The Thai SME Open Innovation Food-Machinery Flexibility Model: Six Patterns of Coupled Knowledge Flows

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ABSTRACT

Food machinery SMEs have been essential constitutional actors in Thailand's food industry. Their participation in food innovation is considerably recognized. However, their innovation logics and practices remain poorly understood. To understand the role of open innovation (OI) in this change, specifically the OI logics and practices in new product development (NPD), the food-machinery framework has been chosen to analyze 109 NPDs in two Thai food machinery SMEs. This model identifies the various flows of knowledge between the different actors. The results demonstrated the new OI practices being absent from previous typologies and six distinctive patterns within the same framework. These alternatives were revealed through the distinction between laboratory and industrial scales. The refined model demonstrated the ability of Thai SMEs to adjust OI logics and practices to the nature of the collaborative strategy associated with each NPD. Finally, the results exposed some Thai SMEs switching their business from generic machinery companies to innovation intermediaries.

KEYWORDS

Food Industry, Knowledge Flows, New Product Development, Open Innovation Logics, Open Innovation Practices, Thailand

1. INTRODUCTION

Thailand has been recognized as an agricultural country. The food industry (FI) is one of the most prominent drivers for the Thai economy. In 2019, Thailand was ranked the 11th most significant food products exporter in the world. The Thai Office of Small and Medium Enterprises Promotion (OSMEP, 2020) reports that food products exported from Thailand are mostly primary and raw in nature. However, products are recently more frequently found in the form of ready-to-eat (RTE) food products. The proportion of RTE foods to freshly produced foods was 35:65 in 1988 but was increased to 50:50 in 2016. This moderately increasing ratio suggests that new product development (NPD) and food technologies have high levels of participation in this industry.

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The FI transforms the agricultural raw materials with various manufacturing technologies to prolong the shelf-life of food products (OSMEP, 2020). Hence, food manufacturing/machinery SMEs are critical actors in this industry. However, academic literature has underestimated its importance.

Thai food machinery SMEs face various challenges to survive their fast-changing environment with limited resources, for example, meeting evolved customer demands and greater compliance with national regulation's complexity. Therefore, most innovative food NPD are initiated in large and multinational companies. This situation contrasts with countries like Italy where innovation is handled mostly by SMEs (De Martino & Magnotti, 2018). Moreover, Thai food NPD shows a 70-80% failure rate (Hongsaprabhas et al., 2018). Along the NPD process, failures can take place at any stage: being unable to pass the laboratory scale, being unable to reach mass production, and being unable to pass the food registration procedure. These failures have prevented new products achieving the legal commercialized requirement.

As such, Thai food machinery SMEs often avoid investing in research and development (R&D), but focus on production and marketing. Only a minority is actually investing in NPD. Since 2017, Thai government support for FI SMEs and investment in OI development to improve their success ratio. Therefore, some Thai food machinery SMEs collaborate increasingly with other actors within and outside the FI, and adopt implicitly open innovation (OI) logics and practices (Jones & Pimdee, 2017). Although the literature already reported this evolution (Bigliardi, 2019), it never enters the black box of OI implementation at the SME level in the FI. This critical research gap hinders the possibility of understanding what types of OI logics and practices are most frequently adopted in food NPD and why.

2. LITERATURE REVIEW

2.1 Open Innovation, OI Logics and OI Practices

For a decade, OI has been proposed as a new tool for innovation management practitioners. Even though OI is a broadly multi-dimensional perspective, most studies adopted Chesbrough's OI definition; "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation, respectively" (Chesbrough et al., 2006, p. 1). Consequently, both technology knowledge and idea have two ways of movement: outside-in and inside-out (Lichtenthaler, 2008).

There are three alternatives for the organization adopting an OI approach (Enkel et al., 2009; Lichtenthaler, 2008). Firstly, engaging in inbound OI practices, or technology exploration, including encompassing other chain actors' knowledge and skills into the internal innovation process. Secondly, they can carry out outbound OI practices, or technology exploitation, earning benefits by bringing their intelligence and ability such as intellectual property rights (IPR), patents, and/or knowledge assets to the market. Finally, the organizations can integrate the two above logics to collaborate with complementary partners called coupled OI processes for maximum value of OI utilization. As Nonaka (1994) explained with his SECI model, only a continuous flow of knowledge can lead to organizational creation and innovation.

Currently, collaborative information technologies and systematic knowledge management practices have accelerated OI practices (Adamides & Karacapilidis, 2020). Despite OI implementation being increasingly successful, the wide utilization and suitability of its associated logics to large corporates (LCs) and multinational enterprises (MNEs), but significant benefits to SMEs remain critical questions (Sulaymonov & Du, 2020). The numerous limitations in the use of OI for many SMEs remains; some are lack of resources, limited R&D, insufficient organizational adaptability, language barriers, and an excess of other existing barriers have also been cited. Simultaneously, conflicting interest becomes a barrier to establishing academic collaborations as the focus in academia is on basic research driven by fundamental science and knowledge, whereas industry is generally driven

by maximizing profitability. This explains why many of SMEs' struggle with OI implementation (Chaochotechuang et al., 2019).

According to the extant literature, only the study of Van de Vrande et al. (2009) identified the specific OI practices in SMEs which link to inbound logic (i.e., customer involvement, external networking, external participation, outsourcing R&D, inward IP licensing) and outbound logic (i.e., employee involvement, venturing, outward IP licensing). However, no study identifies the empirical characterization of OI practices mobilized in coupled OI logics in FI SMEs.

2.2 NPD Process

Throughout the decade, many authors have defined and categorized the process of NPD. In this study, the researcher has adopted the NPD definition proposed by Zhao (2011, p.1), "The set of activities which is beginning with the market perception opportunities, and ending in the production, sales, and the delivery of new product". This definition is close to the context of innovation creation, which is to commercialize the invention.

Beside the varying definitions, there are many NPD processes categorized by other authors. The researcher finds that the NPD process that most suits the current study can be separated into two main stages. Firstly, laboratory scale includes the prototyping of the new product at the research laboratory scale to generate a minimum viable product. Secondly, industrial scale includes the mass production prototyping at the factory production line's level which allows industrial production (Neubauer et al., 2013). Frequently, academic and practitioner food R&D have neglected the industrial scale which leads to overall NPD project failures.

2.3 NPD Characteristics in FI SME

Compared to other industries, FI NPD presents several specific characteristics (National Science and Technology Development Agency [NSTDA], 2018). Moreover, OI NPD in FI is becoming increasingly complex. There are many challenges for FI SMEs such as the difficulties in meeting simultaneous requirements of an increasing number of actors in the value chains such as suppliers, distributors, legislators, and customers (Chaochotechuang et al., 2019). Therefore, FI SMEs must consider the increase in the food safety awareness consistent with law and regulation that is constantly being updated and developed (Tambunlertchai, 2015). That said, even though FI is considered as a low technology intensive industry, the FI SMEs need dynamic new knowledge from external organizational boundaries to operate their businesses. This new knowledge involves all dimensions of FI SMEs such as NPD, production, distribution and commercialization. Most knowledge has been associated with NPD in FI concerning the legal requirement imposing manufacturers operations in order to comply with regulations. People involved in R&D must consider the legal constraints for each NPD in order to reduce failure (Cooper & Edgett, 2008).

There are many NPD projects in FI, both from the public and private sectors. However, only the effective NPD can create the organization's competitive advantage (Chaochotechuang et al., 2019). Most projects are only prototypes or patents that do not lead to the legal commercialization (Tambunlertchai, 2015). If NPD is unable to be developed through the final product for the consumer, the knowledge used for that NPD is not practical in industrial settings (Galanakis, 2016). NPD failure rate in FI is quite high. Only one-fifth of NPDs were reported successful in this context (NSTDA, 2018). Apart from common reasons such as FI SMEs being unable to explore the market for true consumer demands before starting the NPD (Bigliardi, 2019), the most widespread reasons of food NPD failure are:

1. The selected new agricultural raw materials used in the new product do not provide a continuous process for mass production. Take for instance, some organic fruits are seasonal agricultural ingredients which cannot be produced throughout the year or maintain their quality/quantity in low season. These kinds of ingredients are usable for laboratory scale but not suitable for

continuous mass production (Niyomrath, 2014). In addition, agricultural raw materials are highly variable: they are naturally produced in which their inconsistency has controlled the nutrients in each crop: carbohydrates, protein, fats, fiber, and vitamins. The different quantity of usage provides different results during the food processing (Niyomrath, 2014). In the experimentation of NPD recipes, the laboratory scale uses a small amount of experimental raw materials which are always different from the materials used in large quantities at the industrial scale. The variations in a product's quality might occur.

2. Different food suppliers are involved during NPD experimentation at the laboratory and industrial scale. This variation of agricultural raw material provided by different suppliers can affect the characteristics of the commercialized product (NSTDA, 2018).
3. Inability to up-scale from the laboratory scale to industrial scale for mass production (Hongsaprabhas et al., 2018). The result of the laboratory scale is mostly a proof of concept to propose a minimum viable product (MVP) (Neubauer et al., 2013). Most MVPs at the laboratory scale are not ready for mass production and did not obtain legal authorization for commercialization at that stage. The industrial scale will determine if the NPD can be completed; specifically, in Thai FI SMEs as important factors differentiating the final product from the MVP.
4. New food products are not able to be registered by the Food and Drug Administration (FDA) to lead to legal commercialization such as unclear regulations for the imported new food additive being used in new products. In some cases, the regulations/standards do not specify the levels of control required when using such ingredients. Another example is the FI SMEs possess the production licenses that do not cover the types of their new food products. This is because the innovation of their new product causes changes in product manufacturing classification.

Therefore, there are many more dimensions in food NPD that both academic and practitioner developers must thoroughly consider before starting any new food product development.

Historically, Thai FI SMEs mainly focused on the development of new products on their own due to fear of leakage of business confidentiality. Nowadays, Thai FI SMEs tend to exchange more of the necessary knowledge with business partners that they consider trustworthy. However, apart from the knowledge of business partners, other types of knowledge which are necessary for NPD may also come from other actors in the value chain (Tambunlertchai, 2015). Hence, FI's NPDs are increasingly leveraging external technology, skills and knowledge which involve OI logics at the laboratory and industrial scale. The increasing application of OI logics and practices has gradually affected all actors in the food value chain and in particular SMEs which have to improve their flexibility and agility. None of the available literature on OI has related to how NPD in FI SMEs differentiate with specific logics and practices attached to the laboratory and industrial scale. Few academics and practitioners are yet aware that FI NPD in these two areas of operation are different and require different types of managerial practices.

3. THEORETICAL FRAMEWORK

A comparison between the events observed in the FI and the descriptions of NPD and OI models, which are presented in the literature, represents some clarity deficiency. This is associated with the actors involved in the food value chain, and also the nature of knowledge that flows across organizational boundaries. OI logic study variates due to individually focused knowledge flows such as food ingredient technology or food recipe knowledge flows. If the study considers all knowledge related to the food NPD, it is complicated to identify the development of specific knowledge that transfers among different actors. Hence, the researcher chose the knowledge flow of food recipe as the studied knowledge because it is the only knowledge flow that regularly exchanges with dynamic evolvement among actors since the first step of NPD, laboratory and industrial scale, FDA registration, mass production until delivery to end consumers. An exchange of knowledge among

actors is regularly proceeding. Therefore, it is challenging to decide the knowledge flow direction, inbound or outbound. To clarify this, the researcher applied Bigliardi and Galati (2013) theoretical framework in this current case study.

Regarding the extant literature, only 8 food NPD models for OI have been developed (Galanakis, 2016). The “food-machinery framework” appears the best adapted view compared to Thai FI SMEs context that need the food machinery company for mass production.

Figure 1. The food-machinery framework (Bigliardi & Galati, 2013, p.21)

The model as depicted in Figure 1 is one of the most frequent in the food machinery industry (Grimsby & Kure, 2019). The authors indicated that the raised SMEs’ needs for multiple external knowledge sources for NPD leads to the increased complexity of the food supply chains. The model is specific to the innovative role of a supplier within the OI process, thus referring to a particular case of the food supply chain and not to a general one.

4. METHODOLOGY

In order to refine the food-machinery framework for a better reflection of the FI SME’s NPD, a diachronic case study of 2 Thai food machinery SMEs has been conducted to investigate their NPD projects over a period of eight years from 2012-2020 (SME[A]; NPD case A01-A92), and the period of five years from 2015-2020 (SME[B]; NPD case B01-B17), totally 109 NPD cases. Since the food machinery SMEs who also act as an OI intermediary for the NPD process are difficult to find, the researcher adopted the purposive sampling with the criterion sampling type. The researcher got the confirmation by the investigated Thai food machinery SMEs that they have collaborated with many organizations in NPDs, and passed FDA registration.

This study focuses on the food machinery boundary. Hence, the food-machinery framework has been applied to analyze the reciprocal interaction among actors in the food value chain. This is due to

studying and identifying the relationship of each actor, OI logics and practices in the food machinery company's perspective. The actors involved in each NPD have been identified. The food recipe has always been considered as the key element in the exchange of knowledge flows by considering the food machinery company as the central actor as proposed in the food-machinery framework (Bigliardi & Galati, 2013). OI logics are established using exchange of food recipe flows. When the OI logic is coupled with an equal number of inbound and outbound practices, the exchanged volume resources are considered to define either inbound or outbound dominant. OI practices associated with each NPD have been qualified and classified using the typology of Van de Vrande et al. (2009) at the laboratory and industrial scale. When the OI practices observed mismatch the typology, a new category of practice has been created and defined.

To ensure that the empirical data collected has been adequately analyzed, one series of interviews has been conducted 5 times per SME over a period of 4 months to progressively enrich the data collected. The researcher adopted Yin's (2003) method in data collection and analysis as following: 1) conduct semi-structured interview; 2) transcribe interview; 3) pattern matching to the theoretical framework; 4) linking collected data to the literature; 5) logic model: display the relationship among proposed construct, sequence the position of involved actors reflected the reality, and emerged all the themes to the framework; 7) cross case synthesis: analyze patterns among cases, identify the contradiction and similar findings of each case, explain support reasons, and synthesis the proposed OI framework of Thai food machinery SMEs.

5. RESEARCH FINDINGS

The 109 cases of food NPD were investigated, the food machinery SME[A] and [B] have performed 92 and 17 different NPDs, respectively. Among these NPDs, the researcher found the common points and categorized them into 6 groups by focusing on the new product IPRs (Recipe owner) and the initial creator of the food recipe. The collaboration NPD with different organizations identified (Table 1), SME[A] collaborated with Food company A01-A24, University A01-A03, Hospital A01, and National research laboratory A01. SME[B] collaborated with Food company B01-B04. All the investigated food NPDs combined exploration and exploitation, and consequently inbound and outbound OI logics.

The finding of OI logic; the inbound or outbound dominance of the applied OI logic depends on the purpose of each NPD and on the nature of the partners involved. The finding reveals the associated OI logics as summarized in table 2. At the laboratory scale, the OI logic adopted in 59 NPDs required a coupled OI logic inbound dominant (Group 1, 2, and 4), while 11 NPDs required a coupled OI logic outbound dominant (Group 3). Moreover, there were 39 NPDs that the investigated SMEs had not involved at the laboratory scale (Group 5 and 6). On the other hand, at the industrial scale, OI logics implemented are coupled logic inbound dominant in all cases (Group 1-6).

The finding of OI practice; the OI practices that are not categorized in Van de Vrande's et al. (2009) typology (the practices with "*" in table 3) were enriched (Table 3). The finding reveals the higher numbers of OI practices occurred in the industrial scale in comparison to laboratory scale in all groups of NPDs (Table 2). Undoubtedly, this is due to those more involved actors and more activities being required to be carried out for NPD achievement in the industrial scale. The variety of OI practices is correspondingly raised by the number of involved actors. In comparison, between SME[A] and [B], SME[A] has more OI practices than SME[B] i.e., outward IP licensing and outsourcing R&D at the laboratory scale. This causes the more categorized NPDs in SME[A], group 2 and 3.

The researcher repeated the qualitative data collection regarding the related actors, empirical OI logics and practices based on the process repetition from each interview. Therefore, the researcher sequenced the actors involved in the food-machinery framework (Bigliardi & Galati, 2013) regarding knowledge sequence of producing new products (Table 1). The core focused actor was a food machinery company. The researcher still maintained 3 key main actors in the framework (new/regular suppliers, food machinery company and food company) and added other actors which occur in the investigated

Table 1. Involved actors in 109 NPDs

No.	Involved actors	Total 109 NPDs	
		Involved NPDs	Amount of actor involvement
1	Food companies	89	28
2	Food experts & consultants	7	5
	-Universities	5	3
	-Hospitals	1	1
	-National research laboratories	1	1
3	Marketing organizations, distributors and retailers	15	15
4	New suppliers	98	98
5	Regular suppliers	109	109
6	Regulatory bodies and testing laboratories	109	109
	-Thai FDA	109	109
	-Testing laboratories	109	109
7	Consumers (for sensory testing)	104	104
8	Machinery sellers	10	5

NPDs. To enhance the study in the aspect of actual NPD process, stages were distinguished as laboratory and industrial scales, until the commercialization. The direction of knowledge flows or OI logics (inbound, outbound and coupled) were indicated by the arrows. The coupled OI logic was presented by reverse black and grey arrows. The dominance direction was presented by black arrow, and inferiority direction was presented by grey arrow. To do so, the researcher has refined the food-machinery framework (Bigliardi & Galati, 2013) and proposed “The Food-Machinery Flexibility Model” (Figure 2).

In addition, these 109 OI NPD projects can be classified into 6 sub-patterns (Figure 3-8) within the same model, following the IPR of the new product and the initial recipe creator. Each NPD pattern requires the implementation of different OI logics and practices, and the types of actors involved in the NPDs processes.

The 1st Pattern: The Development of the Food Machinery Company's New Product with its Recipe

The finding shows 13 NPDs within this pattern (10 from SME[A] and 3 from SME[B]). The ideas of new products and original recipes were created by the food machinery company. The intellectual property rights (IPR) of the new product belongs to the food machinery company. The 1st pattern is suitable for a food machinery company with an internal R&D capability to develop new products with their own brand. This pattern suggested that the laboratory scale was almost similar to closed innovation but in reality, it is not. Even though it is almost done by the food machinery company internally, the new food material/ingredient knowledge (e.g., characteristic, special feature, limitation, harvest season for planning purposes, order quantity and cost) for the NPD were provided by the new suppliers. Moreover, the insight needed for new products were acquired from the group of marketing organizations, distributors, and retailers. The food machinery company takes the dominant role in organizing the overall OI NPD until the new product reaches the legal commercialization stage.

Table 2. OI logics and practices found in the 6 groups of food OI NPDs

Group of NPD project (109 NPDs)		Laboratory scale (70 NPDs)		Industrial scale (109 NPDs)	
		OI logics	OI practices (SME[A]/[B])	OI logics	OI practices (SME[A]/[B])
Group 1: 13 NPDs (Case A01-A10, B15-B17)	The 1st pattern – the development of a food machinery company's new product with its recipe.	Coupled OI: Inbound dominant	Outbound practices: 26 practices Employee involvement (20/6 practices) Inbound practices: 29 practices Customer involvement (13/3 practices) Supplier involvement (10/3 practices)	Coupled OI: *Inbound dominant	Outbound practice: 65 practices Employee involvement (50/15 practices) Inbound practices: 65 practices Customer involvement (20/6 practices) Supplier involvement (20/6 practices) Regulatory body involvement (10/3 practices)
Group 2: 2 NPDs (Case A11-A12)	The 2nd pattern – the development of a food machinery company's new product with the food expert's recipe.	Coupled OI: Inbound dominant	Outbound practices: 4 practices Employee involvement (4/0 practices) Inbound practices: 6 practices Customer involvement (2/0 practices) Outsourcing R&D (2/0 practices) Inward IP licensing (2/0 practices)	Coupled OI: *Inbound dominant	Outbound practice: 12 practices Employee involvement (12/0 practices) Inbound practices: 12 practices Customer involvement (4/0 practices) Supplier involvement (6/0 practices) Regulatory body involvement (2/0 practices)
Group 3: 11 NPDs (Case A13-A23)	The 3rd pattern – the development of a food company's new product with the food machinery company's recipe.	Coupled OI: Outbound dominant	Outbound practices: 22 practices Employee involvement (11/0 practices) Outward IP licensing (11/0 practices) Inbound practices: 11 practices Customer involvement (11/0 practices)	Coupled OI: *Inbound dominant	Outbound practices: 55 practices Employee involvement (44/0 practices) Insourcing R&D (11/0 practices) Inbound practices: 55 practices Customer involvement (22/0 practices) Supplier involvement (11/0 practices) Regulatory body involvement (11/0 practices) Inward IP licensing (11/0 practices)
Group 4: 44 NPDs (Case A24-A55, B01-B12)	The 4th pattern – the development of a food company's new product with its recipe	Coupled OI: Inbound dominant	Outbound practices: 100 practices Employee involvement (64/24 practices) Insourcing R&D (12/0 practices) Inbound practices: 132 practices Customer involvement (32/12 practices) Supplier involvement (32/12 practices) Inward IP licensing (32/12 practices)	Coupled OI: *Inbound dominant	Outbound practices: 269 practices Employee involvement (164/61 practices) Insourcing R&D (32/12 practices) Inbound practices: 269 practices Customer involvement (64/24 practices) Supplier involvement (68/25 practices) Regulatory body involvement (32/12 practices) Inward IP licensing (32/12 practices)
Group 5: 34 NPDs (Case A56-A87, B13-B14)	The 5th pattern – the development of a food company's new product with the food expert's recipe.	No OI logic	No OI practice	Coupled OI: *Inbound dominant	Outbound practices: 206 practices Employee involvement (162/10 practices) Insourcing R&D (32/2 practices) Inbound practices: 206 practices Customer involvement (64/4 practices) Supplier involvement (66/4 practices) Regulatory body involvement (32/2 practices) Inward IP licensing (32/2 practices)
Group 6: 5 NPDs (Case A88-A92)	The 6th pattern – the development of a food expert's new product with the food expert's recipe.	No OI logic	No OI practice	Coupled OI: *Inbound dominant	Outbound practices: 26 practices Employee involvement (21/0 practices) Insourcing R&D (5/0 practices) Inbound practices: 26 practices Customer involvement (5/0 practices) Supplier involvement (11/0 practices) Regulatory body involvement (5/0 practices) Inward IP licensing (5/0 practices)

Remark:^{***} In case of equal number of inbound and outbound practices, the exchanged volume food recipe resources are considered to define either inbound or outbound dominant (identified by the interviewee).

The 2nd Pattern: The Development of the Food Machinery Company's New Product with the Food Expert's Recipe

The finding shows 2 NPDs within this pattern (SME[A] only). The idea of new products was created by the food machinery company but it lacked internal R&D capability. Hence, although an external food expert (University A01) was hired to create the original recipe, the IPR of the new product belongs to the food machinery company. The 2nd pattern is most suited to a food machinery

Table 3. Eight OI practices in the investigated food OI NPDs

OI practices		Definitions
Inbound practices	Customer involvement	Directly involving customers in the innovation process e.g., by active market research to check customer needs, conduct sensory tests, and/or by developing products based on customer specifications.
	Supplier involvement*	Directly involving suppliers in the innovation process. The Knowledge provided here concerns either raw materials or machine settings. <ul style="list-style-type: none"> ● Inward ingredients fitness: e.g., a regular or new supplier specifies which ingredients are best suited to complete the development of the food recipe. ● Inward machinery fitness: e.g., the completion of the NPD at the industrial scale requires to buy a new machine to achieve a better new product quality and/or better production efficiency, and the supplier optimize the settings of the machine to achieve such goals
	Regulatory body involvement*	Directly involving regulatory bodies in the innovation process to fulfill legal commercialization of new product requirements. The knowledge provided here concerns law and regulation to achieve FDA registration of food products. Tangible knowledge as the explicit documents is strongly needed e.g., 1) FDA supported documents (microbial reports, nutrition fact sheets) from accredited testing laboratories, and 2) FDA registration report from FDA.
	Outsourcing R&D	Buying R&D services from the external network partners e.g., universities, public research organizations, food experts, commercial engineers or suppliers.
	Inward IP licensing	Buying or using intellectual property e.g., patents, copyrights and/or trademarks, of other organizations to gain more revenue from the external knowledge.
Outbound practices	Employee involvement	Leveraging the knowledge and initiatives of employees who are not directly involved in NPD or R&D department e.g., by taking up suggestions, exempting them to implement ideas, creating autonomous teams to realize innovation.
	Insourcing R&D*	Selling R&D services to other organizations to gain more revenue from the existing internal knowledge, skills and/or machinery.
	Outward IP Licensing	Selling or offering licenses to other organizations, to gain more revenue from the existing intellectual property e.g., patents, copyrights and/or trademarks.

company with the ability to make its own brand products, but lack the internal R&D capability to complete laboratory scale itself. Hence, this pattern suggests “outsourcing R&D” with “the food experts and consultants”. The external food experts and consultants should provide the prototype for a new product, new ingredient knowledge, the food recipe, and suggested production techniques for laboratory scaling. The critical factor to achieving these NPDs is to decide the requirements of new products from a market perspective, and communicate this to the food experts and consultants. The precision with which a new product requirement is delivered (new product scope, special features, ideal cost, market preference, the limitation of production facility, mass production condition, the related law and regulation of new product), the greater the NPD success rate. The main obstacle for this pattern is that they were found time-consuming and costly. Additionally, new machinery may be required to achieve NPD in terms of mass production.

The 3rd Pattern: The Development of the Food Company’s New Product with the Food Machinery Company’s Recipe

The finding shows 11 NPDs within this pattern (SME[A] only). The original recipes were created by the food machinery company. However, the IPR of the new product belongs to the food company. The 3rd pattern is suitable for the food machinery companies who want to exploit their existing food recipes to other food companies by offering the NPD of original equipment manufacturer (OEM) brand products. Hence, no supplier involved in the laboratory scale. As the food recipes are the organization’s asset of the food machinery company, this pattern benefits the food machinery company through

Figure 2. The Food-Machinery Flexibility Model

Figure 3. The 1st pattern of Food-Machinery Flexibility Model

Figure 4. The 2nd pattern of Food-Machinery Flexibility Model

better utilization of its recipe by other food companies. The new products have a slight adjustment compared to the original food recipe, for instance the ratio of ingredients or minor taste factors to meet the ideal price point to satisfy the food company's target market. This pattern is convenient for the other food machinery companies to implement, but the new product from this pattern tends to be less unique. The initiation of this type of OI NPD is generated from the food machinery company (supply side), not from the consumer side. The food company also benefits from this pattern as it extends their new product range with low initial investment. This is a win-win situation for the food machinery company and the food company.

The 4th Pattern: The Development of the Food Company's New Product with its Recipe

The finding shows 44 NPDs within this pattern (32 from SME[A] and 12 from SME[B]). The idea of new products and original recipes were created by the food companies, which resulted in the IPR belonging to them. The 4th pattern is suitable for the food machinery companies who position themselves as a superior OEM for a variety of food company's NPDs. The diversification of many new product categories is considered to be a paradigm shift of food OEM business. This pattern benefits the food machinery company by increasing the new S-curve of product availability, and reducing the risk within an uncertain business environment. The main task of the food machinery company is to implement the food company's recipe with its technology at the laboratory and industrial scales. This pattern suggests the food machinery company has agility and flexibility with the overall NPD process, and the adjustable mass production line. Therefore, the food machinery company has to be aware that its production license should cover the scope of new products. If not, the new product could not be registered with an FDA number. In other words, the food machinery company must be prepared to respond to the different requirements of each NPD from the different food companies. The

Figure 5. The 3rd pattern of food-machinery flexibility model

critical factor to achieve such NPDs is the ability to identify a suitable food company as a strategic partner and work towards developing a long-term relationship, because the adjustable production line is very costly to the food machinery company.

The 5th Pattern: The Development of the Food Company's New Product with the Food Expert's Recipe

The finding shows 34 NPDs within this pattern (32 from SME[A] and 2 from SME[B]). The idea of new products has been created by the food company, but the original recipes are created by the food experts & consultants. The IPR of the new product belongs to the food company. The 5th pattern is suitable for food machinery companies who position themselves as a superior OEM for a variety of food companies, but does not include the laboratory scale. The laboratory scale will have been completed with R&D cooperation between the food company and the external food experts & consultants. The critical task for the food machinery company is to obtain relevant food recipe knowledge at the laboratory scale, and adjust accordingly to suit their production facilities. They can then move to production and legal commercialization phases. This pattern suggests the food machinery company should consider handing the task of laboratory scale developments to experts in that field and focus their expertise to focus upon developing their capability to implement an industrial scale NPD. The greater number of new products that can be mass-produced and legally commercialized, the more long-term benefit to the food machinery company. Most of the investigated cases concerned NPDs in which the food companies bought the new product IP from universities. This shortens the overall development process in terms of the initial knowledge requirements, and the prototype development. However, the difficulty of this pattern is the food machinery company's ability to upscale the prototype.

Figure 6. The 4th pattern of Food-Machinery Flexibility Model

Since the food machinery company was not involved in the laboratory scale, the prototype was created by lacking the inputs of actual limitation from the production side. Any diversions between laboratory and industrial scales could produce significant differences to the final merchandise when mass-produced. These can range from different sources of the same ingredient from a different food supplier affecting the product taste, affecting as the percentage of yield loss at the actual production stage is always higher than the laboratory scale. These issues also affect the calculations for the new product costs and ingredient planning. Moreover, the most common obstacle from this pattern is that the production conditions of laboratory scale provided by the food experts and consultants might not comply with food laws and regulations.

The 6th Pattern: The Development of the Food Expert's New Product with the Food Expert's Recipe

The finding shows 5 NPDs within this pattern (SME[A] only). The idea of new products and the original recipes were created by the food experts & consultants. The IPR of the new product belongs to the food experts & consultants. The 6th pattern is quite similar to pattern 5 as the food machinery company is only involved at the industrial scale. The laboratory scale was developed by the food experts & consultants. No consumer involved in both scales due to the strict insourcing R&D contract. In the past, the ultimate aim of the food NPDs from academic researchers tended to focus only on the laboratory scale, but it is quite difficult for the private sector to mass produce and legally commercialize at this scale. However, this finding shows some gradual changes to this matter. Some food experts & consultants have now extended their NPD/R&D/IP scope to cover the industrial scale including FDA registration. This will assist the private sector food companies and/or food machinery companies

Figure 7. The 5th pattern of Food-Machinery Flexibility Model

make commercialization easier to achieve. This pattern is rarely found in the Thai FI at the moment, but one of the interviewees strongly believed it will be growing in the future in respect of national policy change. The value pattern 6 is to obtain advanced knowledge at minimum cost, for example the application of new food techniques and processes, and the application of new food ingredients. Even though each NPD has always had an agreement on new product confidentiality, the food machinery company can apply some of this knowledge to the different NPDs, and still behave ethically. The difficulty with this pattern is the communication gap between the academic and practitioner.

Figure 8. The 6th pattern of Food-Machinery Flexibility Model

6. CONCLUSION

This study points out a new perspective for food machinery companies: there is a direct connection between OI logics and OI practices in the food NPD. However, the finding shows no absolute inbound and outbound OI, the coupled OI logic with the dominance characteristic of inbound and/or outbound is more accurate to describe reality than usual perspective exploited in the OI in SMEs literature (Van de Vrande et al., 2009). Dominant outbound practices and dominant inbound practices are connected to exploitation and exploration respectively. To understand the reason behind this, it was evident from the interviewees that the flow of knowledge always exchanges in 2 ways between the food machinery company and the external actors to varying degrees. Therefore, the researcher can identify the dominance of the knowledge flow in coupled OI logics by identifying the frequency of OI practices mobilized. If the organization engages inbound practice more than outbound practices, it is coupled OI logic: inbound dominance, and vice versa. Interestingly, results are different at the laboratory and industrial scale. This result should be taken into account in subsequent analysis of SME's food NPD. Finally, such level of agility in a FI SMEs as, to the researcher's knowledge, has never been reported. This finding is in agreement with Sulaymonov and Du's (2020) argument that inbound approach is more adopted in FI SME. However, the outbound approach of SME[A] in the laboratory scale of NPD group 3 shows the flexibility in adopting different OI approaches to survive in its competitive business environment.

The food academics and practitioners who plan to develop new products can use the food-machinery flexibility model as their NPD guideline. Each sub-pattern of the model has different unique characteristics. The origin of the food recipe is evidently the strategic drivers for the choice

of OI logics and practices. To develop its organizational agility regarding each specific requirement (client's demands, limitation of food technology and ingredients), the investigated food machinery companies developed a high level of flexibility in their operational routines based upon organizational vision and knowledge management. The findings of the overall model demonstrate the flexibility of the investigated food machinery companies to apply one of OI logic or another, and to implement the associated OI practices in their NPDs. All NPD cases are the combination of exploration and exploitation. This agility to adopt various OI logics and practices helps the food machinery company to develop new core competencies besides its production technology. The benefit of understanding the true nature of OI logics and practices also help the practitioner to switch from description to prediction, reducing failure NPD by predicting the associated OI practices needed for each case.

Some limitations must be noticed. To confirm the researcher's observations, a further study should compare the current results with more food machinery companies. The choice of the additional SME is of central importance as they can act as simple suppliers in their value chain or as OI intermediary like the investigated SMEs. A comparison of different types of FI SMEs innovation strategies should help the researcher to define a typology combining strategy, innovation logics and innovation practices.

As the investigated food machinery companies' innovation logics and practices flexibility are based on their ability to constantly recombine its routines and reconfigure their procedures to adjust them to the specific goal of each NPD, a further exploration of the dynamic capabilities (DCs) developed by FI SMEs would contribute to a better understanding on how internal and external learning strategies affecting the evolution of the business model and the dominant innovation logic (Teece, 2020). The investigated food machinery companies demonstrated their ability to absorb new external knowledge and recombine it by its own. The empowerment of absorptive capacity explains; at least partially, its structural, managerial and strategic evolution from an ordinary food machinery company to a food OI intermediary. The researcher nevertheless concludes that the investigated SMEs developed their associated DCs to reach the optimum required OI logic and practice flexibility in their NPD. Hence, that is why they successfully adopted an OI when others failed. This is in agreement with Teece's (2020) argument concerning the existing relationship between DCs and OI. They are mutually reinforcing and strengthening each other.

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