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Author(s)	Lalinorasate, Paveena; Miyazaki, Kumiko
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Core Technological Competence and Knowledge Accumulation in Japanese Food Firms: Empirical Study on トクホ。

○Paveena Lalinorasate, Kumiko Miyazaki（Tokyo Institute of Technology）

Abstract - **Japanese functional food industry has demonstrated that, apart from conventional market-driven process in food industry, technological progress has also played an important role in facilitating the development of high-value added products. The role of core technological competence and the accumulation of technologies in 5 Japanese food firms are investigated through patent analysis to illustrate how core technological competence influence the searching direction and the accumulation of technologies necessary for the successful functional food innovation.**

Index Terms – **FOSHU, Technological competence, Patent**

1. Introduction

Until the recent, food industry has been regarded as low-tech due to the low overall R&D intensity. Innovation is mostly driven by the market-demand and the main source of technology is supplied by somewhere else. The role of technological competence inside firms is hardly mentioned as a source of competitiveness. Nevertheless, many literatures have indicated that food firms especially in Japan have actually dealt with wide area of non-food technologies ranging from mechanical, chemical, pharmaceutical and biotechnology(Tunzelmann, 1998). Firms accumulate knowledge and built up technological competence in several areas to achieve productive resources and to interact with the rapid changing technologies and opportunities(Grant, 1996). The complication and intense in both regulation and production techniques in Japanese functional food that food firms have to deal with are the proof of the competences in food firms.

The development of technological competence comes with cost and time. Firms are barely willing to spend their resources on unknown profits. In the case of functional food, food firms have to face new opportunities and threats that they are unfamiliar with. The general process of product development that they usually follow may not able to fully to answer the requirements(Betoret, Betoret, Vidal, & Fito, 2011). Core technological competences that firms hold could assist them in coping with emerging technologies at the beginning period, and learning process becomes necessary for the efficient competition in the era of rapid changing environment and technologies.

This study investigates how Japanese food firms respond to functional food opportunities via their core technological competence and knowledge accumulation.

2. Background

2.1 Functional Food Industry in Japan

The concept of functional food has begun in Japan in 1980s among Japanese scientific academia, where functional food was defined as food with tertiary or physiologically active functions, such as the regulation of a physical condition or the prevention of certain kinds of disease (Arai et al., 2002; Nagata & Yamada, 2008). The first legal approval system for commercialization of functional food has been established by the Ministry of Health and Welfare in 1991. In this system, Functional Food is categorized in “Food for Specified Health Uses—特定保健用食品”, or FOSHU (トクホ) in short. Each FOSHU product has to pass the assessment of FOSHU individually. FOSHU system requires all food that label with health claims meet the FOSHU conditions, which include: (1) scientific evidence of the effectiveness of the functional component on human body, (2) absence of any safety issues, as assessed from historical consumption pattern data, (3) use of nutritionally appropriate ingredients, (4) guarantee of compatibility with product specification by the time of consumption, and (5) established quality control methods, such as specifications of products and ingredients, processes, and method of analysis. The data from the Consumer Affair Agency,

Government of Japan[1] revealed that there are totally 1063 approved FOSHU products from October 1997 to June 2013, with a market value of be 5175 hundred million yen in 2011[2]. The top companies with highest number of approved products are from the top Japanese food companies.

The development and commercialization of functional food is more complex, expensive and riskier than that of traditional food product. While the marketing and management challenges are the common challenges for food firms, special requirements from regulators and technological challenges become another barrier that prevent many food firms from participating in functional food industry. The technical challenges exist in the complex process of the functional food production such as specific technologies for preventing the deterioration of physiologically active compound (Table1). Additionally, to comply with the governmental regulations, production of functional food requires additional steps such as confirmation of bioactive ingredients activity and guarantee of safety in human which could be challenging for food firms that have no experience in a clinical trial process.

Table 1 Topology of Process of food engineering in Food industry, based on the type of the end product made and the functional food manufacture technologies (Betoret, Betoret, Vidal, & Fito, 2011; Bruin & Jongen, 2003; Jousse, 2008)

Process Typology	Examples
Structuring Processes (Forming complex structure)	Emulsification, Crystallization, Extrusion, Biopolymer mixture, Fat replacement, Foaming, Baking
Separation Processes (Splitting intermediate product from raw material)	Isolation of oil fractions, Sugar extraction, lipid fractionation, Freeze-drying, Membrane separation
Stabilization & Preservation Processes (preventing spoilage)	Thermal processing, UHP pasteurization and sterilization, pulsed electric field, microbial deactivation, reduction of water activity
Bioconversion Processes (I.e. to form flavor or fermentation)	Use of complex enzymatic reaction
Specific processes for preventing deterioration of active compounds	Micro-Nano encapsulation (including spray-drying and coating), Edible films and coating, Vacuum impregnation

2.2 Core Technological Competences and the Accumulation of Technology

Core technological competences are parts of the firm's specific competences that are embed in the organization. Prahalad (1993) described the concept of technological competence as a source of competitive advantage that results when firms learn to harmonize technologies. Teece, Pisano, & Shuen (1997) also mentioned core competence as a firm's fundamental business which can be enhanced by combination with the appropriate complementary assets. Goddard (1997) explained functions of core competences as: differentiating the company from competitors, creating values to customers, acting as a platform for growth and providing strategic focus and direction. Core technological competence of a firm is a result of long period of knowledge accumulation. A study from Miyazaki (1994) in the Japanese and Europe optoelectronics sector has illustrated the case of technological accumulation of firms in high-tech sector on how these firms build competences via the process of searching, learning and experimenting. The prior accumulated knowledge was also mentioned by Cohen & Levinthal (1990) as an important factor that gives firms the ability to recognize the value of new, external information and apply it to the commercial ends.

We propose that core technological competences are fundamental to firms' business and innovative activities such as how firms respond to emerging opportunities, and the strategies are readjusted according to experience firms have learnt.

3. Data and Methodology

[1] Consumer Affairs Agency also provides information of food label, and details of FOSHU approval system. (http://www.caa.go.jp/foods/index4.html#m02)

[2] A market survey from Japan Health and Nutrition Food Association taken in 2011

As to illustrate Japanese food firms in functional food industry, five Japanese food firms with approved FOSHU products were chosen. These firms differ in business activities, size and R&D figures as shown in Table 2. Patent applications filed during 1988-2011 of these five firms were acquired from Japanese Patent Office (JPO) via the JP-NETe service, which were later studied as indicators for firms' technological activities. Functional food related patents were identified using a method of keywords search in the patent title, abstract and claims, which was described earlier by Xie and Miyazaki (2012) as the best method to retrieve patents from the interdisciplinary domain. Totally, there are 7,002 patent applications from all patenting activities, and among them, there are 650 patents identified as relating to functional food. Each patent was then classified based on the WIPO technology-IPC concordance (2013), which classifies IPC codes into 35 technological fields.

Table 2 Corporate Business and R&D Data

Company (established year)	Core business (Sales, % of total)	Other businesses (Sales, %)	R&D Expenditure*
Ajinomoto (1917)	Food and Beverage – Seasonings, Processed foods (50.1), Bioscience Products and Fine chemicals – amino acids, specialty chemicals (17.4)	Pharmaceuticals (6.1), Others (21.3)	37
Suntory (1899)	Food and Beverage (53), Alcoholic Beverage (30)	Others (17)	16.6
Yakult (1930)	Dairy Products - Fermented milk (40.4), Pharmaceuticals (22.5), Beverages (21.2)	Cosmetics (3.7), Others (8.8)	9.6
Nisshin Oillio (1907)	Oils and meals - Edible oils (64.2), Processed oils & fat – margarine, shortenings (27.5)	Fine Chemicals (3.4), Healthy foods (2.3), Others (2.6)	2.3
Itoen (1966)	Japanese tea (46.3), Fruit and vegetable juice (16.8), Other tea and coffee (16.7)	Tea leaves (8.8), Others (2.0)	1.5

***The figures are approximated for 2010 in billion yen unit.**

4. Technological Competence in Food Firms

4.1 Identifying Core Technological Competences

Core competences of the firms even though contribute to the main business activities such as shown in Table 2, they cannot be simply defined by glancing at the business profiles. Core technological competences for functional food here are defined via functional food related R&D activities, which could be represented by patenting data.

Profile of technological competencies (Figure 1), developed by Patel and Pavitt was adopted in this study to explain the core technological competences. Technological profiles are classified into four groups: core, background, marginal and niche based on patent share and RTA[3]. Core and niche competency are technological fields that are comparatively stronger than the others. The difference is that the core competence indicates main competence of the firm, and thus locates in the region of high patent share and high RTA, while niche competence is located in the region of low patent share but high RTA. Background competency is where a firm allocates large amount of share in its resources in, but considering the size of field, a firm gains no higher advantage than the others. Marginal competency is where firm neither allocates large share of resources nor gains more advantages than others (Patel & Pavitt, 1997).

4.2 Technological competences profile

3 If P_{ij} denotes the number of patents filed in the technological activity i to firm j in a particular group, the RTA index is defined as: $RTA_{ij} = (P_{ij}/\sum_j P_{ij}) / (\sum_i P_{ij}/\sum_{ij} P_{ij})$

Core technological competences for functional food development in each firm (Table 3) in the early period (1988-1995) were compared with the more recent period (2004-1011) to see the differences in firms' strategies at the very beginning period of functional food development and after the accumulation of knowledge.

In the early period, core competences were noticeably similar among firms that involve in similar technological areas in their core products. For example, biotechnology, or more specific fermentation technique, is highly important for the core products of Ajinomoto (amino acid), Suntory (alcohol) and Yakult (fermented milk). Continuity of core competences emphasis is observable in the later period in most firms. Even so, core competences may lose their positions to other technological area or to firms that invest more heavily in the later period (2004-2011). In comparison, smaller firms with lower R&D expenditure seem to have better focuses on their core functional food R&D. For example, Ito en had allocated its resource to only a specific number of fields while Nisshin Oillio is the only firm in the group that emphasizes basic material chemistry field from the beginning (as it has high relation to the oil-meal business). Note that the separation between 'core' and 'background' competences were not highly distinctive in most cases in this group samples since all firms may have interest, or functional food R&D focus are in the similar technological areas.

Firms that have several business groups are rather multi-technology and engage in a wide range of technological activities such as Ajinomoto and Suntory have interested in utilizing niche competences in functional food development. The examples are using IT in managing nutritional and dietary system and using a combination of measurement, biotechnology and organic chemistry in the creation of devices for determining the amount of biological compound and detecting bacteria.

The result also revealed that there are common areas of technologies that functional foods require and it agreed with the previous work of Bröring and colleagues (2006) on the convergence of pharmaceutical and food in the functional food industry, as all firms have made pharmaceuticals area either background or core competence in the functional food development.

Table 1 Technological Profiles in five companies

Company (Period)	Ajinomoto		Suntory		Yakult		Ito en		Nisshin Oil.	
Technological field	(I)	(III)	(I)	(III)	(I)	(III)	(I)	(III)	(I)	(III)
Basic materials chem.	*	*	*	****		****			****	****
Biotechnology	****	***	***	****	****	****	***	***	***	*
Chemical engineering	**	**			***	***			****	
Food Chemistry	****	***	***	***	***	****	****	****	***	****
IT methods		**								
Macromol. Chem.	**	**		*	**			**		
Measurement		**		**						
Medical Technology		**		**						
Micro and nano-tech		**								
Organic fine chem.	***	***	****	****	****	*	***	****	****	***
Other special machine		**		*						
Pharmaceuticals	***	****	****	***	****	***	****	****	***	***
Surface technology	**									
Textile& paper	****	**								

Firms' technological profiles in two periods, 1988-1995 and 2004-2011 are denoted by (I) and (III) respectively. The symbols indicating technological competences are as follow:

Background	***	Core	****
Marginal	*	Niche	**

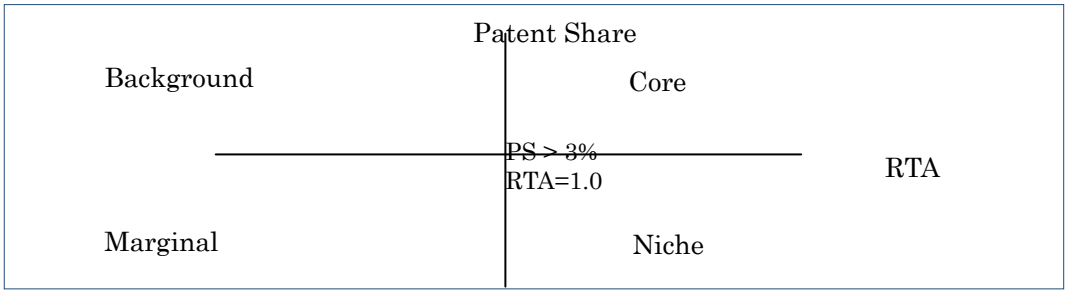

Figure 1 Classification of firm's technological profiles (Patel and Pavitt, 1997)

4.3 Technological accumulation and searching

Suppose that each firm has attempted to continuously search for the most suitable path for their product development, the direction and breadth of technological accumulation could be hardly constant. Comparison of the RTA correlation in three consecutive periods has shown the differences in firms' focuses in the early and later periods.

The positive changes in the focuses of searching space in all firms are observed in Table 4. However, some distinctions among firms with different R&D size can be observed. Firms with lower R&D expenditure and narrower business range such as Nisshin Oillio and Itoen seem to locate their R&D activities in the preferable technological area from the beginning with only a slight increase in focus. On the other hand, negative RTA correlation was observed at the first two periods (1988-1995/1996-2003) in the firms with high R&D expenditure and wide business range like Ajinomoto and Suntory. A large stock of knowledge may obscure these firms on what they should have focused. Together with the results from technological competences profile, it is found that these firms have later utilized other technologies other than their core competences on functional food activities. The effects of technological focus after long period of trial-and-error and searching have been discussed earlier by Miyazaki (1994). Regardless of the differences between optoelectronics and food industry, searching for the right direction at the initiation phase is not a simple task even in high experienced firms. One possible reason is that functional food requires competences from several technological areas including chemicals and pharmaceuticals, so the learning process could resemble the high-tech industry.

Table 2 Comparison of the correlations between the same types of RTA over three periods

	Correlation of RTA between two periods		
Company	1988-95/1996-2003	1996-2003/2004-11	Change (+/-)
Ajinomoto	-0.238	0.930*	+
Suntory	-0.401	0.871	+
Yakult	0.476	0.62	+
Itoen	0.889*	0.966*	+
Nisshin Oillio	0.938*	0.974*	+

* Correlation is significant at the 0.05 level (2-tailed).

5. Conclusion and Implications

This study illustrated that core technological competences facilitate Japanese food firms on responding to functional food challenges and that food firms have learnt and changed their strategies accordance to the cumulative knowledge.

Coping with the emerging opportunity exerted by functional food industry, food firms may have localized search for the most reachable solution, for example firstly rely on their existed core competences. As shown in the technological competences profiles, functional food related activities at the beginning are mostly related to the technological fields firms usually utilize in their core activities. While larger firms may have built up competences in a wider range afterwards, smaller firms with limited resources may prefer to focus on their cores. Here, we tentatively conclude that core competences play a

key role in food firms' functional food development such as being a foundation for the further exploration and experimentation.

The results of trial-and-error at the beginning period shape the direction of learning and searching at the later period. After some experimentation, the searching space of each firm has been reduced after the desirable path was chosen. For firms that have technological activities involving a wide range of technologies, searching process allows them to try their stock of knowledge on functional food development, while the core technological competences are keeping them on tracks. In the firms that are more specialized, their core technological competences could be directly related to the competences necessary for functional food; however, it is still necessary to learn and adjust timely accordance to the rapid changing environment.

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