intensity are estimated by ordinary least squares regression (OLS). The inverse Mills ratio term predicted from the first equation is included to deal with the selection bias. It can be shown as follows:

$$log(R\&DIntensity) = \beta_2 X_2 + \beta_\lambda \lambda + \varepsilon_2 \quad (2)$$

Where R&D intensity denotes a proportion of R&D spending to revenue. X2 denotes the same set of explanatory variables as the first equation. λ denotes an inverse Mills ratio predicted from the first equation. β denotes a set of variable coefficients. ε2 denotes an error term.

4.2 Innovation Equation

In this step, the impacts of factors influencing technological innovation, a dummy variable, are analyzed using probit regression. The coefficients are estimated by calculating the average partial effect (APE).

$$Innovation = \beta_{R\&D}(R\&DIntensity) + \beta_3 X_3 + \varepsilon_3 \quad (3)$$

Innovation denotes technological innovation (product or process innovation). R&D intensity indicates the proportion of R&D spending to revenue. X3 denotes a set of explanatory variables consisting of labor, FDI, export, the importance of cooperation with other organizations (locally-owned suppliers, foreign-owned suppliers, parent company, private non-profit, competitors, and professional and industry associations), acquisition of machinery, equipment, and software, acquisition of other external knowledge, innovation training, market introduction, product design, government support (BOI, NIA, NXPO), cooperation with universities, collaboration with a public research institute, and KIBS. β denotes a set of variable coefficients. ε3 represents an error term.

4.3 Productivity Equation

The effects of technological innovation and other factors on labor productivity can be estimated by two-stage least squares (2SLS) regression. The 2SLS model reduces the simultaneity bias from the correlations between innovation and other unobserved factors. The instrumental variables of innovation in the first-stage equation are R&D decisions, FDI, exports, the importance of cooperation with the parent company and business service provider, and the acquisition of machinery, equipment, and software. Technological innovation and other control variables can be written in the following equation:

$$log(\frac{Re\,venue}{Labor}) = \beta_I(Innovation) + \beta_L\, log(\,Labor) +$$

$$\beta_C\, log(\,Capital)\beta_4 X_4 + \varepsilon_4 \quad (4)$$

Where revenue/labor denotes labor productivity (the proportion of revenue to labor). Innovation denotes technological innovation (product or process innovation). Labor denotes the number of laborers. Capital denotes the amount of capital. X4 denotes the set of control variables, including non-technological innovation (organizational and marketing innovation), firm age, FDI, and export. β denotes a set of variable coefficients. ε3 denotes an error term.

4.4 Descriptive Statistics

The descriptive statistics shown in the appendix summarize a data set from the RDI survey. It covers 31,208 firms, including 21,782 manufacturing firms and 9,426 service firms (including 712 KIBS firms). KIBS consists of a computer consulting sector (ISIC 62), architecture and engineering activities, a testing and technical analysis sector (ISIC 71), and scientific research and development (ISIC 72) (Mercedes Rodriguez & José Antonio Camacho, 2010). The survey is cleaned up by dropping some companies that reported unrealistic information such as negative revenue, a high proportion of R&D intensity (more than 50% of revenue), and high profit (more than twice revenue).

5. Results and Discussion

The results from the CDM model consist of R&D decision and intensity, innovation, and productivity equations, which can be explained as follows:

5.1 R&D Decision Equation

The estimation of factors influencing a firm's decision to carry out R&D activities using 2-step Heckman regression is illustrated in Table 2. The model passes the specification test and correctly classified about 77.85%, 70.72%, and 85.12% of the samples in all industrial and service sectors, respectively. For all samples, our results show that R&D decisions are positively correlated with labor (firm size), export (international competition stimulates R&D activities), and patent (intellectual protection leads to the chance to make a profit from innovation). Patent protection does not affect the decision to engage in innovation and R&D activities in the manufacturing sector. However, it can play an important role in the R&D decisions of service firms.

Foreign investment reduces R&D decisions because foreign firms import technology from their country, and firm age has a significant effect on R&D decisions because firms can apply internal knowledge.

The comparison between manufacturing and service firms' R&D decisions shows that export is more critical for service than for the manufacturing sector in R&D decisions. The result aligns with Sujarittanonta, P., and Kamseang, C. (2017), who state that market competition contributes to innovation. The influence of patents on R&D decisions is more essential for service firms than for manufacturing firms. The number of staff has a more positive and significant effect on manufacturing than the service sector. The result is a significant negative effect of foreign investment on manufacturing firms' R&D decisions but is insignificant in the service sector. The service sector is more likely to serve domestic customer needs. In addition, more KIBS than traditional services choose R&D activities.

Table 2: The estimation of factors influencing a firm's R&D decision

Dependent variable: R&D decision (dummy)	**All sectors**			**Manufacturing sector**			**Service sector**		
	Coef.		**P>|z|**	**Coef.**		**P>|z|**	**Coef.**		**P>|z|**
log(Labor)	0.290	***	0.000	0.326	***	0.000	0.196	***	0.000
FDI (dummy)	-0.248	***	0.000	-0.394	***	0.000	0.205	***	0.000
Export (%)	0.630	***	0.000	0.448	***	0.000	0.731	***	0.000
Patent (dummy)	0.050	**	0.025	-0.053	**	0.031	0.272	***	0.000
log (Age)	0.152	***	0.000	0.158	***	0.000	0.098	***	0.000
Market share	-0.017	***	0.000	-0.023	***	0.000	0.003		0.325
KIBS							0.468	***	0.000
Number of obs			31,107			21,719			9,388
Uncensored obs			10,362			8,802			1,560
Wald chi2			1175.47			1273.35			48.19

Dependent variable: R&D decision (dummy)	**All sectors**		**Manufacturing sector**		**Service sector**	
	Coef.	**P>|z|**	**Coef.**	**P>|z|**	**Coef.**	**P>|z|**
Prob > chi2		0.000		0.000		0.000

Source: Author's analysis based on RDI survey from 2011 to 2018
Note: *** denotes a statistical significant at 1 percent level, ** denotes a statistical significant at 5 percent level, * denotes a statistical significant at 10 percent level

5.2 R&D Intensity Equation

The study estimated the R&D investment equation using the Heckman 2-step model (see Table 3). We found that the Lamda or Inverse Mill ratio calculated in the first step of the Heckman 2-step model significantly impacts the intensity of R&D investment in both the manufacturing and service sectors.

Looking at the entire sample, we find that the factors affecting R&D investment and a group of R&D capital decisions are in the same direction. Those factors are the number of employees and domestic market share. While foreign investment and exports have the opposite effect on R&D investment intensity,

Comparing the R&D intensity between the manufacturing and service sectors, we found that firm size, foreign investment, and patent licensing resulted in higher R&D investments in the manufacturing sector but not in the service sector.

Firm ownership has also been analyzed in terms of its effects on the decision to innovate. In general, previous studies have had dual findings. Some authors agree that firms with foreign ownership tend to perform more innovative activities. At the same time, other studies have shown that firms with a certain degree of foreign ownership do not perform innovation activities. Our results suggest that firms in the manufacturing sector with foreign ownership (higher than 50 percent of capital) show a higher R&D intensity.

This result corresponds to previous discussions (Crespi and Zuñiga, 2010). Crespi and Zúñiga (2010) found that firms in Latin America with more than 10 percent foreign ownership are more prone to innovate and also have a higher rate of R&D intensity. These firms invest in R&D to adapt existing products to the local market. Lasserre, 2011). In contrast, our results found that foreign ownership has no distinctive effect on the propensity to innovate by service firms. Foreign ownership in these service firms might not play an essential role in innovating, as they might not follow an active R&D strategy.

Surprisingly, this study found that export experience reduces R&D intensity for both manufacturing and service firms. These results contradict those by Ebling (2000), Chaminade and De Fuentes (2012), and Fuentes et al. (2015), who found that active export behavior has positive effects on firms' R&D performance. In contrast, domestic market share has a positive impact on R&D intensity for both manufacturing and service firms. Service firms that invest more in R&D are more likely to serve domestic customer needs. The study also found that KIBS tends to have more R&D intensity.

Table 3: The estimation of the R&D intensity equation

Dependent variable: Log (R&D spending)	All sectors			Manufacturing sector			Service sector		
	Coef.		P>|z|	Coef.		P>|z|	Coef.		P>|z|
Log (Labor)	0.323	***	0.000	0.350	***	0.000	0.086	*	0.058
FDI (dummy)	0.287	***	0.000	0.299	***	0.000	0.151		0.154
Export (%)	-0.426	***	0.000	-0.431	***	0.000	-0.415	**	0.048
Patent (dummy)	0.067	*	0.057	0.112	***	0.002	-0.216	*	0.067
log (Age)	0.000		0.987	0.028		0.309	-0.033		0.608
Market share	0.042	***	0.000	0.074	***	0.000	0.014	**	0.013
KIBS (Dummy)							0.421	***	0.002

Mills : Lamda	-0.329	***	0.000	-0.385	***	0.001	-0.761	***	0.000
Number of obs			31,107			21,719			9,388
Uncensored obs			10,362			8,802			1,560
Wald chi2			1175.47			1273.35			48.19
Prob > chi2			0.000			0.000			0.000

Source: Author's analysis based on RDI survey from 2011 to 2018
Note: *** denotes a statistically significant at 1 percent level, ** denotes a statistically significant at a 5 percent level. * denotes a statistically significant at 10 percent level

5.3 Technological Innovation Equation

The study estimated various factors that affect the productivity of technological innovations using the Probit model. Estimated results show that, considering the total sample, R&D intensity increases the likelihood of productivity in product innovation or process innovation (see Table 4). The results show that the effects of R&D intensity are statistically significant on innovation output. R&D intensity impacts about 1.049 for manufacturing, and it reported an impact of about 0.322 for service firms. This result confirms those by Crespi and Zúñiga (2010), Griffith et al. (2006), and Raffo, Lhuillery, & Miotti (2008). It indicates that firms with higher R&D intensity per employee are more likely to introduce at least one product or process innovation.

Surprisingly, there is a comparison between Knowledge Intensive Services (KIBS) and other service businesses. This study found that the innovation output in KIBS was statistically lower than non-KIBS. The KIBs in Thailand that focus more on marketing innovation without technology development may have lower productivity.

Foreign ownership is the determinant of technological innovation, but only for manufacturing firms. Manufacturing companies with export experience in the service sector also have a higher R&D intensity as measured by expenditures.

Manufacturing firms with export experience have, in general, increased innovation output. However, firms in the service sector did not confirm this result.

Other factors positively correlated with the productivity of technological innovations include firm size, exports, cooperation with various sectors (including local suppliers, the parent firm, competitors, public research institutes, and universities), Measures to support technology and innovation from NIA and NXPO, including activities related to innovation, including the acquisition of machinery and software, the acquisition of external knowledge, training for innovative activities, the market introduction of innovations, and design activities. However, the factor that did not result in more significant innovation was being a multinational firm. Cooperation with foreign suppliers, private non-profits, and professional associations

When considering innovation outputs between manufacturing and services, the study found cooperation with parent firms and competitors, acquisition of external knowledge, market introduction of innovations, and incentive programs provided by BOI and NXPO. These factors have a more significant impact on the innovation output of the service sector than the manufacturing sector.

Our results show that public funds for innovation are essential for innovation activities across manufacturing and services. An open innovation strategy plays a critical role in innovation investment across all models in the services and manufacturing sectors. The findings support the idea of open innovation and reaffirm the importance of non-R&D activities for innovation in the service sector. Our results are similar to those of studies by Tether (2005), Aboal & Garda (2016), and Fuentes et al. (2015).

Service firms that access market sources of information invest more in R&D and innovation activities than firms that do not benefit from this particular source of information. Surprisingly, this result suggests that spillovers from public data sources have a higher impact on service firms. To the extent that service firms can access free general information, they will increase their investment in innovation. We can argue that firms in the service sector will invest in innovation intensity to obtain information.

Table 4: The estimation of the innovation equation

Dependent variable : Technological Innovation (dummy)	**All sectors**		**Manufacturing**		**Service**	
	Coef.	**P>|z|**	**Coef.**	**P>|z|**	**Coef.**	**P>|z|**
R&D intensity (%)	0.718***	0.00	1.049***	0.00	0.322**	0.03
log (Labor)	0.034***	0.00	0.036***	0.00	0.025***	0.00
FDI (dummy)	-0.014	0.17	-0.020*	0.10	0.010	0.64
Export (%)	0.055***	0.00	0.059***	0.00	0.012	0.65
Local suppliers (dummy)	0.051***	0.00	0.052***	0.00	0.048***	0.00
Foreign suppliers (dummy)	0.001	0.91	0.013	0.31	-0.034*	0.10
Parent company (dummy)	0.028***	0.00	0.027**	0.02	0.036*	0.05
Private non-profit (dummy)	-0.003	0.85	-0.013	0.44	0.033	0.19
Competitors (dummy)	0.052***	0.00	0.046***	0.01	0.057**	0.01
Professional associations (dummy)	-0.031*	0.06	-0.030	0.12	-0.032	0.32
Acquisition of machinery & software (dummy)	0.050***	0.00	0.061***	0.00	0.027**	0.02
Acquisition of external knowledge (dummy)	0.107***	0.00	0.089***	0.00	0.138***	0.00
Training for innovative activities (dummy)	0.037***	0.00	0.047***	0.00	0.016	0.16
Market introduction of innovations (dummy)	0.061***	0.00	0.053***	0.00	0.073***	0.00
Design activities (dummy)	0.226***	0.00	0.228***	0.00	0.216***	0.00
BOI (dummy)	0.011	0.24	0.003	0.79	0.042**	0.03
NIA (dummy)	0.096***	0.00	0.102***	0.00	0.084**	0.05
NXPO (dummy)	0.149***	0.00	0.090**	0.04	0.283***	0.00

Dependent variable : Technological Innovation (dummy)	All sectors			Manufacturing			Service		
	Coef.		P>|z|	Coef.		P>|z|	Coef.		P>|z|
Cooperation with PRIs (dummy)	0.109	***	0.00	0.113	***	0.00	0.098	***	0.00
Cooperation with universities (dummy)	0.085	***	0.00	0.085	***	0.00	0.085	***	0.00
KIBS (dummy)							-0.045	**	0.03
The number of obs.	22,696			15,982			6,714		
Wald chi2	2377.09			1711.17			620.27		
Prob > chi2	0.0000***			0.0000***			0.0000***		

Source: Author’s analysis based on RDI survey from 2011 to 2018
Note: *** denotes a statistically significant at a 1 percent level, ** denotes a statistically significant at a 5 percent level, * denotes a statistically significant at 10 percent level

5.4 Labor Productivity Equation

This study estimated the linkage of technological innovation productivity to productivity using the 2SLS model (see Table 5). This study found no problems: over-identification and weak instrumentation of the model.

Our results show that innovation output has a significant and positive impact on a firm's productivity for both service and manufacturing firms. However, differences arise in terms of the impact. Service firms seem to grasp more benefits from innovation output to increase their productivity. Technological innovation has a more powerful effect on fostering productivity in service firms than in manufacturing firms. Surprisingly, our results show a negative impact of non-technological innovation on firm productivity in both the service and manufacturing sectors. Contrast this with previous studies that point to the existence of complementarities between technological and non-technological innovation that foster firm productivity (Fuentes et al., 2015).

Firm size is an essential determinant of firm productivity. Our result suggests that smaller firms have higher productivity measured in terms of revenues per employee. Our result is similar to those of Fuentes et al. (2015), which suggests that smaller firms might have more flexibility to introduce changes needed in a changing environment, thus positively affecting their productivity. Other factors that positively affect productivity are capital and firm age.

When comparing the manufacturing and service sectors, the study found that technological innovation produces more productivity in the service sector than in the manufacturing sector. These findings differ from Tether (2005) and Aboal & Garda (2016), which found that non-technological innovation is essential to productivity in the service sector, mainly traditional service businesses. This fact may partly be because most of the Thai service sector is traditional. They are SMEs that do not focus on technology but use low-skilled labor to provide services. The study also found that being a very old (experienced) entity increased productivity.

R&D investment in the manufacturing sector will generate more productivity gains than in the service sector. Service innovations cost less to develop, which is an opportunity for service providers, especially SMEs. We also found that KIBS has higher productivity than other businesses in the service sector.

Other factors, such as R&D investment in revenue, headcount, exports, acquisition of machinery and software, training for innovative activities, design activities, incentive programs provided by the NIA, and cooperation with PRIs, will affect productivity and innovation in the manufacturing sector rather than the service sector. Cooperation with universities and local suppliers has a different effect on innovation in the manufacturing and service sectors.

In sum, our results show that the effects of technological innovation and R&D intensity on innovation output and productivity are statistically significant for services and manufacturing. The results did not show a difference in terms of significance between manufacturing and services. Technological innovation and R&D intensity have a higher impact on the complete service sample than on manufacturing firms. These results indicate that service firms can benefit from their investment in innovation and R&D activities when it comes to innovation output and productivity.

Table 5: The estimation of the labor productivity equation

Dependent variable : log (Revenue/Labor)	**All sectors**			**Manufacturing**			**Service**		
	Coef.		**P>|z|**	**Coef.**		**P>|z|**	**Coef.**		**P>|z|**
Technological Innovation (dummy)	0.471	***	0.00	0.41	***	0.00	0.43	***	0.00
Non-technological Innovation (dummy)	-0.074	***	0.00	-0.07	***	0.00	-0.04	*	0.07
log (Labor)	-0.668	***	0.00	-0.67	***	0.00	-0.68	***	0.00
log (Capital)	0.370	***	0.00	0.42	***	0.00	0.28	***	0.00
log (Age)	0.043	***	0.00	0.05	***	0.00	0.04	*	0.08
KIBS (dummy)							0.13	***	0.00
The number of obs.			22,626			15,934			6,692
Wald chi2			11141.07			8561.52			3378.55
Prob > chi2			0.000			0.000			0.000

Source: Author’s analysis based on RDI survey in 2014
Note: *** denotes a statistically significant at a 1 percent level, ** denotes a statistically significant at a 5 percent level, * denotes a statistically significant at 10 percent level

6. Conclusion

This study investigates the determining factor of research and development (R&D) and the impacts of R&D on firms' innovation performance and productivity. This study analyzes the data from the Thailand R&D/Innovation Survey 2011–

2018 and applies a structural model that describes the link between R&D expenditure, innovation output, and productivity.

The results from the CDM model on innovation determinants and the impact of innovation on productivity show that innovation intensity has a substantial effect on innovation output, and innovation output also demonstrates a high impact on a firm's productivity. These results are consistent with those by Crépon, Duguet, and Mairesse (1998), Crespi and Zúñiga (2010), and De Fuentes et al. (2015), as firms that invest more in R&D and innovation activity and have more R&D intensity will have a higher propensity to produce innovations. Those firms also show higher productivity performance.

This study highlights the importance of promoting R&D activities and innovation as the basis for improved productivity among service firms in Thailand. This study also highlights some differences in R&D activities and innovations between the service sector and the manufacturing industry.

The policy recommendations are as follows: Firstly, our findings show that the firms' resource base is vital for innovation. Therefore, the government should promote supply-side measures for service innovation, such as increasing money. Research and development people should increase the efficiency of R&D in government research units and motivate R&D investment in the private sector. The government should use demand measures to boost technology development in service businesses. Moreover, service firms are small and lacking resources, so the government should promote open innovation by encouraging the exchange of knowledge in various forms of cooperation and promoting a robust service innovation system.

Second, the driving forces of service innovation are the firms’ executives' intentions to innovate. Competition and integration as part of the global service value chain will force domestic firms to develop innovation and improve productivity. Therefore, the government should promote competition in the service sector. Liberalizing services sector markets would strengthen the competitiveness of the services sector and boost productivity not only in the service sector but also in the manufacturing sector, which relies on these services as input (Suzuki et al., 2020).

Third, there is a link between R&D activities, service innovation, and productivity, so if Thailand wants to promote innovation in the service sector, the government should encourage R&D activities in the service sector. R&D activities in the service sector are different from those in the industry. Technological innovation plays a vital role in increasing the productivity of the service sector. The Thai government should not promote non-technological innovation activity alone. R&D activities are not the only focus of innovation policies in the service sector. Tax incentives for encouraging R&D are more difficult to use for small service firms and favor large-scale, capital-intensive manufacturing firms. Thai governments should have a broader definition of promoted research and development activities. The government should also promote non-R&D technology development activities.

Finally, this study has several limitations, such as the underutilization of panel data that can better analyze the drivers of innovation and its effect on innovation output and productivity. Moreover, this study explores the differences between the service and manufacturing sectors. Further study should classify subsectors into KIBS and traditional service sectors and hi-tech and low-tech manufacturing sectors.

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