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Identifying Innovation Determinants and Enhancing Innovation Capabilities of SMEs: Empirical Analysis in Korean Firms

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이 용 호

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지도교수 박 용 태

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Abstract

Identifying Innovation Determinants and Enhancing Innovation Capabilities of SMEs: Empirical Analysis in Korean Firms

Yongho Lee

Department of Industrial Engineering

The Graduate School

Seoul National University

In developed countries, small and medium sized enterprises (SMEs) account for the vast majority of firms and a large share of gross domestic product (GDP), so driving SMEs' innovation is crucial to boosting national innovation and economic growth. Despite various suggestions, there is a consensus that innovation depends on firms' innovativeness, in other words, their capability to introduce new processes, products, ideas, etc.

From the theoretical perspective, there have been three deficiencies in previous studies: there has been little focus on the systematic integration of innovation factors; nor on how the attributes of such factors change over time; and little consideration of region-specific characteristics. From the business perspective, being successful in implementing innovation requires considerable resources, but most SMEs have limited resources: approaches to enhancing SME innovation will need to consider this limitation.

This doctoral dissertation consists of two themes, each of which deals with these issues from different perspectives. Theme#1 aims to increase our understanding about changing patterns of SMEs' innovativeness via a

field study which tries to identify how Korean SMEs could be grouped in terms of their innovativeness, and how the innovativeness of those groups has changed over time. Specifically, we suggest a way of identifying the principal types of SME business models (BMs), and of associating the evolving paths of SMEs' business models with the changing patterns of their innovativeness. Based on the results of a survey of 400 Korean SMEs, four principal types of business models are identified, and distinguished in terms of their innovativeness. Through interviews and additional surveys of 30 globalized SMEs, four evolving paths of SME business models are explored.

Theme#2 aims to develop a framework that analyzes technological opportunities considering SMEs' internal capabilities, so producing what can be regarded as a technological exploitation framework of a company. An approach to exploring technology opportunities based on SMEs' capabilities is suggested. Patent citation analysis is used to construct a patent pool containing potential emerging areas, after which text mining is used to develop a technology application table that includes the principal attributes of technologies, and suggests emerging opportunities in the form of applications which consider firms' technological capabilities. Outline direction for R&D efforts which correspond to chosen opportunity options are also suggested.

Keywords: Innovativeness, Emerging opportunity, Business model, Technology management, small and medium sized enterprises (SME)

Student Number: 2001-30324

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Chapter 1. Introduction

1.1 Background and motivation

Small and medium enterprises (SMEs) have recently come to be been regarded as the engines of national economic and employment growth, with their role becoming more important as the growth of industry giants has slowed. Korean SMEs have increased their share of both exports and imports over recent decades, and this trend - for them to become the driving forces of economic growth and technological innovation - is expected to continue (Yang, 2006). Led by the Small & Medium Business Administration (SMBA), Korean SMEs play a pivotal role in national economic growth, accounting for 99.9% of all enterprises (about 3 million SMEs), 87.7% (13.1 million) of all employees, and 49.4% of total production.

Driving SME innovation is seen as crucial to boosting national innovation and economic growth, and there is a consensus that national innovation depends on firm innovativeness, in other words, their capability to introduce new processes, products and ideas (Damanpour, 1991; Hult et al., 2004). Early studies defined innovativeness from various perspectives, but it has recently been conceptualized as 'strategies and actions that the firm may undertake in order to actualize corporate orientation and goals' (Hult et al., 2004). This focus has led to a shift from a traditional mix of product and process innovation to a market-oriented strategic process. In

terms of SMEs, the basic definition is the same, but responsiveness to the changing economic and technological landscape has been further emphasized (Hausman, 2005; Drozdow et al., 1997).

In simple terms, the development of SMEs is intimately linked with the economic development of a country. But SMEs find themselves in an environment of constant technological change. The increasing pace of technological change and tough market conditions has lead companies to become more innovative.

In this respect, great attention has been paid over recent decades to issues which encourage innovation in SMEs. Despite the attention to and importance of SMEs' innovativeness, attempts to enhance their innovativeness based on understanding the realities of SMEs have been relatively neglected. While a number of studies have suggested approaches to enhance SMEs' innovativeness, they have been subject to certain limitations that stem from only considering the key determinants involved, rather than developing practical frameworks to diagnose the patterns of SMEs business development. Thus a large scale survey needs to be conducted to identify such patterns among Korean SMEs and to suggest frameworks to enhance their innovativeness. These provide the underlying motivation for this dissertation, which aims to address these matters fully. Part 1 concerns diagnosing key factors, and Part 2 is about developing practical solutions to enhance innovativeness.

1.2 Purpose

The overall purpose of this dissertation is to identify the current state of innovativeness in Korean SMEs and to suggest a methodology to enhance that innovativeness based on understanding the business dynamics of such firms. Software has been developed to semi-automate the process, thus reducing the burden of manual work. From the empirical perspective, this dissertation explores the present condition of SMEs' business development from an innovativeness perspective. From the theoretical perspective, it develops a methodological framework for enhancing their innovativeness by applying text mining methodology. The dissertation is comprised of two themes, the objectives of which are:

Theme#1 seeks to understand the changing patterns of SME innovativeness via field study in Korean SMEs. The study aims to identify the principal types of SME business model in terms of their innovativeness and explore the evolving paths of SMEs' business development.

Theme#2 aims to develop a framework to analyze technological opportunities which takes SMEs' capabilities into account, and which can be regarded as a technological exploitation framework for the companies. The framework's main function is to suggest opportunities which the company can exploit, i.e., to provide technology applications appropriate to firms' technological capabilities. A secondary function is to suggest general directions for R&D efforts that correspond to the opportunity options identified.

1.3 Scope and framework

We can define SMEs' innovativeness as ever-changing environment-responsive strategies and actions to achieve corporate goals.

A number of studies have suggested a variety of key determinants of SMEs' innovativeness, and further investigate how they affect its business and innovation performance (Hult et al., 2004; Radas et al., 2009; Voudouris et al., 2000).

From the theoretical perspective, previous studies show three deficiencies. First, there has been little focus on the systematic integration of innovation factors; second (in the same vein), there has been little focus on how the attributes of those factors change over time; third, there has been little consideration of region-specific characteristics. From the business perspective, the increasing pace of technological change and difficult market conditions have led companies to make different efforts to survive in business. Succeeding in innovation requires considerable resources – but most SMEs have few. To overcome the limitations of SMEs, the mobilization of existing internal resources is needed. This approach to enhancing an SME’s innovativeness should help promote the introduction of new products or services.

The framework suggested in this dissertation, as shown in Figure 1-1, tries to overcome these deficiencies and problem.

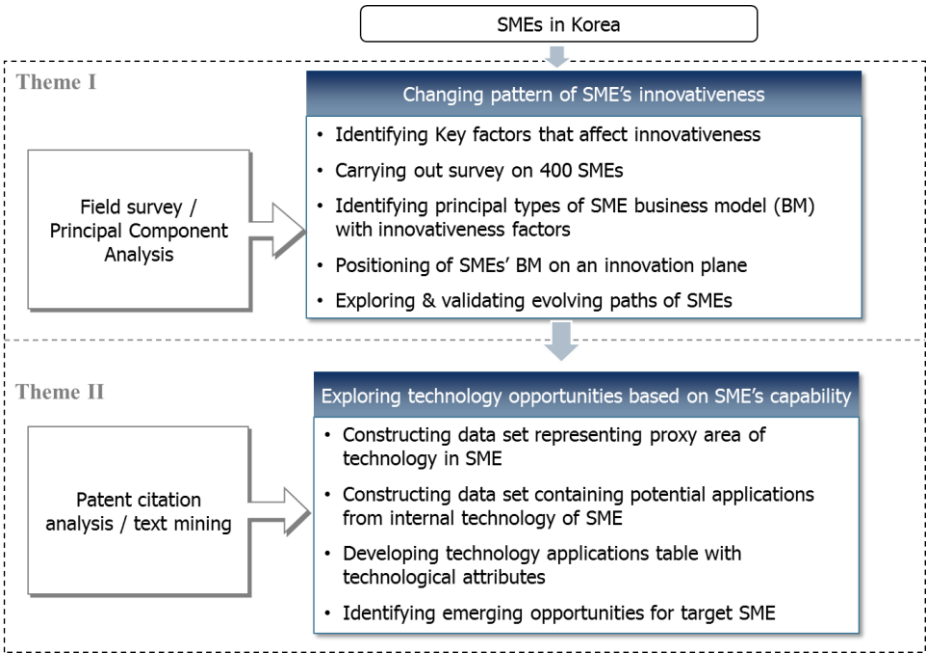


Figure 1-1 Scope and framework of the dissertation

This dissertation comprises 5 chapters encompassing the two themes discussed in Chapter 1, and is organized as follows. Chapter 2 provides the theoretical background, which covers the study of SMEs' innovativeness, and business models as a means of integrating their determinants, and the methodological background, which covers the various methodologies and tools applied in this dissertation. Chapters 3 and 4 contain the main body of the dissertation: each chapter explains its own theoretical foundation and its methodology. Chapter 5 summarizes the dissertation's conclusions, and contributions, as well as its limitations and suggestions for future research.

Chapter 2. Background

2.1 Theoretical background

2.1.1 Business Model

Recent large-scale surveys on leaders from the corporate and public sectors show that BM innovation is becoming increasingly important in practice (Pohle et al., 2006): one in three CEOs expected BM innovation to be important factor for corporate growth (Klang et al., 2010). But BM research covers a broad area of research interests, and key categories and components need to be specified and classified. Pateli and Giaglis (2004) suggest that BM research is composed of six sub-domains; 1) Definition; 2) Components; 3) Taxonomies; 4) Representations; 5) Change methodologies; and 6) Evaluation models, while Osterwalder, Pigneur and Tucci (2005) suggest three categorizations; 1) Categorization of different models which define Business Models as abstract overarching concepts encompassing all real world businesses; 2) Taxonomy identifying and categorizing different types of business models; and 3) Categorization of examples describing and conceptualizing particular real world BMs. Clearly, these can be linked to one another, and most researchers deal with more than one category.

We are interested in deriving key BM components affecting SMEs' innovativeness, and thus focus on the 'Components' research domain.

Research in this domain is concerned with analyzing the BM concept to further deconstruct it into its fundamental components (Pateli et al., 2004), which have been variously referred to as ‘functions’, ‘attributes’, ‘elements’, or ‘pillars’ (Afuah et al., 2003). Since these terms are (in effect) almost synonymous, we use the label ‘BM component’ to represent them. We collected articles on BM components from various journal databases, scrupulously excluding those whose primary focus was on other subjects, such as definitions, taxonomy, etc.

2.1.2 Innovation and SMEs

Innovation is important for structuring businesses in the most effective ways to increase their performance. Models that have been tried include those where innovation is driven by technology, which attempts to find a market, as well as those where new technology solutions have been encouraged by the market. New models have emerged that combine both these sets of principles consecutively in an iterative process that brings together an understanding of technology, a clear view of a market, and an appreciation of the business economics behind each step in the process.

In the past, the process of generating commercial innovations was considered to be confined within firms’ boundaries, but this has changed in the modern knowledge-based economy. Nowadays, a firm’s innovation emerges from its interactions and technological cooperation with other firms, universities or R&D organizations. Commercializing an innovation often

requires interaction between numerous stakeholders, including financiers, suppliers, buyers, regulators, etc., so firms are now not isolated in their innovation activities, but rather performs them in collaborative networks, and those activities are highly dependent on their external environments.

Some authors argue that SMEs are likely to have limited resources and capabilities for conducting in-house R&D activities (Hausman, 2005), weak external contacts (Srinivasan et al., 2002), and underdeveloped education and training opportunities (Romano, 1990). Public intervention has frequently been advocated to help them overcome such disadvantages (Massa et al., 2008).

2.2 Methodological background

2.2.1. Patent citation analysis

Patent information has long been regarded as a useful information source for technology management because it includes the technical, commercial, and proprietary information about a specific technology (Yoon et al., 2007). Especially, citation-based patent study has been increased over recent decades to technology and corporate management issues. The key idea behind patent citation analysis is that when a patent is highly cited then the cited paten is likely to contain important information such as technological advance, business idea, etc.

Increasingly researchers in technology management are using patent citations as an indicator of companies' innovation performance and the measurement of knowledge flows or spillovers. In previous studies, information about such elements as inventors, affiliations and technology fields were the chief means of exploring and analyzing technology development. Patent citations build technological relationships by linking the granted patents to their prior art, so serving as a means of information exchange between sciences and technologies (Narin et al., 1987). The spillover effects resulting from patent citations illustrate that they are a significant knowledge source for technological breakthroughs and product design (Jaffe et al., 2000; Duguet et al., 2005).

Patent citations include both backward citations and forward citations - backward patent citations are defined as the number of references a patent makes to prior patents, while forward patent citations are defined as the number of citations a patent receives from subsequent patents: thus patent citations have often been treated as a measure of the knowledge diffusing outward from patents.

2.2.2. Text mining

Text mining is a technique than can be used to augment existing data in databases by making unstructured text data available for analysis. There is simply too much information to read in patent documents and it is buried and often difficult to find with conventional search tools and manual

analysis (Yang et al., 2008). So text mining is often employed when dealing with patent documents, as it is one of the data mining techniques used to discover knowledge within unstructured data. The usual practice is to put sets of labels on words in documents so that discovery operations – which typically involve information retrieval, lexical analysis to study word frequency distributions, pattern recognition, tagging/annotation, information extraction, visualization, and predictive analytics - can be performed on the labels. Thus documents in text format can be categorized by keywords that are extracted through text mining algorithms (Yoon et al., 2004).

Chapter 3. Identifying innovation determinants of SMEs: Empirical analysis in Korean firms

3.1. Introduction

It is very important to understand the factors that contribute to the success of SMEs. Much research has been conducted to determine which factors affect their levels of success and innovativeness. SMEs have been regarded as important engines of economic growth and employment. Their roles in exports and imports in Korea have expanded due to recent economic development (Yang, 2006), and driving SMEs' innovation has been seen as crucial to boosting national innovation and economic growth. There is a consensus that national innovation depends on a firm's innovativeness, in other words, its capacity to introduce new processes, products, ideas, etc. (Damanpour, 1991; Hult et al., 2004). At the outset, innovativeness was defined from various perspectives, but it has recently been conceptualized as ‘strategies and actions that the firm may undertake in order to actualize corporate orientation and goals (Hult et al., 2004). The focus has shifted from a traditional mix of product and process innovation to a market-oriented strategic process. The basic definition of innovativeness is the same for SMEs, but research communities have emphasized responsiveness to the changing economic and technological landscape (Hausman, 2005; Drozdow et al., 1997). Considering these factors, we can define SMEs' innovativeness as the ever-changing environment-responsive strategies and actions they

employ to achieve their corporate goals.

A number of studies have suggested SMEs' innovativeness is subject to a variety of key determinants, and go on to investigate how those affect their business and innovation performance (Hult et al., 2004; Radas et al., 2009; Voudouris et al., 2000). Some studies try to bring together determinants in a systematic manner. Notably, Keizer, Dijkstra and Halman (2002) build a taxonomy that classifies key determinants into internal and external factors, where internal variables refer to SMEs' characteristics and the government policies that affect them, while external variables refer to all the opportunities SMEs can seize from the surrounding environment. Such external variables include 'collaboration with other firms', 'linkage with knowledge centers', 'utilizing financial resources or the use of support regulations', and so on. Recent studies have argued that collaborations with other industry players such as suppliers, business partners or customers are likely to become more important for SMEs' innovation (Birchall, Chanaron and Soderquist, 1996; Forrest, 1990; Lipparini and Sobrero, 1994; Le Blanc et al., 1997). Focusing on knowledge acquisition and sharing, some studies argue that linkages with knowledge centers which stimulate university-SME technology/knowledge transfer are also key factors, emphasizing the role of bridging institutions (Birchall, Chanaron and Soderquist, 1996; Hoffman et al, 1998). Finally, another consensus is that most SMEs have difficulty in financing, so that the availability of R&D funding, government subsidies and supporting regulations are regarded as important factors (Le Blanc et al., 1997;

Oerlemans, Meeus and Boekema, 1998).

On the other hand, internal variables include the characteristics of SMEs and government policies that affect them, and can be roughly divided into 'Strategy', 'Structure', 'Technology policy', 'Level of education' and 'Investments in R&D' categories, while typical managerial factors such as organizational structure or corporate strategy have also been studied (Freel, 2000; Kaufmann and Todtling, 2002). To mention some of these previous efforts briefly: Birchall et al. (1996) and Carrier (1994) suggest that appropriate strategies should stimulate both internal creativity and risk-taking behavior; Hoffman et al. (1998) find that strategic factors like marketing involvement contribute a lot to successful innovation; Larson, Gobeli & Grey (1991) and Meer et al. (1996), examining the relationships between management structures and innovation activities, suggest the importance of appropriate structures; Oerlemans, Meeus and Boekema (1998) argue that a firm's technology policy will have a bearing on its innovativeness; while more recently, Radas and Bozic (2009) have stressed the importance of market factors such as international market pressures.

Examining the determinants of SME innovativeness, it is notable that those which concern SMEs' structures and strategic behaviors are more responsive to external opportunities than they used to be. Although several taxonomies and concepts have been suggested, the business model (BM) is one of the most appropriate in terms of bringing them together in a systematic manner. Above all, the BM is a holistic concept, encompassing most of the above-mentioned elements to build the anatomy of a firm's core

logic for value creation and appropriation (Amit and Zott, 2001; Dubosson-Torbay, Osterwalder and Pigneur, 2002; Hedman and Kalling, 2003). Recent studies also argue that the BM is a key driver of innovation, allowing entrepreneurs to identify opportunities and thus to generate innovations (Doganova et al., 2009; Teece, 2010). Put simply, the BM is not only a system of innovation, but a way of making innovations. The BM focuses on the ability to identify, and seize opportunities from the market and technological change, which is innovativeness in itself. This means it is a better way to explain SME's innovation than some of above-mentioned elements, which is why we use the BM as a framework to explain SME innovation.

This study therefore aims to identify principal types of SMEs' BMs, to understand how they are composed, to analyze what kinds of innovation they drive, and thus to explain SMEs' innovation in terms of their BMs. An important point to note about Korean SMEs is the effect of globalization. A recent study reports that globalization has forced Korean SMEs to develop a variety of global-level capabilities, and contributed greatly to enhancing their innovativeness (Pateli, 2002). Given their saturated domestic market and the penetration of global companies, SMEs cannot help but try to compete with global market leaders. Another important element is that any company's BM must be transformed, augmented, extended or evolved if it is to sustain its competitiveness (STEPI, 2009). Considering these factors, we also try to identify several paths for developing global BMs.

3.2. Methodology

3.2.1. Research framework

The overall process of our research is shown in Figure 3-1. Categorizing Korean SMEs' BMs according to their key dimensions, we can trace their past evolution and predict their future development. Reviewing 125 previous BM studies, we extract four key BM components, and reduce those to three dimensions, which were enabled by an easy-to-understand visualization of Korean SMEs' principal BMs. A survey was made of 400 Korean SMEs to collect data about the current status of their BM components and, after processing the data, we used K-means vector clustering to identify the principal types of their BMs. Data on complementary attributes - such as types of competitive advantage and business performance - were also collected, and used to understand the differences between these principal BM types in more detail. Focusing on distinct innovativeness between these principal types, we carefully select innovativeness-relevant factors, and used PCA (principal component analysis) to reduce them to two innovation components. An innovation plane was then generated using these two components as axes, allowing the SMEs to be located on that plane. Examining the overall distribution of the four principal BM types, we predicted SMEs' key evolution paths in terms of their BM and innovativeness. To identify the real evolution paths, we conducted a second survey and in-depth interviews on 30 global SMEs selected via a literature

review, and again filtered according to whether they showed higher innovativeness on the innovation plane. These interviews enable us to identify the stages of each SMEs' BM history. Then, carrying out surveys for each stage, we are able to position the SMEs' past and present BMs on the innovation plane and, finally, to visualize their evolution paths, and thus to identify some typical paths.

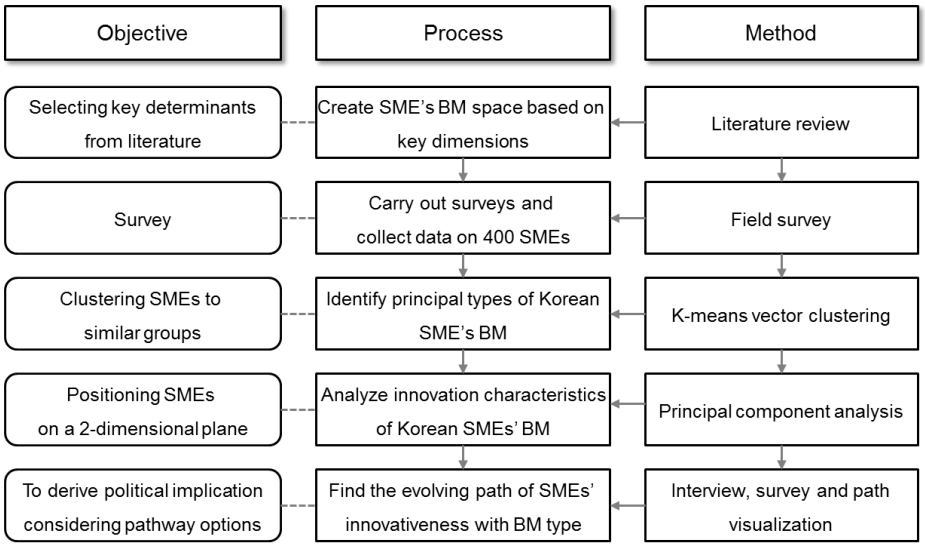


Figure 3-1 Process of the proposed research

3.3. Creation of SME's BM space

3.3.1. Selection of key BM components

Recent large-scale surveys on corporate and public sector leaders

show that BM innovation gains importance in practice (Pohle et al., 2006). One out of three CEOs said that BM innovation was important for corporate growth (Klang et al., 2010). However, it should be noted that BM research covers a broad area of research interests, and thus needs to specify key categories and components. Pateli and Giaglis (2004) suggest that BM research is composed of six sub-domains; 1) definition 2) components 3) taxonomies 4) representations 5) change methodologies and 6) evaluation models. Another view comes from Osterwalder, Pigneur and Tucci (2005). They suggest three categories; 1) a definition-meta model category which describes the BM as an abstract overarching concept encompassing all real world businesses; 2) a taxonomy of types of category identifying and structuring different types of business models and 3) an instances category describing and conceptualizing particular real world BMs. They can be linked to one another, so most researchers touch on more than one category.

We are interested in deriving key BM components affecting SMEs' innovativeness, and thus focus on the 'components' category. Research in this domain is concerned with analyzing the BM concept to further deconstruct it into its fundamental components (Pateli, 2004). BM components are usually referred to as 'functions', 'attributes', 'elements' or 'pillars' (Afuah et al., 2003). As these terms are fundamentally same, we can use the term 'BM component' to represent them. We collected articles on BM components from various journal databases, scrupulously excluding those which focused more on other subjects such as definitions, taxonomies, etc.

Reviewing 125 relevant papers, we can identify eight key BM components - mission, offering, strategy, capability, business process, value network, financing and globalization - as shown in Table 3-1. These have consistently been chosen as key components in the literature, but some have been regarded as being more important than others in various contexts (Morris et al., 2005; Shafer et al., 2005). Thus, some are important for large industry firms, but less so for SMEs – which is why ‘business process’ and ‘value network’ are excluded - and some are of little use in distinguishing certain SME's BM from others: in particular, ‘mission’ is too abstract to be used as a classification - when it is generally defined (such as ‘making a profit’) it is of little help, nor is it when a company customized definition is used. From an empirical viewpoint, the ‘financing’ component is of little use, as most Korean SMEs are under similar financial constraints, having few effective ways of financing.

Given these limitations, the four key BM components chosen to characterize Korean SMEs' BMs were: offering, strategy, capability and globalization. As previously noted, the last is the strongest influence on environmental change in Korean SMEs – the others represent different ways in which SMEs adapt themselves to respond to that influence. Thus our selection comprises both the key general BM components based on previous studies, and also reflects realities and characteristics of Korean SMEs.

Table 3-1 Key BM components

Key BM components (Literature review)	Appropriateness as discerning criteria	Key BM Components (Final selection)
Mission	Too general	
Offering	Appropriate	Offering
Strategy	Appropriate	Strategy
Capability	Appropriate	Capability
Business process	Little difference among SMEs	
Value network	Little difference among SMEs	
Financing	Little difference among SMEs	
Globalization	Appropriate	Globalization

3.3.2. Key BM dimensions

To visualize and understand the position of SMEs' BMs, it is of great help to reduce four key BM components to three dimensions. A number of studies, covering a wide array of countries and industries, have found that global SMEs' BMs are completely different from domestic SMEs', implying that globalization have forced Korean SMEs to shift to new BMs.

Thus, as previously mentioned, the degree of globalization is a key dimension representing external forces. Among internal components, strategy and capability have been regarded as key factors of innovativeness (Radas et al., 2009; Sawer et al., 2008), so the degree of innovativeness can be seen as a good integrated measure of these two BM components. Another measure of innovativeness is offering, meaning how a company delivers value to its customers. Many companies have recently expanded the scope of

their offerings, while others have shifted from manufacturing-oriented items (such as components or single products) to integrated and complex items such as product+service ‘solutions’. Driven by this trend, Korean SMEs' types of offerings have also shifted, illustrating the changes their BMs and innovativeness, which is why we chose offering as the third dimension.

So Korean SMEs’ BM spaces can be mapped according to these three key dimensions, as shown in Figure 3-2. Most domestic SMEs are characterized by low innovativeness, domestic market and component/single product, and so have kept to traditional BMs, so we can expect them to be located in the dotted inner box. However some, driven by globalization, have shift out of the box towards new BMs. Put simply, our research concerns where Korean SMEs’ BMs have moved, and how their innovativeness has changed under their new BMs.

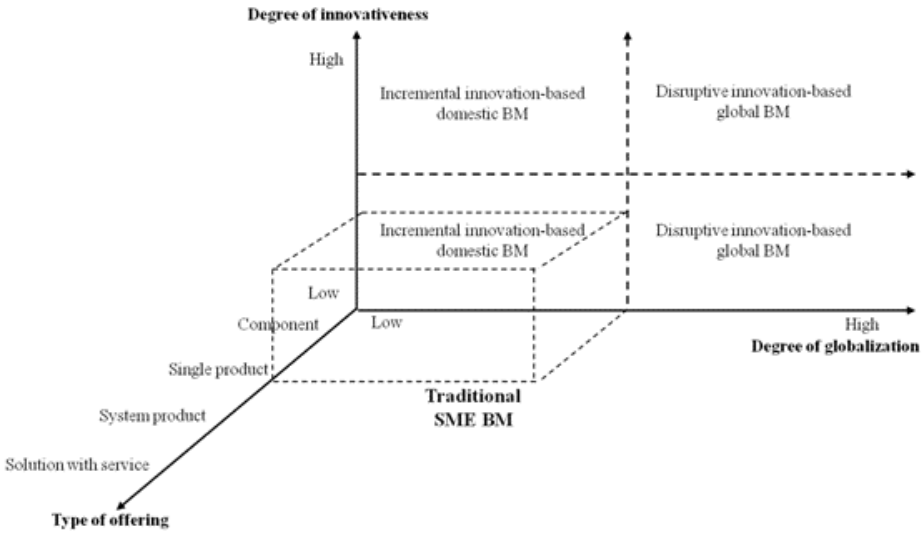


Figure 3-2 Korean SME’s BM space

3.4. Identification of principal BM types

3.4.1. Data

400 Korean SMEs are randomly chosen among 7,731 SMEs applying for the ‘New technology commercialization program’ supported by Korean Small & Medium Business Administration between 2005 and 2009. This government program aims at finding SMEs at a technology frontier, and facilitating their next-generation technology commercialization. However, the selection is based not on R&D capability but mainly on excellence of technology and commercialization potential, implying that some companies with weak R&D capability can be selected. Any capability is little biased to both ends, implying that the strength of capabilities is fairly evenly distributed. A survey is made online over four weeks, and 77% of SMEs up to 306 answered. After eliminating some responses with random or missing values, 124 usable responses were left and used.

3.4.2. Principal types of SME’s BM

In our data, SMEs have different BMs, and further belong to a wide array of industries from traditional manufacturing to emerging industries. Governmental support customized to an individual SME is ideal, but neither efficient nor practical. Thus, it is necessary to classify SMEs' BMs into

principal types based on similarity. Well-structured classification scheme of SMEs' BMs can also contribute a lot to making SME support policy more efficient and effective.

To this purpose, the first thing to do is to represent SME's BM as a vector of key BM components. Key BM components are composed of many sub-components, and thus should be broken into a set of appropriate measures. First of all, the degree of innovativeness is a good measure both of capability and strategy. As for capability, typical value chain capabilities comprising R&D, production, logistics, marketing and service are chosen. Besides these, financial and collaboration capabilities have become more and more important recently, and thus are added to the capability category. Following a generic strategy scheme by Porter (1985), we choose four strategies; 1) low cost 2) differentiation 3) focus-1 (low-cost) and 4) focus-2 (quality). Notably, Korean SMEs argue that market innovation strategy has become crucial (SMBA, 2010). Thus, it is necessary to measure innovativeness of market strategies as well as that of generic strategies. Through a preliminary survey, we can identify four types of market innovation strategies; 1) new market development 2) niche-1 (customer) 3) niche-2 (region) and 4) collaborative market development. SMEs sticking to a domestic market fall under the niche-2 (region), but those trying to penetrate into an overseas market even with a single product belong to the niche-1 (customer). Collaborative market development covers any type of collaboration for market penetration or expansion regardless of the size, nationality and others of partners.

The influence of globalization can be measured by the degree of SMEs' responsiveness. Measures are speed and scope of globalization. Put simply, the stronger the external force of globalization is, the broader and faster SME's way of globalization is. The speed is measured by the time taken to SME's first export, the scope by the number of countries SME exports. As mentioned earlier, type of offering is classified into four types comprising 1) component 2) single product 3) system product and 4) solution with service. On the survey, each SME is asked of scoring the innovativeness of capability, generics strategy and market strategy, and also the scope and speed of globalization by 5-likert scales. Type of offering is measured on a binary scale where types of offering accounting for major shares are marked by 1, and others are by 0. Multiple marks over four types are allowed such as (1, 1, 1, 0). Put these scores together, we construct SME's BM vector as shown in Figure 3-3.

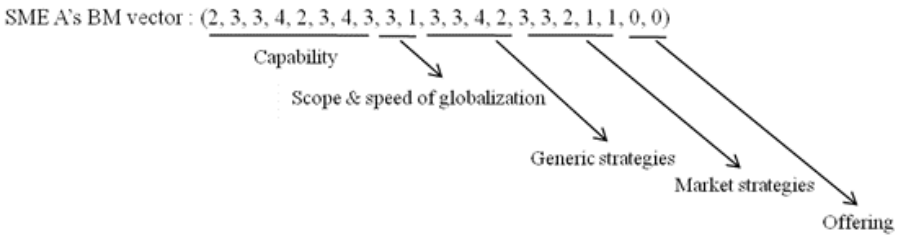


Figure 3-3 An example of SME BM vector

With 124 SMEs' BM vectors, K-means vector clustering allows us to group similar BMs. Considering expected strong correlation among vector components, we use Mahalanobis distance measure. The ratio of inter-group

variance to intra-group variance is maximized when four clusters are formed, implying that there should be four principal types of Korean SME's BMs.

Table 3-2 shows four principal types of BMs with the average score of lowest-scoring measures over four key BM components and of the number of responses in the offering.

Table 3-2 Characteristics of four principal BMs

BM type	N	Capability*	Strategy		Globaliza-tion**	Offering ***
			Generic*	Market*		
Global champion	12	R&D (1.2) Marketing(1.6) Production(1.8)	Differentiation (1.2) Focus-2 (1.8)	New(1.0)	Speed(1.2) Scope(1.8)	Component (2.4) Product(2.6)
Focused R&D	23	R&D(1.4) Production(2.2)	Focus-1(1.2) Differentiation (3.1)	Niche-1(1.6) Collaboration (2.2)	Speed(1.8) Scope(2.2)	Component (2.8) Product(2.9)
Global niche market	25	R&D(2.4) Production(1.6)	Focus-2(1.6) Low cost (2.2)	Niche-1(1.4) New(3.2)	Speed(2.4) Scope(2.8)	Component (2.2) Product(2.4)
Global infant	64	R&D(3.3) Network(3.5)	Low cost (1.7) Focus-1(2.8) Focus-2(3.7)	Niche-2(1.8) Niche-1(3.8) New(4.0)	Speed(3.9) Scope(4.2)	Component (3.2) Product(2.2)

*: average innovativeness score (1: very innovative, 2: innovative, 3: average, 4: poor, 5: very poor)

**: average score (1: very fast/very broad, 2: fast/broad, 3: average, 4: slow, 6: very slow/narrow)

***: the number of responses

Except for offering, the lower the score is, the more a company is innovative and globalized. However, high score in a type of offering means that many companies regard that type as being more important than others. N denotes the number of SMEs in each BM type. One thing to note is that types of offering do not vary by BMs against our expectation. Most Korean SMEs do not make a shift to new offerings such as system/solution products, and still remain component/single product manufacturers.

Table 3-3 shows the four BMs' characteristics by dominant innovativeness factors.

Table 3-3 Characteristics of four principal BM type

BM type	**Characteristics**
Global champion BM	High-speed globalization, focusing New market development, well-balanced capability
Focused R&D BM	Strong R&D capability, concentrating on Focus-1(low-cost) strategy & customer-oriented market strategy
Global niche market BM	Strong production capability, Concentrating on customer-oriented market strategy
Global infant BM	Stick to domestic market segment (Niche-2 strategy), concentrating on low-cost strategy, overall weak innovativeness

Looking into four principal BMs in more detail, the global champion BM is characterized both by high-speed globalization and well-balanced capability. In this category, SMEs have consistently recorded financial performance such as sales and profits far better than others, and have recently been focusing on new market development to keep the high growth rate more than 20% on average. However, it should be noted that some SMEs with the same BM have not developed any differentiated product or service, and thus cannot help depending on competitive edges from high quality/low cost products. To the contrary, almost half of SMEs stick to a small but safe domestic market segment, and does not have any motivation to innovate. Global infant BM shows such SME's inertia without any innovation, having neither superior capability nor concrete strategy. Almost same number of firms are on the way of globalization, but can be divided into two BMs. SMEs with focused R&D BM concentrate heavily on R&D, and challenge global players with next-generation technology and well-established high-quality production process. They tend to focus on the narrow range of products, and make alliances with foreign distributors due to weak global market presence. Other SMEs get a safe way, and pursue global niche market BM. Capability development is not lopsided but fairly even. They aim at not surpassing global leaders based on technological innovation but catching up with them by doing reverse engineering, developing all innovation capabilities incrementally and building the complete lineup of products. Competitive advantages come from same quality/low cost with little vulnerability. It is no wonder that those SMEs do not have any new-to-

the-world product. Put simply, both BMs are in common driven by globalization. However, the former is a typical high risk-high return BM to seize highly challenging future R&D opportunities. To avoid the high risk, the latter takes advantages of high quality production at a lower cost.

Characteristics of four BMs imply that there might be several evolving paths of SME's globalization along with the changing BM and innovation focus. Globalization seem to force SMEs from global infant BM to either focused R&D or global niche market BM. Accelerated globalization has boosted innovation, making some SMEs develop far better innovation strategies and capabilities than those of global infants. However, others are under threatening conditions because competitiveness builds on cost performance rather than on differentiation. A few SMEs pursuing differentiation are exposed to high R&D risk. Once they fail, most cannot turn around due to severe financial loss. Considering these, it might be rare that SMEs reach up to the global champion BM without above-mentioned transitional BMs.

3.5. Changing pattern of SME’s BM and innovativeness

3.5.1. Positioning of SMEs’ BMs on an innovation plane

Although we can guess the evolving paths of Korean SME's BM driven by globalization, the changing pattern of innovativeness is neither obvious nor supported by evidences. To make it clear, it is all about how

innovativeness of SME's BM is measured. It is necessary to visualize the position of each SME in terms of innovativeness let alone its intensity. Analytically, the simplest way is to estimate the regression coefficients of a specific BM component such as R&D capability by using a multiple regression, but those are likely to be biased much due to severe multicollinearity among BM components. For instance, marketing capability is likely to be correlated strongly with market innovation. Thus, it is necessary to reduce BM components into a smaller number of independent, at the very least, or little correlated components. Employing PCA, we can transform 17 BM measures into two principal components. Type of offering is excluded because it does not vary significantly over four types of BMs. As shown in Table 3-4, two principal components account for 78.48% of total variances in all BM measures, implying that those could be good representatives. Both KMO (Kaiser–Meyer–Olkin) measure (0.747) and Bartlett's test of sphericity (459.639 with significance 0.00) confirm the adequacy of data for PCA. Put simply, two principal components can be used to quantify the innovative position of SMEs.

Table 3-4 Total variances explained by principal components

Component	Extraction sums and squared loadings		
	Total	% of variance	Cumulative %
1	9.59	56.43	56.43
2	3.75	22.05	78.48
3	0.671	3.95	82.43

To understand two innovation components in more detail, we look into the composition of each principal component. As shown in Table 3-5, the first component is characterized by strong R&D and marketing capability, wide and rapid globalization, differentiation-oriented strategy and focused but continuous market innovation. Contrastingly, the second component is a combination of relatively strong production capability, low cost strategy and niche market innovation. Considering characteristics of Korean SME's four BM types, Christensen's innovation theory provides us with a good way of labeling two components (Christensen et al., 1995). The first component represents a typical of innovation, implying that SMEs focus on either technological or marketing innovation, and penetrate into new global markets broadly and rapidly. To the opposite, many SMEs pursuing improvement based on existing capability and strategy can be described well by the second component.

Innovation orientation can be defined in terms of technological superiority. For example, a firm pursuing innovation orientation means that it devotes their energy toward inventing and refining superior products. This conceptualization consists of both openness to innovation and a capacity to innovate (Berthon et al., 1999; Siguaw et al., 2006). Put simply, innovation orientation is generally considered an intentional and calculated plan or strategic intent that provides direction toward an organization-wide commitment to more and faster innovations (Worren et al., 2002). On the other hand, improvement orientation is understood as intent to just meet the market standard or to react to innovation that other competitors have already

introduced into the market. It may give a competitive advantage but also can be easily copied by other competitors.

Table 3-5 Component matrix of two principal components

Component	Principal components (factors)	
	Innovation orientation	Improvement orientation
R&D	0.74	0.25
Production	0.32	0.33
Logistics	0.12	0.23
Marketing	0.59	-0.05
Financing	0.53	0.41
Service	-0.08	-0.29
Collaboration	0.12	-0.12
Globalization (speed)	0.65	0.08
Globalization(scope)	0.39	0.13
Low cost	-0.06	0.35
Differentiation	0.86	-0.02
Focus-1(low-cost)	0.20	0.25
Focus-2 (quality)	0.28	0.08
New Market	0.47	-0.05
Niche-1(customer)	0.63	0.25
Niche-2 (region)	-0.07	0.34
Collaborative market innovation	-0.38	-0.11

With two principal components, we can position 124 Korean SMEs on the plane shown in Figure 3-4. You can easily recognize that the x axis should represent the component of improvement orientation and y axis

should do the component of innovation orientation. To create the plane, the factor loading values of two components are used as x–y coordinates of SMEs. The level of globalization is calculated by taking the average of globalization speed and scope scores, and can be represented as an isoquant.

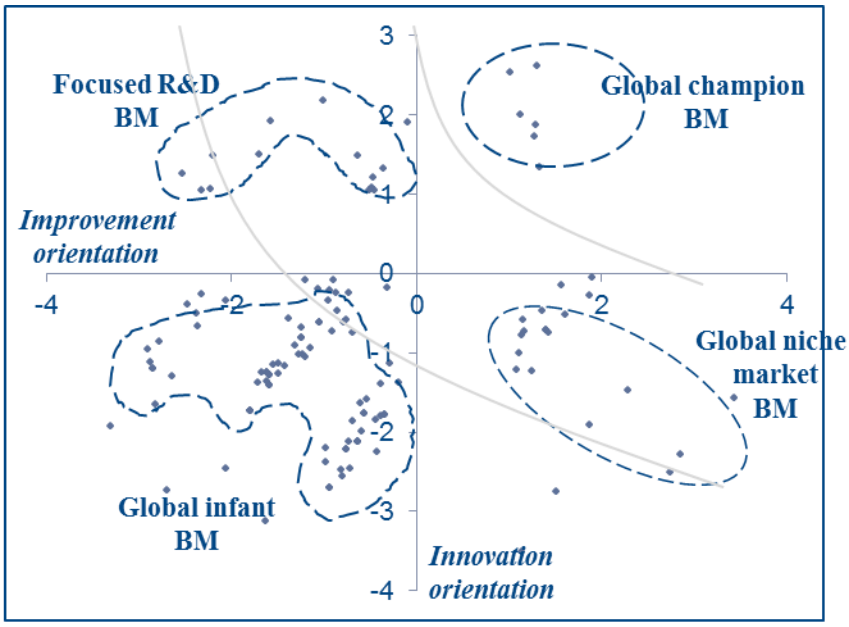


Figure 3-4 Korean SMEs on the 2-dimensional plane

The value 1.9 is the mean value of the upper-right isoquant enveloping 12 global champions, and the value 3.6 is that of the lower-left isoquant between the area of global infant BM and that of two transitional BMs.

The global champion BM is usually characterized by highest innovation orientation and good improvement orientation. Those already enter into a virtuous circle of innovation and growth. However, some SMEs

have below-average improvement oriented capability, and can be vulnerable to either rapid market growth or the challenge by same quality–low cost competitors. Contrastingly, a half of SMEs falls under the region of the global infant BM, roughly the third quadrant in Figure 3-4, meaning that these SMEs have very poor innovation or improvement oriented capability locked in a small domestic market. Look over the distribution of these global infant SMEs which can be divided into four groups below the lower isoquant. The first group is located in the lower-right area, showing relative concentration on improvement of offerings. The second in the central region is pushing both innovation and improvement simultaneously. The third in the upper-left area has poor improvement oriented capability, but focuses narrowly on innovation. The fourth group in lower-left is not willing to push any innovation or improvement. Put simply, there might be three ways of developing innovation or improvement capability to become a global champion, which are shown in Figure 3-5.

However, the distribution of two transitional BMs implies explicitly that the probability of success should vary by three groups. Some SMEs develop a focused R&D BM, pursue innovation, and accelerate toward the global champion BM. Reviewing the history of 12 global champions, we find four SMEs along this path. Behind the glittering success, the small number of SMEs scattered in the region of focused R&D BM shows the difficulty to cut through this area.

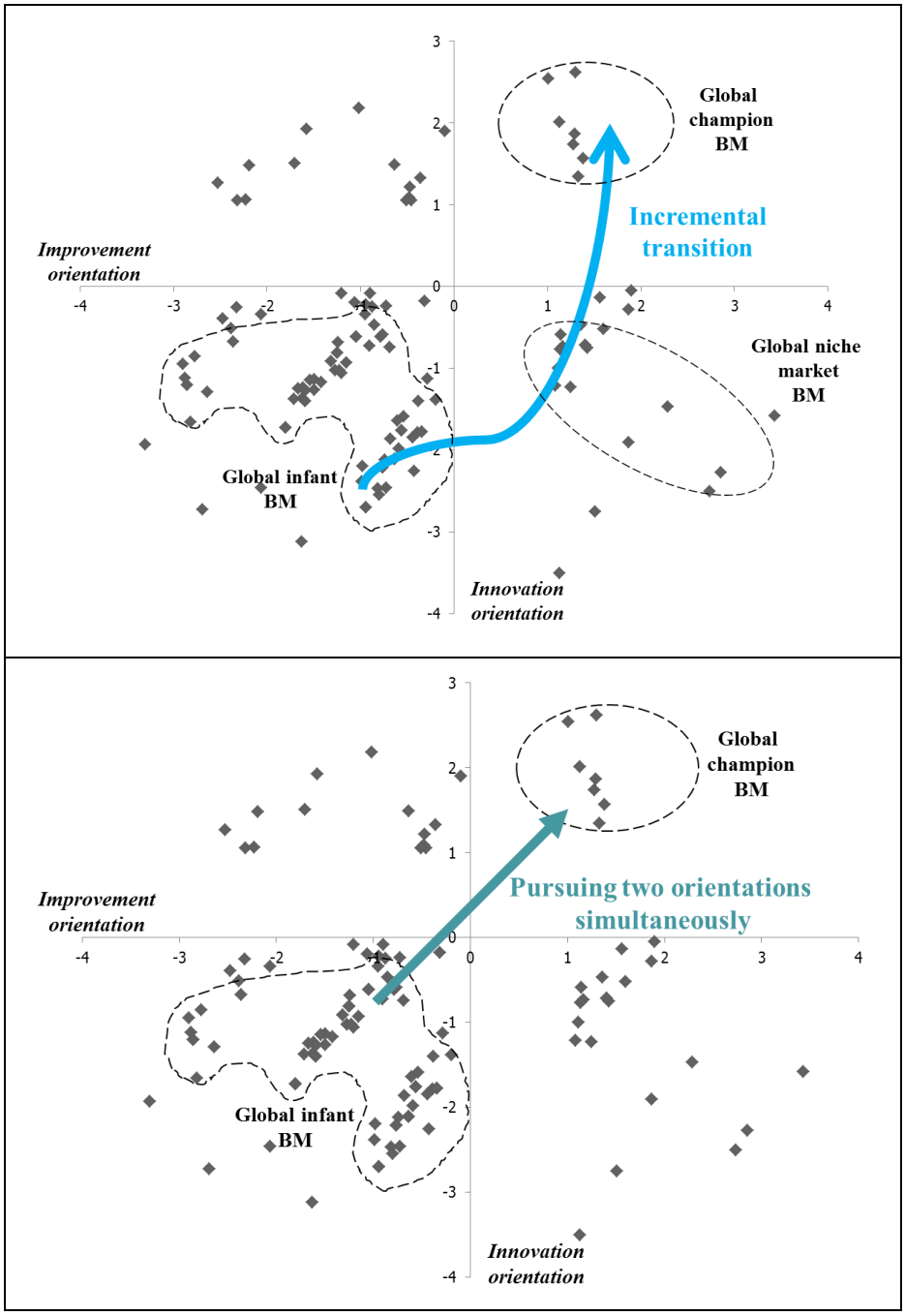


Figure 3-5 Three ways of developing innovativeness by BM type

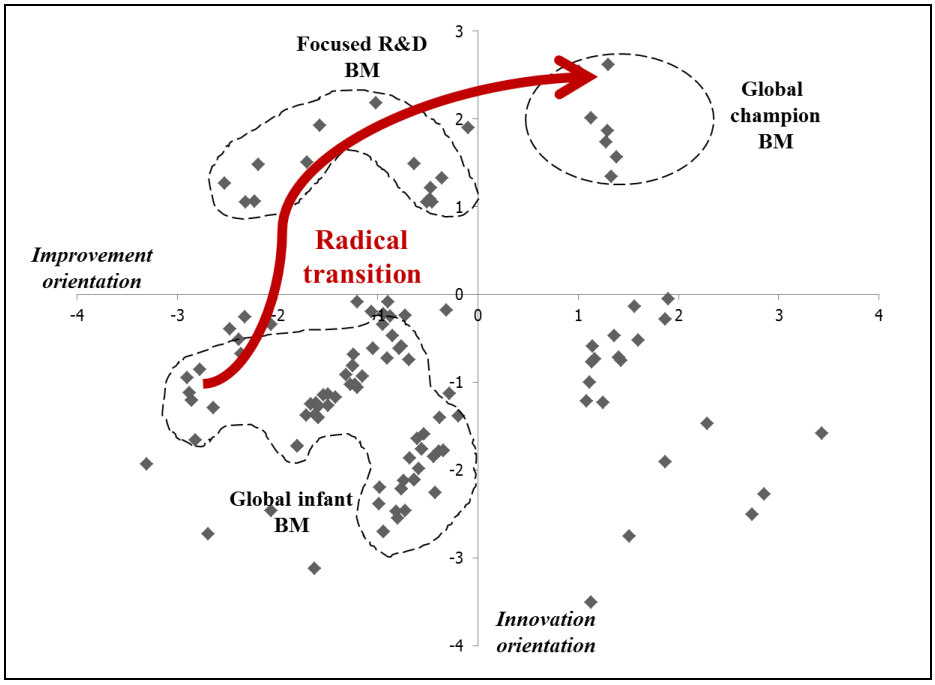


Figure 3-6 Three ways of developing innovativeness by BM type (continued)

This is mainly due to the high risk involved in any radical technological innovation process. To avoid the risk, other SMEs take another way, and are making a gradual shift to the global champion BM. They usually choose the global niche market BM, and push continuous improvement in business. Seven global champions have taken this path, and provide us with some evidences of low risk and high success probability.

Put these together, the evolving paths of Korean SMEs are, at the very least, more than two. The radical transition path starts from the global infant BM, passes through the focused R&D BM by boosting innovation, and ends in the global champion BM. Along the incremental transition path,

global infant SMEs develop improvement oriented capability gradually, and emerge as a leading firm in a global niche market BM and land softly at the global champion BM area. The latter takes more time to become a global player, but takes an advantage of less risk than the former. Some SMEs aim at developing both capabilities simultaneously. However, it took so much time and investment that they rarely cut through the area of transitional BMs. We can find only one global champion to follow this way of innovation. However, above-described evolving paths are just presumptive, and thus should be supported by solid evidences.

3.5.2. Explorations of SMEs' evolving paths

As noted in the previous section, two evolving paths are presumed, but cannot be validated by our cross-sectional data. Overcoming this limitation as possible as we can, we try to tracing the historical evolving paths of SMEs with global champion BMs on the 2-dimensional plane, and compare their actual paths with those presumed. However, there are several unavoidable problems. Above all, with only 12 samples, it is too small to get an unbiased distribution. To overcome this, reviewing several reports and lists on the best Korean globalized SMEs, we add 18 new SMEs which are likely to have global champion BMs (SMBA, 2010; STEPI. 2009; Korea Chamber of commerce & industry, 2009). It should be noted that only 12 global BMs are identified through a survey on 400 SMEs. It is difficult to find above-three digit numbers of SMEs without a large-scale survey.

Another problem comes from data structure. To identify paths accurately, annual discrete time-series data are ideal, but had better not being collected because of expected inaccuracy. As an alternative, a snap-shot approach is chosen. Through an interview, the history of each SME is divided into two or three distinctive periods between which the difference of BM is clearest. Then, a same survey on the BM is made per each period of every SME, enabling us to position SMEs of past periods on the plane.

As shown in Figure 3-6, 28 SMEs are proven to have global champion BMs, and thus are projected in the upper-right quadrant. Two SMEs are excluded because those should remain global niche market BMs yet. Note that points in the first quadrant represent current SMEs and other points to those in the last period. As presumed, two evolving paths are easily recognized, accounting for the changing BMs of 20 SMEs.

Seven SMEs make a radical transition from focused R&D BM to global champion BM, crossing the border from the upper-left to the upper-right quadrant. One thing to note is that the movement should be twofold. Among those, four SMEs move upward to the right, boosting both types, i.e. developing capabilities relating innovation orientation and improvement orientation. Meanwhile, three SMEs show a downward movement to the right, focusing on improvement capabilities with decreasing innovation capabilities. Figure 3-7 shows the detailed evolving paths of seven SMEs, respectively.

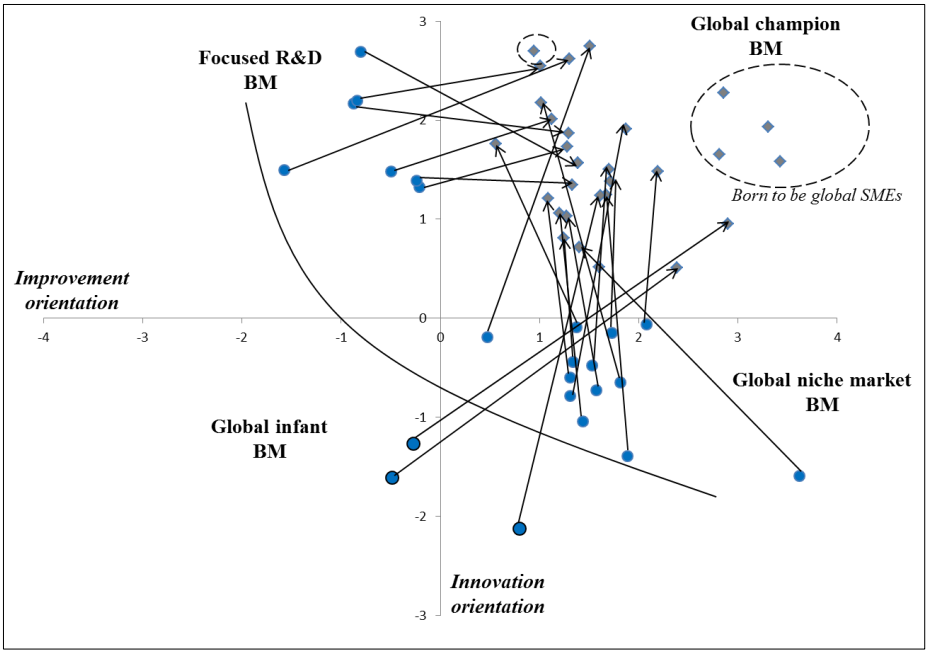


Figure 3-7 Evolving paths of Korean SMEs on the plane

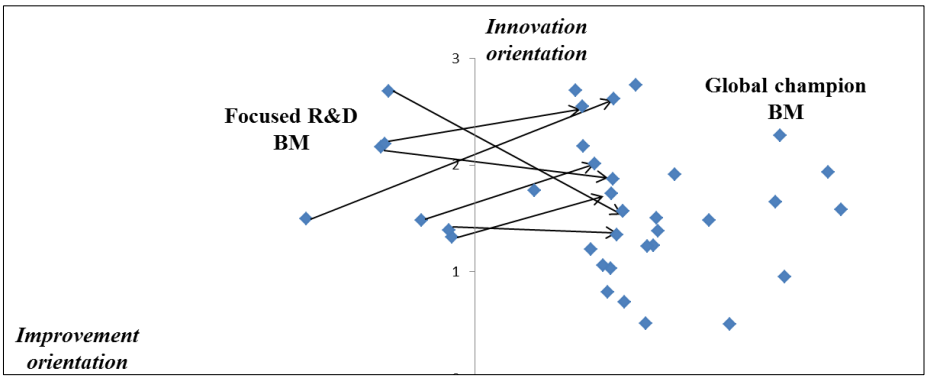


Figure 3-8 Historical tracking of SMEs on radical transition – snapshot of 2nd to 3rd period

Also as expected, 13 SMEs almost accounting for 50% of 28 SMEs make an incremental transition from the global niche market BM to the

global champion BM, moving upward from the lower-right to the upper-right. It is notable that these SMEs should move just a bit horizontally as shown in Figure 3-8. In other words, those SMEs concentrate on innovation with little regard to product/service improvement.

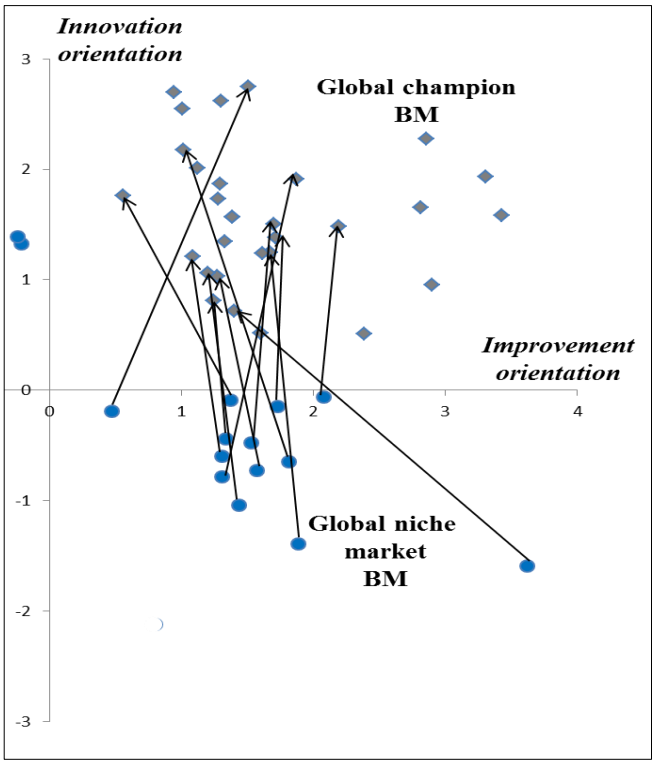


Figure 3-9 Historical tracking of SMEs on incremental transition – snapshot of 2nd to 3rd period

Not surprisingly, all of these 20 SMEs start from global infant BM at the outset even if each group is on a different track afterwards. Considering these, suffice it to say that there should be two evolving paths of SMEs. The first path is from the global infant through the focused R&D

finally to the global champion, the second is through the global niche market with the same starting and ending points.

Besides these gradual paths, two paths, characterized by a rapid change, are identified. Surprisingly, three SMEs shown in the lower-left region had remained global infants for more than several decades, but became global champions, at most, within five years. These SMEs hold in common strong ties with multinational giants, and are likely to become global rapidly mainly due to close collaboration with those. Although the number of samples is too small to argue as such, this leapfrogging path is much likely to exist, and is worthy of investigation as a way of globalization. Final path has consistently been emphasized as a rare but effective way of SME's rapid globalization, and thus is called ‘born-to-be global’ (Moen et al. 2002). Shown within two circles in the upper-right quadrant, five SMEs build the global champion BM within three years, recording an eye-popping speed of globalization. Moreover, four of those have better overall innovation capabilities than others, implying that this is a way both of effective and efficient globalization as well as innovation. Figure 3-9 shows these paths.

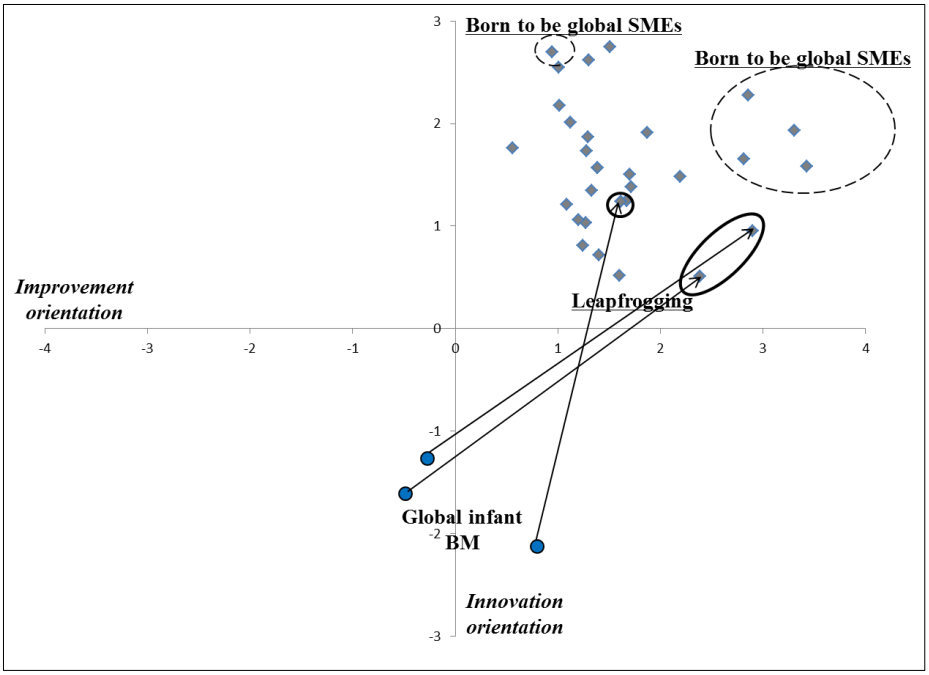


Figure 3-10 Newly identified evolving paths through historical tracking

So far, as shown in Table 3-6, four evolving paths of Korean SMEs can be identified to boost innovation and globalization. Although the sample size is small, SMEs more than 70% take a gradual evolving path, making existing core capabilities stronger. Note that gradual paths are twofold. To catch up with leaders, some SMEs focus on R&D, develop a next-generation technology, and boost radical innovation. With this typical high-risk/high-return strategy, these SMEs take the radical transition path. The second path is also in nature gradual, but is characterized by incremental innovation, low risk and much time taken. On this incremental transition path, SMEs push incremental innovation, strengthen all the capabilities gradually, and compete with leaders with same quality and low cost. Whatever path a SME take, to

build a global champion BM, it should be equipped with both innovation capabilities beyond a certain threshold. That is why SMEs on the radical transition path develop incremental innovation capabilities at the last stage. Similar is the movement of SMEs on the incremental innovation path. About 30% of SMEs go through a sudden change along two other paths. The leapfrogging path seems to make SMEs jump from a domestic player to a global player. Another is the born-to-be-global path along which SMEs build the global champion BM without any prior BM. The changing speed is extremely high, usually within five years.

Table 3-6 Four evolving paths of Korea SMEs

Path	# of SMEs	BM per a period		
		1st period	2nd period	Final period
Radical transition	7	Global infant	Focused R&D	Global champion
Incremental transition	13	Global infant	Global niche market	Global champion
Leapfrogging	3	Global infant	None	Global champion
Born-to-be-global	5	None	None	Global champion

3.6. Conclusion

SME's innovation is crucial for the economic growth of any country, and it is evident that innovation depends on innovativeness. SMEs' innovativeness has been investigated on the assumption that some key factors must exist, and a number of studies have tackled this issue, identifying both internal and external factors. However, most research merely lists these factors, but does not integrate them into a system where their roles and intensity factors become evident. Considering both conceptual comprehensiveness and flexibility, we adopt the BM concept, select key BM components, reduce them to three dimensions and create the BM space for Korean SMEs. Then, Korean SMEs are surveyed and the results analyzed, which allows us to identify four principal types of SME's BMs, and understand how each is characterized by key BM components such as capabilities, strategies and responsiveness to globalization. Further, through an additional survey on 30 global SMEs for snap-shot comparison, past and present SMEs are projected on the innovation plane, enabling us to identify four evolving paths of SMEs.

Analytic results support the idea that globalization has forced SMEs' BMs to evolve according to specific patterns of changing innovativeness. Many are struggling to get out of the domestic market, and so stick to an infant global BM, with no global competitiveness. In contrast, some SMEs respond actively to globalization, and develop new BMs. Despite high risk, some SMEs boost radical innovation, led by R&D-oriented strategies. Half

make efforts to minimize the risk, and concentrate on improvement-oriented strategies focusing on a mix of low cost and high quality: in contrast to these gradual paths, a small number undertake sudden change. Born-to-be global SMEs aim at becoming global SMEs from the outset by actively developing both innovation capabilities. Finally, there is a path along which SMEs jump straight from being domestic to global players.

As industry giants face growth limitations, many countries such as Korea regard SMEs as their new growth engines, and establish various policies to increase their number of leading global SMEs. With no systematic guide of SMEs' evolution towards globalization – and given their uneven R&D funding - the effectiveness and efficiency of government policies towards SMEs will always be in doubt. Our study can thus serve as a semi-customized policy tool for SMEs with different types of BMs, and so contribute to improving government SME policies, as well as guiding policymakers in identifying the most appropriate ways to support SMEs which have different BMs (as shown in Table 3-7).

SMEs with infant global BMs cannot decide which way to push because they have little knowledge about global markets and competitors. A policy program to collect such information and guide them as to how to develop fundamental capabilities would be of great help. SMEs wanting to pursue innovation usually suffer from shortages of R&D investment, so need to be able to access adequate public R&D funding. Even when their R&D efforts are sufficient, their weak marketing capabilities may mean they also need government support to develop foreign markets. SMEs focusing on

incremental innovation also need ongoing support, because their innovation efforts take more time than others to mature: lack of or breaks in government support are likely to hurt them more than others. Our framework can also act as a strategic tool for SMEs, giving them a prognosis on both their current innovative positions and their BMs, so helping them find the most appropriate strategic paths to both globalization and new BM development.

Table 3-7 Support policy directions by BM characteristics

BM type	Implications	Support policy directions considering their innovativeness
Global infant BM	–Needs to decide which path to push –Insufficient foreign market information	–Policy programs to support target market /competitor information –Programs to enhance basic capability
Focused R&D BM	–Taking on radical transition path –R&D investment shortage –Weak marketing capability	–Public R&D funding –Policy support for market penetration
Global niche market BM	–Taking on incremental transition path –Weak differentiation, new market strategy –Long time to create incremental innovation	–Consistent support program –Policy support for product quality improvement –Policy support for new market development

The financial support programs run by SMBA (Small and Medium Business Administration) in Korea have a tendency to consider fairness rather than effectiveness. Support is offered for programs for entrepreneurship, human resources, finance, marketing, technology and micro-enterprises but, looked at as a portfolio, they are neither differentiated by business development stage nor customized according to such SME characteristics as innovativeness. Such programs require more customer orientation and integration to improve their effectiveness, and a more developed indirect (non-financial) support policy (as well as direct financial support programs) is needed to enhance innovativeness. As noted above, financial support for SMEs is not the fundamental solution needed to enhancing their capabilities - non-financial support which meets their needs - such as information about market, competitors or new business opportunities - can be of great help in developing SMEs.

Despite the value of our findings, our study has several limitations, which indicate potential directions for further studies. First and foremost, we do not examine the causal relationship between BM components, and thus can predict neither synergies nor conflicts between them which might arise when investments are made into certain components. Generally facing budget constraints, SMEs are eager to maximize return on their investments, so the identification of such causal relationships could contribute much to enhancing the value of our approach. Another problem comes from industry differences: developing R&D capabilities is likely to vary across industries, so guidance for developing new BMs needs to be customized to specific

industries. Last, but not least, in terms of its data and methodology, this study faces biased sample problems in terms of sample size, selection, etc., nor does its time-series data enable the examination of SMEs' historical evolution paths at acceptable levels of granularity.

Chapter 4. Enhancing innovation capabilities of SMEs: A framework for discovering emerging opportunities

4.1 Introduction

In developed countries, small and medium sized enterprises (SMEs) account for the vast majority of firms and a large share of the gross domestic product (GDP). SMEs in the United States account for approximately 50% of private non-agricultural GDP and employ roughly half the non-farm private sector workers. In the EU, two out of every three jobs, and 58.6 % of value added within the non-financial business economy, come from SMEs. In the case of Korea, SMEs definitely play an even more pivotal role in the economy, accounting for 99.9% of all enterprises and 87.7% of all employees.

Overall, the development of SMEs is intimately linked with the economic development of a country. But SMEs find themselves in an environment of constant technological change, the increasing pace of which, combined with tough market conditions, force them to make other attempts to survive in business. Thus the exploration and exploitation of emerging market/technology opportunities has gained ever-greater importance in ensuring firms' survival and continuous growth.

The first step for SMEs seeking to profit from emerging opportunities begins with identifying technology developments or emerging

technologies related to their business areas, and the second is to identify and seize emerging opportunities. New and developing technologies can offer rich sources of technological and market opportunities for some firms, but may also threaten others (Srinivasan, 2008).

Studies on emerging technologies have developed from various perspectives. Some have identified them by using expert judgment, and this kind of research has also been used to validate emerging technologies from among candidates suggested by domain experts (Daim, 2006; Valk et al., 2009). Bengisu & Nekhili (2006) identified emerging technologies in the machine and materials category by analyzing the growth curves of 20 candidate technologies suggested by experts, and used frequency of patent registration and publications to evaluate them.

Several studies over the past decade have focused on bibliometric methodologies to predict emerging technologies (Smalheiser, 2001; Shibata et al., 2008; Lee et al., 2009). Kostoff (2001) suggested an approach that integrates citation bibliometrics with text mining, and other studies have combined patent data with other methodologies, such as topology and social networks (Shibata et al., 2008; Lee et al., 2010). For example, Shibata et al. (2008) used the patent citation approach to conduct comparative research on two technology domains. Lee et al. (2009) suggested a framework using the patent map approach: keyword vectors were extracted from patent sets to visualize a patent map, and PCA was applied to generate a 2-dimensional keyword based patent map. Empty areas surrounded by patent clusters on the patent map could then be defined as ‘technological opportunity areas’, and

the surrounding clusters' characteristics used as pointers to indicate the likely opportunities.

Despite the rise in the numbers of studies on emerging technology, many of them have been focused at the national or industry levels, rather than the firm level, and have tended to consider radical emerging rather than incremental technologies - and little research in this area has considered the characteristics of SMEs. Some authors argue that SMEs have limited resources and capabilities with which to conduct R&D (Hausman, 2005; Massa et al., 2008), so emerging technologies for SMEs should be considered in the light of these limitations, implying that SMEs' possible development paths should be considered as being based on limited technological capabilities

From a resource based perspective, the exploration of opportunity is often considered as a primary strategy generally adopted by companies. Silverman (1999) empirically proved that firms' diversification is highly relative to their technological resources, so the main object of this study is to propose a systemic framework to discover emerging opportunities based on SMEs' technological capabilities. The rest of this research is organized as follows. First, it is imperative to clarify what we mean when we talk about emerging technologies for SMEs, so this question is addressed in section 4.2. Section 4.3 introduces the research framework, tools and the data used. Section 4.4 and 4.5 present the analysis results and conclusions, respectively.

4.2. Emerging technology for SME

Srinivasan (2008) defined technology as a set of discipline-based skills that are applied to particular products and markets. Emerging technologies refer to those with the potential to lead to science-based innovation, and thus to create new industries or to transform existing ones. Emerging technologies include radical technologies that emerge from new scientific discoveries, and incremental technologies that follow from the convergence of existing technologies (Day and Schoemaker, 2000).

From a resource based perspective, SMEs are regarded as companies with limited human/financial/technological resources (which are crucial to innovation), that have low productivity, and have low R&D capacity compared to their production capacity. These limitations must be taken into account when defining emerging technology for SMEs, so the techniques for deriving emerging technologies for SMEs should differ from such analyses at national or industry levels. And the process should also differ from those employed with large enterprises, which place more emphasis on emerging areas with high growth potential.

Putting these considerations together, we operationalize ‘emerging technologies for SMEs’ as those which are useful for developing new products or services, to make new businesses or transform existing businesses, but within their limited resources, and which can maximize the probability of success for companies seeking to penetrate ‘new’ markets. Types of emerging opportunity and their technology-product relationships

can be conceptually depicted as in Figure 4-1.

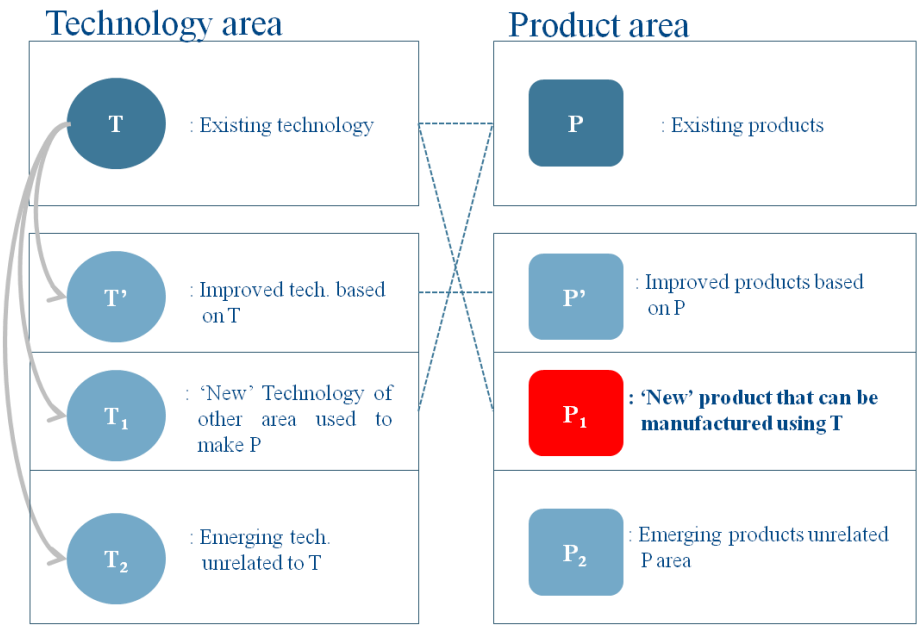


Figure 4-1 Types of emerging opportunity in technology/product area

If T represents an existing technology and P existing products, improved technologies and products can be shown as T' and P', respectively. Improved products (P') refers to those with performance improvements compared to existing products, or with reduced production costs through manufacturing process improvements. Technologies from other technology areas (T_1), which can make products for the same uses as existing ones, but better, or more effectively or cheaply, can be seen as 'emerging technologies' because they have the potential to secure producers a competitive advantage

in price or quality by technology substitution. Technologies which are unrelated to those in the company's existing portfolio (T_2) are the most common type of 'emerging technologies' found in national and industry level technology foresight exercises.

Product areas can be understood in the same manner. New products (P_1) that can be manufactured with existing technologies T (or with only minor R&D activity) represent the principal area that SMEs need to investigate because they can generate new profits without additional technological capacity. New Products (P_2) unrelated to existing products in their categories have similar implication to T_2. Our study is concerned with exploring the P_1 area of the framework, and identifying the technologies needed to develop such new products.

4.3. Methodology

4.3.1. Research Framework

Figure 4-2 illustrates the overall process of our research. The technology applications of specific firms are identified in this process, and can be regarded as emerging opportunities. The first step in this analysis is to construct patent data sets including the potential technology applications for those firms, and semantic text mining is used to identify emerging opportunities for applying those technologies. The framework summarizes the objectives, processes and methods of the different steps involved.

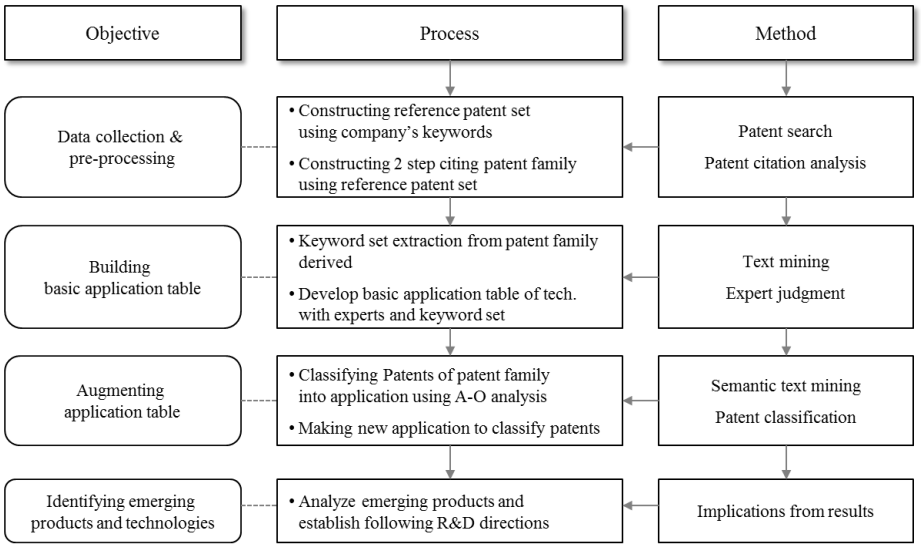


Figure 4-2 Overall process of the proposed research

The methodology used should meet the following conditions to achieve the research goals outlined in 4.1. Firstly, the data set should include technology application(s) on the basis of target company's internal technology capabilities. Secondly, the technology application(s) should derive explicitly from data set. Thirdly, the methodology can be used to prioritize the technology applications so as to choose from among candidate emerging opportunities. The methodologies are explained in the following section.

Table 4-1 show the programs used in this research. Those used in data collection are based on Java and are used to collect patent documents: those used in table augmentation are based on Python, C# and are used to analyze patent documents' contents.

Table 4-1 Programs for each process

Program name	Process	Objective
DownPatent.java	Data collection	Extracting patents from USPTO
HtmlToText.java	Data pre-processing	Transforming form html form to text form
DBConstruction.java	Data pre-processing	Composing DB from text form documents
KeywordSearch.py	Table augmentation	Searching keyword in patent documents
AOSearch.py	Table augmentation	Searching AO chunk in patent documents
PropertiesSearch.cs	Table augmentation	Searching properties in patent documents

4.3.2. Data collection and pre-processing

We use patent information to identify emerging technologies, as it is a useful source of knowledge about technical progress and innovative activity. Patent documents are easily accessed via public databases, and generally provide a standardized representation of technical information, so have been used to gauge technology resources in many studies (Ernst, 2003; Narin, Albert & Smith, 1992; Nielsen, 2004; Seol et al., 2011). Blackman (1995) argued that patents can represent target technologies because they contain 80% of the relevant information. This study used the US Patent and Trade Office patent database (USPTO).

First, we need to construct a patent pool to identify potential

emerging areas. An initial keyword set is made on the basis of products and their associated technologies: technical documents, publications and interviews are useful for this task. We chose keywords according to 3 categories (use, technical configuration and product), to construct what we term a 'reference patent set', which can be regarded as representing of a company's capabilities in terms of patent information. Patents from the reference patent set are then forward cited to the second level in order to expand the potential product, technology, and use areas, respectively. This expanded patent set (the 2-step citing patent family induced from the reference patent set) is then applied to the data source for analysis. Fig. 4-3 illustrates the concept of expanding the patent set.

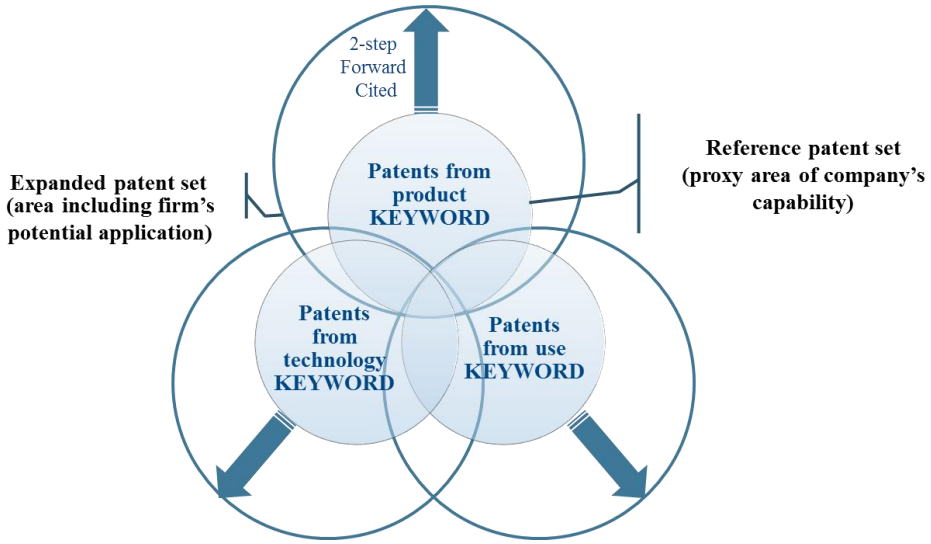


Figure 4-3 Conceptual diagram of expanded patent set

4.4. Constructing the technology application table

Technologies have various sets of attributes - such as form or materials - which decide their applications, and it seems impossible to identify and evaluate technology opportunities without knowing the relevant technical attributes. A technology application table (such as given in Figure 4-4) includes the principal attributes of a specific technology or product, and its potential applications as identified by domain experts. It is similar to a technology tree except it focuses on technology application features.

Technical Attribute				Application
Sub-attribute 1	Sub-attribute 2	Sub-attribute 3	Sub-attribute 4	
keyword	keyword	keyword	keyword	A area
keyword	keyword	keyword	keyword	B area
keyword	keyword	keyword	keyword	C area

Figure 4-4 Conceptual scheme of technology application table

4.5. Augmenting the technology application table using text mining

Next, patents in expanded patent sets are matched to applications in the technology application table in a two-stage process. The first is to classify patents according to the technology application table. Keywords are extracted from the patent documents and cross-checked with keywords in the

application table. In the second phase, we construct a so-called AO set for unclassified patents only according to the applications which augments the table. We compare the AO set in the patent keywords to those in the AO application set and match patents to the appropriate application categories.

The text mining technique applied in the first phase does not take account of the context of sentences, and this affects its classification performance. Extracting chunks of text including objects and related actions can be useful in improving classification rates. Among the chunk analysis methods available, SAO (Subject-Action-Object) analysis can infer relations between subjects, actions and objects from plain text sentences. SAO analysis has considerable advantages in terms of identifying logical relationships, such as means-end or problem-solution relationships. But the variety of relationships can lead to misleading interpretations. In practical terms, we had difficulties using SAO analysis in this research as only a few sentences could be extracted. So, instead of an SAO set, we constructed an AO (action-object) set to improve data availability in a two stage process: first, we tagged parts of speech for every word in the patent documents, and second, we identified the semantic arrangement of words in the document and compared them to those in the application AO set. We used UPenn Treebank II Word Tag to tag parts of speech, as shown in Figure 4-5.

To identify tagged words in patent documents, we separated words according to the process shown in Figure 4-6, thus transforming HTML patent documents into word sets with word tags.

- CC - Coordinating conjunction
- CD - Cardinal number
- **DT** - Determiner
- EX - Existential there
- FW - Foreign word
- **IN** - Preposition or subordinating conjunction
- **JJ** - Adjective
- JJR - Adjective, comparative
- JJS - Adjective, superlative
- LS - List item marker
- MD - Modal
- **NN** - Noun, singular or mass
- NNS - Noun, plural
- **NNP** - Proper noun, singular
- NNPS - Proper noun, plural
- PDT - Predeterminer
- POS - Possessive ending
- PRP - Personal pronoun
- PRP$ - Possessive pronoun
- RB - Adverb
- RBR - Adverb, comparative
- RBS - Adverb, superlative
- RP - Particle
- SYM - Symbol
- **TO** - to
- UH - Interjection
- VB - Verb, base form
- VBD - Verb, past tense
- VBG - Verb, gerund or present participle
- **VBN** - Verb, past participle
- VBP - Verb, non-3rd person singular present
- **VBZ** - Verb, 3rd person singular present
- WDT - Wh-determiner
- WP - Wh-pronoun
- WP$ - Possessive wh-pronoun
- WRB - Wh-adverb

Figure 4-5 UPenn Treebank II Word Tag

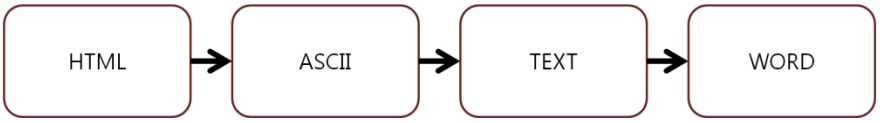


Figure 4-6 Patent treatment for AO analysis

The process for constructing an AO set is as follows: We start by identifying Actions from the original Object set and adding them to an Action set, after which new objects are extracted from this updated Action set and added to the Object set. This process continues iteratively until there are no more actions or objects to be added to either set. The resulting AO set is the used to classify patents to appropriate applications. Figure 4-7 illustrates this concept of augmenting the technology application table.

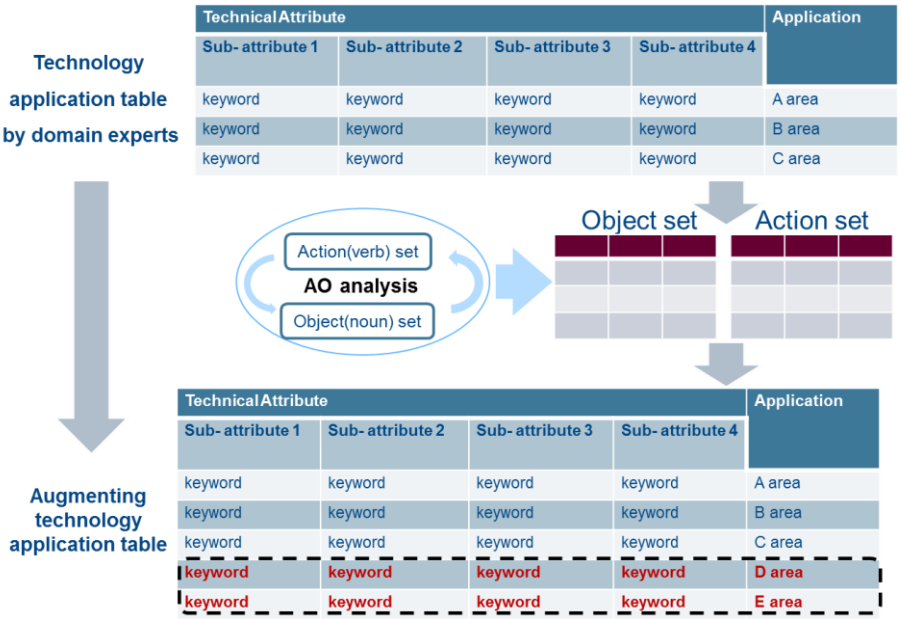


Figure 4-7 Conceptual process of augmenting technology application table using AO analysis

4.6. Exploring emerging opportunity with augmenting technology application table

The next step in the process is to position a particular technology used by the focal company in the augmenting technology application table to ascertain the 'best fit'. The technology must be expressed in a set of keywords from those in the table - if it contains all keywords which belong to specific application, this area can be seen as an 'immediate' emerging opportunity for the company, for which it needs no additional technological capability. It can be regarded as an emerging 'P_1', opportunity (as shown in Figure 4-1) - that is to say, it is a new application area that can be exploited

by using the company's existing technology base 'T' without needing any major R&D investment (Logically, these kinds of identified opportunities will include areas the company has already entered).

There could be other cases that are matched to some technology attributes but not to others, which can be regarded as emerging opportunities P_1 which require further R&D efforts. In such cases, we can identify the additional R&D directions needed to establish the required technology. Other opportunities may be identified elsewhere in the table that are further away from the firm's current technological capabilities than these two types - but they may not be entirely disconnected, because they may belong to same macro-level product or technology categories.

4.7. Empirical analysis

4.7.1. Company X

Our focal company - Company X - is an SME with a capital of 1,500 million won that manufactures separator membranes, which are secondary battery parts. Secondary batteries (unlike primary batteries, which allow charging and discharging) transform the chemical energy of an internal active material into electrical energy via electrochemical oxidation-reduction reactions, and are used in mobile phones, laptops, and personal mobile devices.

Along with the anodic and cathodic active materials, the separator is

one of the four core materials in secondary batteries, and functions by shutting off the current when heat is generated, preventing short circuits caused by the direct anode/cathode contact, and providing pathways for electrolyte transmission. The demand for secondary battery parts is increasing due to the continuing technological advances in the battery industry, such as for high-performance, light-weight and miniaturized parts, as well as the continually increasing demand for personal devices. But market competition is intensifying, with an increasing number of new entrants attracted by this demand increase. Company X's revenues are generated solely from separator sales, and it only possesses a single patent. Here, we attempt to identify emerging opportunities from its technology.

4.7.2. Technology domain

The Separator consists of a membrane - a thin, film-like structure that separates two fluids – which acts as a selective barrier, allowing some particles or chemicals to pass through, but not others. Synthetic membranes can be fabricated from many different materials - organic or inorganic materials including solids such as metals or ceramics, homogeneous films (polymers), heterogeneous solids (polymeric mixes, mixed glasses), and liquids. Polymeric membranes lead the membrane separation industry because they are very competitive in performance and price, thus matching the low cost criteria of the membrane separation process. Many membrane polymers are grafted, custom-modified, or produced as copolymers to

improve their performance, including such types as cellulose acetate (CA), polyethylene (PE), polypropylene (PP), polysulfone (PSF), polyamide (PA), polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE) etc.. Ceramic membranes are made from inorganic materials (such as alumina, titania, zirconia oxides or some glassy materials) - in contrast to polymeric membranes, they can be used in separators in situations where aggressive media (acids, strong solvents) are present. They also have excellent thermal stability, which makes them suitable for use in high temperature operations. Membranes can be classified into four different types according to their pore diameter, which affects their separation performance: micro-filtration (MF), ultra-filtration (UF), Nano-filtration (NF) and reverse osmosis (RO).

Table 4-2 Characteristics of Membrane by pore size

	MF	UF	NF	RO
Separation mechanism	sieve effect	sieve, adsorption	Mediate between UF and RO	solution-diffusion
MWCO	500,000 ~	1,000~200,000	100~500	20~500
Pore size	0.01~10	20~500	around 10	around 10
Plux (L//hr)	50~500	3~200	20~80	5~40
Removed materials	particle, colloid	particle, protein, colloid etc.	all particle	all particle, ion

4.7.3. Data collection

To construct a reference patent set for Company X, use, technology and product keywords were derived by analyzing Company X's patent, technical documents and on-site information. The keywords of each field were compounded (as shown in Table 4-3) and a search conducted, which was refined to derive 40 patents that composed the reference patent set for company X's internal technology.

Table 4-3 Search keywords to derive reference patent set

	Keyword for "Use"	Keyword for "Technology"	Keyword for "product"
Item	Secondary battery	Stretching	Microporous composite membrane, separator
Search keyword	battery or batteries	stretching* or uni-axial stretching* or bi-axial stretching*	film* or separator* or membrane*

Then, we collected the patents that cited each of these 40 patents, a search that found 1,412 patents. After removing those that duplicated the original 40, a total of 1,198 patents were derived as the target analysis data.

4.7.4. Constructing the technology application table

We developed the initial technology application table in the

membrane field following input by domain experts, as shown in Table 4-4. It is important to take account of technical attributes involved in technology applications because they involve these technical attributes. In this case expert review identified the membrane construction material, form, materials relating to filtration and materials relating to separation as the principal technology attributes.

Table 4-4 Membrane technology application table predefined by expert review

Material		Form	Materials relating filtration	Materials relating separation by size	Applications
Polymer	PES, PVDF, PE, PTFE	Film (Sheet) /Fiber	Virus, bacteria, colloid microorganism	Molecule Microfiltration ultrafiltration	Water treatment(Filtration)
			Urea, Endotoxin, Toxin,		Medical dialysis (Hemodialysis, Hemofiltration, Hemodiafiltration, Plasmapheresis)
	PA, Cellulose	Film (Sheet) /Fiber	Sodium, chlorine, chloride	Reverse osmosis (reverse osmotic)	Sea Desalination
	PTFE	Film (Sheet)	Hydrogen, proton	Ion, Electrolyte, Anode, cathode	Fuel cell membrane
	PE, PP	Film (Sheet)	Lithium		Battery separator
	PI, Polysulfone, Cellulose, Polycarbonate, polyetherimide	Fiber	Hydrogen(h.sub.2), Helium, carbon dioxide(co.sub.2)	Molecule, Microfiltration, ultrafiltration	Gas separation

Table 4-5 Membrane technology application table predefined by expert review (continued)

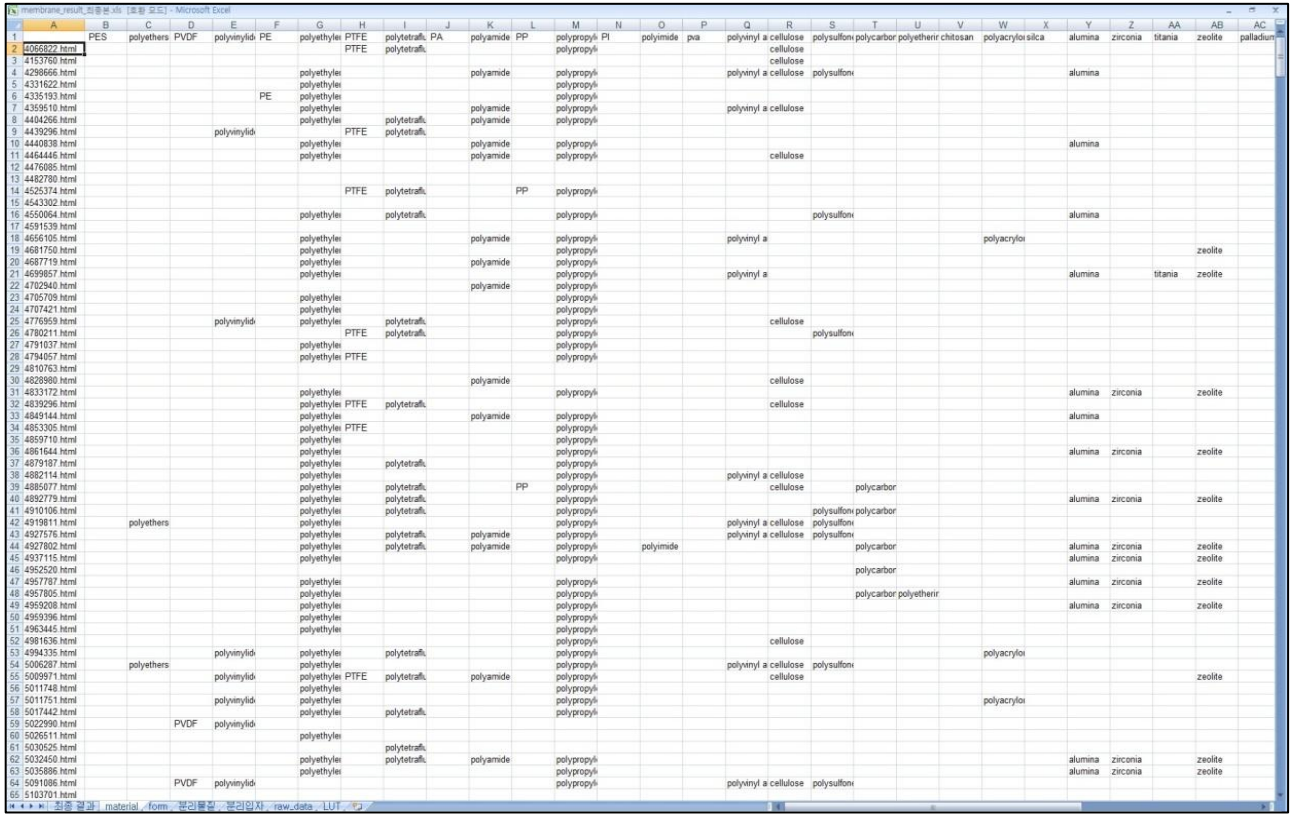
Material		Form	Materials relating filtration	Materials relating separation by size	Applications
Poly mer	PVA, chitosan polyacrylonitrile	Fiber	volatile organic compound (VOC), benzene, ketone	Osmosis, Evaporation, Molecule, Microfiltration Ultrafiltration	Pervaporation
Cera mic	Silca(SiO_2),Alum ina(Al_2O_3), Zirconia(ZrO_2), Titania(TiO_2), Zeolite	Tube, Plate	Virus, bacteria, colloid, Microorganism	Molecule, Microfiltration, Ultrafiltration	Water Treatment(Filtratio n),
			volatile organic compound (VOC), benzene, ketone	Osmosis, Evaporation, molecule	Pervaporation
	Silca(SiO_2), Zirconia(ZrO_2)	Tube, Plate	Hydrogen, proton	Ion, Electrolyte, Anode, Cathode	Sensor, Fuel Cell membrane
Metal	Palladium alloy	Tube	Hydrogen(h.sub.2), Helium carbon dioxide(co.sub.2)	Molecule, Microfiltration Ultrafiltration	Gas membrane

4.7.5. Augmenting the technology application table

As noted in 4.5 above, it is necessary to classify patents of expanded patent sets into technology application categories according to keyword criteria. The keywords in each patent's documentation were analytically compared with those in the technology applications. Where a patent had a keyword associated with a specific attribute, we treated the patent as if it had that attribute. Only if the patent being investigated had keywords of all technology attributes relevant to the specific application category was it classed as falling into that application category.

As a result, 591 of the 1,198 patents (49.3%) fell into the corresponding application category: then the 607 unclassified patents (50.7%) were matched with the AO analysis to see which fell into the application category. The end result of this procedure was that we classified all the patents in the expanded patent set to identify applications, technology attributes and corresponding keywords. While matching patents into the application table was not the main objective, it was a necessary step on the way to the real objective – of finding opportunities.

Keyword searches in patent documents were conducted using KeywordSearch.py: Figure 4-8 shows the search results.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1		PES	polyethers	PVDF	polyvinylid	PE	polyethyle	PTFE	polytetrafl	PA	polyamide	PP	polypropy	PI	polyimide	pva	polyvinyl a	cellulose	polysulfon	polycarbor	polyetherir	chitosan	polyacrylor	silca	alumina	zirconia	titania	zeolite	palladium
2	4066822.html							PTFE	polytetrafl				polypropy					cellulose											
3	4153760.html																	cellulose											
4	4298666.html						polyethyle				polyamide		polypropy				polyvinyl a	cellulose	polysulfon						alumina				
5	4331622.html						polyethyle						polypropy																
6	4335193.html					PE	polyethyle						polypropy																
7	4359510.html						polyethyle				polyamide		polypropy				polyvinyl a	cellulose											
8	4404266.html						polyethyle		polytetrafl		polyamide		polypropy																
9	4439296.html				polyvinylid			PTFE	polytetrafl																				
10	4440838.html						polyethyle				polyamide		polypropy												alumina				
11	4464446.html						polyethyle				polyamide		polypropy					cellulose											
12	4476085.html																												
13	4482780.html																												
14	4525374.html							PTFE	polytetrafl			PP	polypropy																
15	4543302.html																												
16	4550064.html						polyethyle		polytetrafl				polypropy						polysulfon						alumina				
17	4591539.html																												
18	4656105.html						polyethyle				polyamide		polypropy				polyvinyl a						polyacrylor						
19	4681750.html						polyethyle						polypropy															zeolite	
20	4687719.html						polyethyle				polyamide		polypropy																
21	4699857.html						polyethyle						polypropy				polyvinyl a								alumina		titania	zeolite	
22	4702940.html										polyamide		polypropy																
23	4705709.html						polyethyle						polypropy																
24	4707421.html						polyethyle						polypropy																
25	4776959.html				polyvinylid		polyethyle		polytetrafl				polypropy					cellulose											
26	4780211.html							PTFE	polytetrafl				polypropy						polysulfon										
27	4791037.html						polyethyle						polypropy																
28	4794057.html						polyethyle	PTFE					polypropy																
29	4810763.html																												
30	4828980.html										polyamide							cellulose											
31	4833172.html						polyethyle						polypropy												alumina	zirconia		zeolite	
32	4839296.html						polyethyle	PTFE	polytetrafl									cellulose											
33	4849144.html						polyethyle				polyamide		polypropy												alumina				
34	4853305.html						polyethyle	PTFE					polypropy																
35	4859710.html						polyethyle						polypropy																
36	4861644.html						polyethyle						polypropy												alumina	zirconia		zeolite	
37	4879187.html						polyethyle		polytetrafl				polypropy																
38	4882114.html						polyethyle						polypropy				polyvinyl a	cellulose											
39	4885077.html						polyethyle		polytetrafl			PP	polypropy					cellulose		polycarbor									
40	4892779.html						polyethyle		polytetrafl				polypropy												alumina	zirconia		zeolite	
41	4910106.html						polyethyle		polytetrafl				polypropy						polysulfon	polycarbor									
42	4919811.html		polyethers				polyethyle						polypropy				polyvinyl a	cellulose	polysulfon										
43	4927576.html						polyethyle		polytetrafl		polyamide		polypropy				polyvinyl a	cellulose	polysulfon										
44	4927802.html						polyethyle		polytetrafl		polyamide		polypropy		polyimide					polycarbor					alumina	zirconia		zeolite	
45	4937115.html						polyethyle						polypropy												alumina	zirconia		zeolite	
46	4952520.html																			polycarbor									
47	4957787.html						polyethyle						polypropy												alumina	zirconia		zeolite	
48	4957805.html						polyethyle						polypropy							polycarbor	polyetherir								
49	4959208.html						polyethyle						polypropy												alumina	zirconia		zeolite	
50	4959396.html						polyethyle						polypropy																
51	4963445.html						polyethyle						polypropy																
52	4981636.html												polypropy					cellulose											
53	4994335.html				polyvinylid		polyethyle		polytetrafl				polypropy										polyacrylor						
54	5006287.html		polyethers				polyethyle						polypropy				polyvinyl a	cellulose	polysulfon										
55	5009971.html				polyvinylid		polyethyle	PTFE	polytetrafl		polyamide		polypropy					cellulose										zeolite	
56	5011748.html						polyethyle						polypropy																
57	5011751.html				polyvinylid		polyethyle						polypropy										polyacrylor						
58	5017442.html						polyethyle		polytetrafl				polypropy																
59	5022990.html			PVDF	polyvinylid																								
60	5026511.html						polyethyle																						
61	5030525.html								polytetrafl																				
62	5032450.html						polyethyle		polytetrafl		polyamide		polypropy												alumina	zirconia		zeolite	
63	5035886.html						polyethyle						polypropy												alumina	zirconia		zeolite	
64	5091086.html			PVDF	polyvinylid								polypropy				polyvinyl a	cellulose	polysulfon										
65	5103701.html																												

Figure 4-8 Keyword search results by patents

We constructed an AO set for each membrane application based on the ‘target material’ attribute (i.e. the material used to separate impurities) and others. The initial object set mainly consisted of the ‘target material’ keywords. An accompanying action set was constructed on the basis of synonyms of separation, verbs such as ‘remove’, ‘transport’, ‘produce’ and ‘retain’ etc.. Figure 4-9 shows initial AO set sorted by applications.

1		prevent, reduce, kill, destory, neutralize, stop, isolate	relate to	select, accept, allow, absorb, extract
2	Water Treatment	microorganism, bacteria, bacterium	semiconductor	zirconium
3		neutralize terpolymer	depth filtration	fast bioreaction
4		water		
5		toxin		
6				
7	food	food preparation time		juice
8				food, safer food,
9				
10	Medical Dialysis			pathogen
11				
12	medical	catheter		restenosis
13		bacterium		
14		toxin		
15				
16	Sea Desalination			oil
17				gel
18				water
19				
20	Fuel cell	plasticizer	battery	water
21		air flow	capacitor	oxygen
22		hydration	carbon electrode	hydrogen
23		water loss	fuel cell	proton
24		battery reaction	power generation	electron, electrolyte, electrode
25		oxidizing, oxidation	zinc air battery	plasticizer
26				cathode
27				air flow
28				
29	Battery Separator	anode	battery	electron, electrolyte, electrode
30		cathode	battery separator	ion transfer
31		electrode	lithium, lithium polymer, lithium ion	
32		plasticizer	capacitor	
33				
34				
35				
36	Gas separation	carbon dioxide		gas
37				
38				
39				
40	Pervaporation			beer
41				flavor component
42				polyelectrolyte

Figure 4-9 Initial AO set by applications

Figure 4-10 shows the action and object sets for a ‘sea-water desalination’

application.

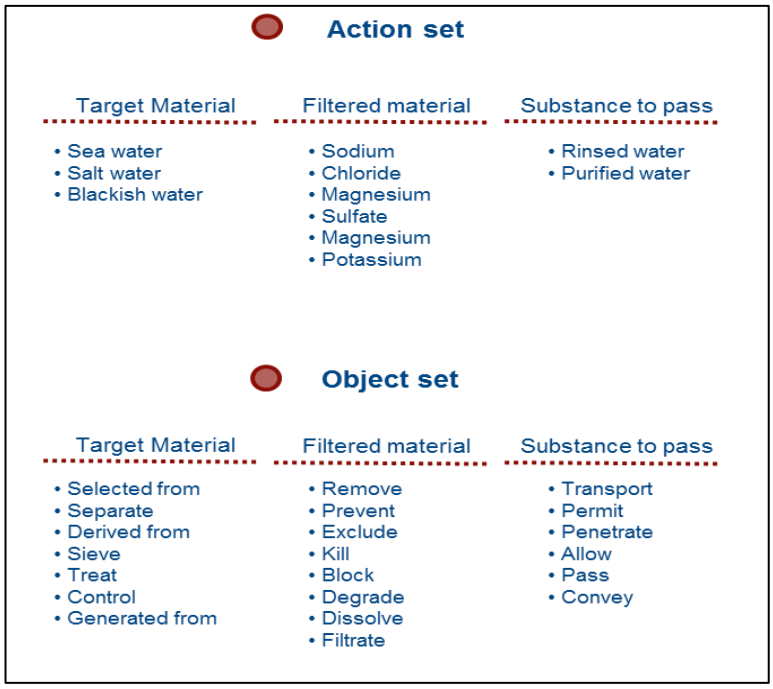


Figure 4-10 AO sets for sea-water desalination application

As noted above, the process for constructing an AO set starts with identifying Actions (verbs) from the original object set (consisting of nouns) and adding them to the Action set, after which the updated action set is used to extract new objects, which are then added to the object Set in a process that iterates until no more actions or objects are added to either set.

In this case, we identified some objects on the basis of action sets - for example, ‘relate to’, ‘separate’, ‘remove’ and ‘produce’ were applied to the process. Object sets such as ‘Battery Separator’, ‘energy storage’,

‘Absorbent Garments’, ‘Semiconductor Device’ were then identified, and , typically, the verb ‘Relate To’ was used to extract applications like Battery Separator, Energy Storage, etc.

40	6291866	(CHUNK relates/VBZ generally/RB to/TO semiconductor/NN device/NN structures/NNS)	semiconductor device
41	6291867	(CHUNK relates/VBZ generally/RB to/TO semiconductor/NN device/NN structures/NNS)	semiconductor device
42	6303894	(CHUNK relates/VBZ to/TO resistance/NN welding/NN apparatus/NN)	welding
43	6316142	(CHUNK relates/VBZ to/TO novel/NN methods/NNS)(CHUNK relates/VBZ to/TO novel/NN electrodes/NNS)	
44	6326099	(CHUNK relate/VBP to/TO gaskets/NNS)	gasket
45	6346341	(CHUNK relates/VBZ generally/RB to/TO batteries/NNS)	battery
46	6346350	(CHUNK relates/VBZ to/TO battery/NN separators/NNS)	battery
47	6348277	(CHUNK correlated/VBN to/TO metal-fuel/NNP zone/NN identification/NN data/NNS)(CHUNK cor	fuel cell
48	6348679	(CHUNK relates/VBZ to/TO compositions/NNS)	
49	6352111	(CHUNK relates/VBZ to/TO filters/NNS)	
50	6352745	(CHUNK relates/VBZ to/TO rubber/NN)	
51	6357664	(CHUNK relates/VBZ generally/RB to/TO cards/NNS)	
52	6361294	(CHUNK relates/VBZ generally/RB to/TO batteries/NNS)	battery
53	6372379	(CHUNK relates/VBZ to/TO separators/NNS)	battery
54	6395422	(CHUNK relates/VBZ to/TO additives/NNS)	
55	6413298	(CHUNK relates/VBZ to/TO water-/NNP)	
56	6414217	(CHUNK relates/VBZ to/TO absorbent/NN articles/NNS)	absorbent article
57	6429261	(CHUNK related/VBD to/TO strength/NN loss/NN)	
58	6440611	(CHUNK relates/VBZ to/TO battery/NN separators/NNS)	battery
59	6444214	(CHUNK related/VBD to/TO strength/NN loss/NN)	
60	6444367	(CHUNK relates/VBZ to/TO battery/NN separator/NN materials./NNP More/NNP)	battery
61	6451463	(CHUNK relates/VBZ generally/RB to/TO improvements/NNS)	
62	6458480	(CHUNK relates/VBZ to/TO improvements/NNS)	
63	6472093	(CHUNK correlated/VBN to/TO metal-fuel/NNP zone/NN identification/NN data/NNS)(CHUNK cor	fuel cell
64	6472103	(CHUNK relates/VBZ to/TO improvements/NNS)	
65	6479150	(CHUNK relates/VBZ to/TO layer/NN materials/NNS)	
66	6495292	(CHUNK relates/VBZ to/TO battery/NN separators/NNS)	battery
67	6500571	(CHUNK relates/VBZ to/TO batteries/NNS)	battery
68	6503236	(CHUNK relates/VBZ to/TO absorbent/NN articles/NNS)	absorbent article
69	6506186	(CHUNK relates/VBZ to/TO absorbent/NN articles/NNS)	absorbent article
70	6515325	(CHUNK relates/VBZ to/TO semiconductor/NN devices/NNS)	semiconductor device
71	6517950	(CHUNK relates/VBZ to/TO multilayer/NN films/NNS)	
72	6521325	(CHUNK related/VBD to/TO mastering/NN method/NN)	
73	6521378	(CHUNK relates/VBZ to/TO improvements/NNS)	
74	6522525	(CHUNK related/VBN to/TO application/NN Ser./NNP No./NN)	
75	6531248	(CHUNK relates/VBZ to/TO battery/NN pastes/NNS)	battery
76	6548340	(CHUNK relates/VBZ to/TO semiconductor/NN fabrication/NN techniques/NNS)	semiconductor device
77	6551457	(CHUNK relates/VBZ to/TO paper/NN)	
78	6552245	(CHUNK relates/VBZ to/TO absorbent/NN articles/NNS)	absorbent article
79	6555213	(CHUNK relates/VBZ generally/RB to/TO image/NN)(CHUNK relates/VBZ to/TO image/NN)	image
80	6558829	(CHUNK related/VBN to/TO U.S./NNP patent/NN application/NN Ser./NNP No./NN)	
81	6558848	(CHUNK relates/VBZ to/TO electrodes/NNS)	

Figure 4-11 Illustrative – derivation of object set using ‘Relate To’

The final action set and object sets in this case analysis are given in Tables 4-5 and 4-6, and were used to classify patents to appropriate applications.

Table 4-6 Final action set from AO analysis

For target	For Removal	For passing through	For results	For including
selected from	remove	transport	produce	comprise
separate	inactivate	permit	decrease	have
derived from	prevent	penetrate	increase	contain
generated from	exclude	allow		include
sieve	destroy	deliver		retain
challenge	kill	transmit		base
treat	limit	conduct		
contact	block	pass		
interrupt	degrade	convey		
control	disperse			
detect	dissolve			
adjust	decompose			
use	separate			
dissolved in	extract			
	filterate			
	sieve			
	challenge			
	immobilize			
	deintercalate			
	hold			
	impede			
	reject			
	scale			

Table 4-7 Final object set from AO analysis

Application	Targets material	Filtered material	Materials that pass through
water treatment	wastewater	Pollens, yeast, bacteria, colloid, micromolecules, virus, organic compound, microorganism, protozoa	fresh water purified water cleaned water ultrapure water
sea desalination	sea water, salt water, blackish water	Sodium, natrium, chloride, magnesium, sulfate, calcium, potassium, metal ion	rinsed water
medical dialysis	Blood, blood cell platelet, plasma	Urea, creatinine, uric acid, inulin, endotoxin, toxin, pathogen	
Fuel cell	Polymer, electrolyte, solid polymer electrolyte, Nafion	hydrogen ion proton	water heat

The technology applications of unclassified patents were then identified using a final AO set. Actions (verbs) and objects (nouns) in the patent needed to be in the form of phrases so we use the AO set to match patents to applications. The basic assumption is that specific AO phrases represent specific technology applications. This process allowed us to match an additional 362 of the 607 unclassified patents (59.6%) to the AO set. Finally, 953(79.5%) patents of the expanded patent set (1,198) were matched to application categories via their technology attributes. 245(20%) of patent

sets turned out to be various general purpose technologies or technologies unrelated to membranes, which seemed reasonable as they had no keywords or phrases related to membranes.

4.7.6. Exploring emerging opportunity

The technology keywords and Company X's AO set can be derived automatically using the developed program interface (appendix B). Figure 4-12 shows the keywords that appeared both in X's patents and the technology application table.

As Figure 4-12 shows, Company X's technology is specialized for battery separators (application ④). Aside from that, fuel cell separators (application ③) can be regarded as the principal emerging opportunity if the company conducts additional R&D. Comparing the blank cells of application ③ with the technology application table, technologies for machining PTFE (Polytetrafluoroethylene) field and removal technologies for hydrogen highlighted the need for manufacturing fuel cell membranes. Emerging opportunities such as ①, ② and ⑤ can be considered in the same manner, showing water treatment, medical hemodialysis, personal care and medical absorbent products as markets into which Company X could move.

Material*		Form	Materials to be removed	Separation performance	Applications
Polymer	PE(polyethylene)	Film			1 Water treatment(Filtration)
					2 Medical dialysis(Hemodialysis, Hemofiltration, Hemodiafiltration, Plasmapheresis)
		Film			Sea Desalination
	PE(polyethylene) PP (polypropylene)	Film		Ion Electrolyte Anode Cathode	3 Fuel cell membrane
			Lithium		4 Battery separator
					Gas separation
					Pervaporation
	PE(polyethylene) PP (polypropylene)	Film			5 personal care and medical absorbent products
Ceramic					Water Treatment(Filtration),
					Pervaporation
					Sensor, Fuel Cell membrane
Metal					Gas membrane

Figure 4-12 Identified emerging opportunity based on technology application table

4.8. Conclusion

Chapter 4 is concerned with enhancing a company's innovativeness - in particular SMEs - by developing a support framework to explore emerging opportunities from a resource based view. The contributions and potential of this research are that we propose an improved method of exploring emerging technology which takes into account the SME's technological capability. We construct a patent family including possible opportunities that SMEs could exploit, and suggest a systematic framework that can identify technologically accessible opportunities and outline related R&D directions.

Despite all the possibilities offered by our proposed approach, it has certain limitations concerning the use of expert judgment. First, in this methodology, the understanding of the domain expert affects the quality of the technology application table. Second, although it is a framework designed for use by SMEs, the entire process of identifying opportunities needs research professionals and domain experts, and it is recognized that SMEs rarely have enough such professional expertise. Public intervention has been suggested to support SMEs in this matter, and a variety of intermediary institutions for innovation have been developed that have proved useful. This methodology is designed for use by experts in such institutions, but its applicability may less effective in practice if there is no public intervention in this field.

Another limitation of the framework is that there are no

comprehensive criteria against which to evaluate emerging opportunity, so candidate opportunities may be chosen simply because they are related to the company's existing internal technology. In addition, technological feasibility is unclear because the framework measures technological accessibility by keyword checks: several other assessment indexes - such as market evaluation, availability of external R&D support, availability of investment and technological feasibility etc. – may be necessary.

Chapter 5. Conclusions

5.1 Summary and contributions

With the increasing pace of change, many enterprises are looking to increase their rates of innovation, so the question of how to enhance innovativeness has attracted a fair amount of critical attention. Kohler (1998) holds that technology management, as an integrated general management task, leads to more innovative SMEs. There are a variety of strategies which can facilitate innovations, including internal restructuring; creating an innovation team, providing funding for innovations, establishing external networks and securing innovation by M&A. The first step for a firm seeking to enhance its innovativeness is to identify its own development direction. Narrowing down the company's range of concerns confines the scope of research to enhance innovativeness to the introduction of newly emerging products or services.

As noted above, SMEs can have difficulty identifying emerging opportunities. Their managers often lack the types of education and training that have been linked with innovativeness (Romano, 1990), and this lack of strategic expertise can prevent them from transforming their superior customer knowledge into new products and services (Davis, Hills & LaForge, 1985; Gruner & Homburg, 2000; Sethi, Smith & Park, 2001).

This dissertation deals with these problems. First, we conducted a

field study to identify the state of SMEs' innovativeness through a field survey which aimed to identify how Korean SMEs could be grouped by innovativeness factors, and how the innovativeness of those groups evolved over time. Specifically, we suggest a way of identifying principal types of SME business models, and of associating their evolving paths with changing patterns of innovativeness. Based on a survey of 400 Korean SMEs, we identified four principal types of business models characterized by distinctive innovativeness. Analyzing our survey results, we found 51% of SMEs business models belong to the global infant model group, which is at the starting line on the innovation plane, while 20% seem to adopt incremental transition paths, focusing on factors related to incremental innovation and 19% took radical transition paths, concentrating on factors that could yield radical innovations.

In this respect, what 90% of SMEs most need is to secure emerging opportunities so as to be able to take the next business model step – to develop new business. To deal with this issue, we develop a systemic framework that analyzes technological opportunities considering the SME's capability. A patent family is constructed which uses patent citation to indicate potential emerging opportunity, and then text mining is used to develop a Technology application table including attributes that configure technology and potential applications. The framework suggests emerging opportunities in the form of technology applications taking into consideration SMEs' technological capabilities, and provides outline R&D directions that correspond to the chosen opportunity options.

As an empirical example, we used this methodology to analyze the company X's membrane technology, and identified five technology applications which took the firm's internal technology into account. Among these, fuel cell membranes were shown as the most promising opportunity from a technological perspective, while water treatment, medical hemodialysis, personal care and medical absorbent product applications were also suggested, together with outline R&D directions.

5.2 Limitations and future research

Despite the value of our findings, the dissertation has some limitations, so there is room for further studies. In Chapter 3, we did not examine the issue of causal relationships between BM components, and thus can predict neither synergy nor conflict between them when investment is made into a certain component. SMEs, which generally face budget constraints, are naturally eager to maximize their returns on investment. So revealing the causal relationships between BM components would contribute greatly to enhancing the value of our approach. Another limitation comes from industry differences. Ways of developing R&D capabilities will vary across industries, suggesting that a guide for developing new BMs should be customized to a specific industry. Last, but not least, in terms of data and methodology, this study is not free from biased sample problems in terms of sample size, selection, etc., nor could we examine SMEs' historical evolving paths at an acceptable granularity of time-series data.

Chapter 4 has limitations concerning expert judgment. At the first stage, the performance of the technology application table depends on the knowledge of domain experts, and the process of using an AO set to identify opportunities or matching processes to patents also needs research professionals and domain experts. As noted above, SMEs are generally seen as having limited resources and capabilities for R&D activities, and as having underdeveloped employee education and training. To overcome such disadvantages, we have advocated public intervention. Although we have developed this framework for research personnel, its applicability in practice may depend on such public intervention.

Another limitation of the framework is that there are no comprehensive criteria to evaluate emerging opportunities: those which are chosen as candidates are simply those which are most closely related to a company's internal technology. Several assessment indexes are needed, such as market evaluation, availability of external R&D support, availability of investment etc. Further research should be conducted to address these limitations.

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Appendices

Appendix A. Questionnaire and survey results

1. 기업 일반현황 및 사업유형
I. 다음은 기업의 일반현황에 관한 질문입니다.

1-1. 귀사의 회사명은 무엇입니까?
주관식

1-2. 귀사의 현재 대표상품 또는 서비스명은 무엇입니까?
주관식

1-3. 대표상품/서비스의 현재 시장 점유율은 대략 몇 % 정도 되십니까?	
	점유율
현재 국내시장 점유율	주관식
현재 해외시장 점유율	주관식

1-4. 귀사에서 판매하고 있는 주력 제품/서비스의 수는 대략 어느 정도 입니까?			
전체 합계		306 명	100.00%
1. 3개이하		145 명	47.39%
2. 4~6개 이하		109 명	35.62%
3. 7~9개 이하		21 명	6.86%
4. 10개 이상		31 명	10.13%

1-5. 귀사에서 새롭게 진입하고자 하는 신사업 분야가 있다면 그 분야를 1줄 정도로 자유롭게 기재하여 주시기 바랍니다.
주관식 내용 참조

1-6. 귀사에서 새롭게 진입하고자 하는 신제품/신서비스가 있다면 그 명칭을 1줄 정도로 자유롭게 기재하여 주시기 바랍니다.
주관식

II. 다음은 기업의 경쟁우위와 성장유형에 관한 질문입니다.
2. 경쟁우위

|

2-1. 귀사는 경쟁사들이 모방하기 어려운 경쟁적 우위를 확보하고 있다고 생각하십니까?			
전체 합계		306 명	100.00%
1. 예		230 명	75.16%
2. 아니오		76 명	24.84%

|

2-2. 다음에 제시된 보기들 중 무엇에 해당된다고 생각하십니까?			
전체 합계		230 명	100.00%
1. 제품의 품질		112 명	48.70%
2. 밀접한 고객관계		9 명	3.91%
3. 영업/마케팅		6 명	2.61%
4. 사후관리 서비스		1 명	0.43%
5. 제품가격		10 명	4.35%

6. 생산효율		6 명	2.61%
7. 물류효율		1 명	0.43%
8. 유통망 확보		1 명	0.43%
9. 진입장벽(특허 등)		84 명	36.52%

|

3. 차별화 우위(프리미엄 가격)

|

3-1. 귀사는 경쟁사보다 높은 가격 전략을 펼치고 계십니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		26 명	8.50%
2. 약간 그렇다		82 명	26.80%
3. 보통이다		120 명	39.22%
4. 약간 아니다		54 명	17.65%
5. 매우 아니다		24 명	7.84%

|

3-2. 높은 가격을 책정한 이유는 무엇인가요?			
전체 합계		108 명	100.00%
1. 차별화된 제품		75 명	69.44%
2. 품질		26 명	24.07%
3. 브랜드		1 명	0.93%
4. 사후관리/서비스		3 명	2.78%
5. 기타주관식 내용 참조		3 명	2.78%

|

4. 가격 우위(원가 절감)

|

4-1. 귀사는 경쟁사보다 낮은 가격전략을 펼치고 계십니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		36 명	11.76%
2. 약간 그렇다		75 명	24.51%
3. 보통이다		102 명	33.33%
4. 약간 아니다		57 명	18.63%

5. 매우 아니다		36 명	11.76%

|

4-2. 제품을 낮은 가격으로 제공할 수 있는 원동력은 어디서 나옵니까?			
전체 합계		111 명	100.00%
1. 기술력		59 명	53.15%
2. 제조 노하우		32 명	28.83%
3. 물류/재고 관리능력		2 명	1.80%
4. 원자재 구매 능력		7 명	6.31%
5. 기타주관식 내용 참조		11 명	9.91%

|

5. 시장혁신

|

5-1. 귀사에 있어 시장혁신은 기술혁신보다 중요합니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		100 명	32.68%

2. 약간 그렇다		110 명	35.95%
3. 보통이다		57 명	18.63%
4. 약간 아니다		21 명	6.86%
5. 매우 아니다		18 명	5.88%

|

5-2. 귀사의 시장혁신의 방법은 무엇입니까?			
전체 합계		306 명	100.00%
1. 특정 지역시장 집중		22 명	7.19%
2. 특정 고객시장 집중		114 명	37.25%
3. 지속적 신시장 개척		140 명	45.75%
4. 해외대기업과의 협력으로 시장진출		20 명	6.54%
5. 기타주관식 내용 참조		10 명	3.27%

6. 대기업과의 관계의 중요도

|

6-1. 귀사의 성장에 있어 대기업과의 관계가 중요합니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		98 명	32.03%
2. 약간 그렇다		89 명	29.08%
3. 보통이다		63 명	20.59%
4. 약간 아니다		22 명	7.19%
5. 매우 아니다		34 명	11.11%

|

6-2. 귀사에게 (대기업이) 어떤 부분에 도움을 주기 때문입니까?			
전체 합계		187 명	100.00%
1. 주요 수요처		115 명	61.50%
2. 필요기술 공동개발/이전		17 명	9.09%
3. 대기업 브랜드 활용		10 명	5.35%
4. 대기업 유통망 활용		41 명	21.93%
5. 기타주관식 내용 참조		4 명	2.14%

|

7. 정부와의 관계의 중요도

|

7-1. 귀사의 성장에 있어 정부와의 관계가 중요합니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		167 명	54.58%
2. 약간 그렇다		76 명	24.84%
3. 보통이다		48 명	15.69%
4. 약간 아니다		11 명	3.59%
5. 매우 아니다		4 명	1.31%

|

7-2. 귀사에게 (정부가) 어떤 부분에 도움을 주기 때문입니까?			
전체 합계		243 명	100.00%
1. R&D 자금 지원		140 명	57.61%
2. 주요 수요처		47 명	19.34%
3. 간접지원(세금, 규제완화 등)		4 명	1.65%
4. 시설/운영자금지원(보조금 등)		29 명	11.93%

5. 해외시장 진출지원		10 명	4.12%
6. 기타주관식 내용 참조		13 명	5.35%

|

2. 사업모델

2-1. 사업전략

|

8. 국제화 속도

|

8-1. 설립이후 처음 수출하는 데까지 어느 정도의 기간이 걸렸습니까? (아직 수출한 적이 없다면 수출하기까지 얼마나 걸릴 것으로 예상하십니까?)

전체 합계		306 명	100.00%
1. 수출하지 않음		51 명	16.67%
2. 설립과 거의 동시		23 명	7.52%
3. 2~3년 이내		121 명	39.54%
4. 3~5년 이내		67 명	21.90%

5. 5~10년 이내		34 명	11.11%
6. 기타주관식 내용 참조		10 명	3.27%

|

8-2. 해외 지사를 처음 설립하기까지 얼마나 걸렸습니까?			
전체 합계		306 명	100.00%
1. 지사 없음		184 명	60.13%
2. 설립과 거의 동시		8 명	2.61%
3. 2~3년 이내		43 명	14.05%
4. 3~5년 이내		31 명	10.13%
5. 5~10년 이내		27 명	8.82%
6. 기타주관식 내용 참조		13 명	4.25%

|

9. 국제화 정도

|

9-1. 귀사에서 현재 수출하고 있는 국가의 수는 어느 정도입니까?

전체 합계		306 명	100.00%
1. 없음		149 명	48.69%
2. 1~2개		81 명	26.47%
3. 3~5개		43 명	14.05%
4. 6~10개		8 명	2.61%
5. 11~20개		10 명	3.27%
6. 기타주관식 내용 참조		15 명	4.90%

|

9-2. 귀사가 현재 수출하고 있는 지역을 모두 체크해 주십시오			
전체 합계		565 건	100.00%
1. 미국		108 건	19.12%
2. 일본		106 건	18.76%
3. EU		63 건	11.15%
4. 중국		110 건	19.47%
5. 아시아		117 건	20.71%
6. 남아메리카		10 건	1.77%
7. 호주		13 건	2.30%

8. 아프리카		6 건	1.06%
9. 중동지역		32 건	5.66%

10. 국제화 방법

10-1. 처음 해외 진출시 다음 중 어떤 방식으로 진출하였습니까? (수출한 적이 없다면 어떤 방식으로 진출하기를 원하십니까?)			
전체 합계		306 명	100.00%
1. 단독진출		59 명	19.28%
2. 현지기업과의 제휴		99 명	32.35%
3. 국내외 기업과 마케팅/유통망만 제휴		101 명	33.01%
4. 진출국 기업과 합자투자		11 명	3.59%
5. 국내외 기업과 합자투자		17 명	5.56%
6. 기타주관식 내용 참조		19 명	6.21%

10-2. 귀사의 현재 해외진출 유형을 골라주시기 바랍니다.			
전체 합계		306 명	100.00%
1. 단독진출		60 명	19.61%
2. 현지기업과의 제휴		98 명	32.03%
3. 국내외 기업과 마케팅/유통망만 제휴		92 명	30.07%
4. 진출국 기업과 합자투자		8 명	2.61%
5. 국내외 기업과 합자투자		15 명	4.90%
6. 기타주관식 내용 참조		33 명	10.78%

2-2. 사업의 Offering

11. 상품의 복잡도와 가치

11-1. 귀사의 핵심상품은 다음 중 어디에 속합니까?			
전체 합계		306 명	100.00%

1. 부품		50 명	16.34%
2. 모듈		38 명	12.42%
3. 단품		69 명	22.55%
4. 소프트웨어 및 유지보수 서비스		23 명	7.52%
5. 컨텐츠		11 명	3.59%
6. 전략/재무/인사 경영솔루션 및 컨설팅		0 명	0.00%
7. 정보시스템 솔루션/컨설팅		20 명	6.54%
8. 디자인 서비스 및 컨설팅		8 명	2.61%
9. 생산/제조 솔루션 및 컨설팅		59 명	19.28%
10. 기타주관식 내용 참조		28 명	9.15%

|

11-2. 상품의 핵심가치가 어느 부분에 있다고 생각하십니까?			
전체 합계		306 명	100.00%
1. 가격		21 명	6.86%
2. 품질		139 명	45.42%
3. 디자인		9 명	2.94%
4. 고객맞춤(Customization)		68 명	22.22%

5. 고객관계관리(CRM)		3 명	0.98%
6. 창의성(Creativeness)		56 명	18.30%
7. 기타주관식 내용 참조		10 명	3.27%

|

11-3. 핵심상품의 매출 확대를 위하여 회사에서 별도로 제공하는 정보나 서비스가 있습니까?			
전체 합계		306 명	100.00%
1. 별도의 정보/서비스 제공하고 있음		91 명	29.74%
2. 없음		215 명	70.26%

|

11-4. 별도로 제공하는 정보나 서비스는 어떤 가격에 제공하고 얼마입니까?			
전체 합계		91 명	100.00%
1. 무상제공		47 명	51.65%
2. 상품가격에 포함		17 명	18.68%
3. 실비제공		11 명	12.09%

4. 이윤 창출수단		16 명	17.58%

|

11-5. 별도로 제공하는 정보/서비스의 내용을 아래의 사례를 참고하여 간단히 기재하여 주시기 바랍니다. * 별도 제공 정보의 예시는 다음과 같습니다. 1) 제품 유지/보수 시기와 방법 정보 제공 2) 직접 제품 유지/보수 서비스 제공 (부품교환, 소모품 제공, 소프트웨어 업그레이드 등) 3) 제품 활용을 위한 교육 및 정보제공 (설비 사용 및 조작교육 등)
주관식

|

2-3. 사업역량

|

12. 연구개발

|

12-1. 귀사의 연구개발능력은 경쟁사보다 뛰어납니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		100 명	32.68%
2. 약간 그렇다		124 명	40.52%
3. 보통이다		66 명	21.57%
4. 약간 아니다		12 명	3.92%
5. 매우 아니다		4 명	1.31%

|

12-2. 귀사의 연구개발능력이 탁월한 이유는 무엇입니까?			
전체 합계		224 명	100.00%
1. 우수한 인력		126 명	56.25%
2. 충분한 투자		18 명	8.04%
3. 고객, 사내 타부서와의 협력		12 명	5.36%
4. 외부기관과의 협력		43 명	19.20%
5. 기타주관식 내용 참조		25 명	11.16%

|

13. 생산/제조

|

13-1. 귀사의 생산/제조능력은 경쟁사보다 뛰어납니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		39 명	12.75%
2. 약간 그렇다		103 명	33.66%
3. 보통이다		127 명	41.50%
4. 약간 아니다		27 명	8.82%
5. 매우 아니다		10 명	3.27%

|

13-2. 귀사의 생산/제조 능력이 탁월한 이유는 무엇입니까?			
전체 합계		142 명	100.00%
1. 첨단설비 도입		8 명	5.63%
2. 철저한 교육훈련		14 명	9.86%
3. 우수한 생산/제조관리체계		58 명	40.85%
4. 직원들의 자발적 참여와 문화		53 명	37.32%

5. 기타주관식 내용 참조		9 명	6.34%

|

14. 물류/유통

|

14-1. 귀사의 물류/유통 능력은 경쟁사보다 뛰어납니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		12 명	3.92%
2. 약간 그렇다		50 명	16.34%
3. 보통이다		166 명	54.25%
4. 약간 아니다		48 명	15.69%
5. 매우 아니다		30 명	9.80%

|

14-2. 귀사의 물류/유통 능력이 탁월한 이유는 무엇입니까?			
전체 합계		62 명	100.00%
1. 첨단설비 도입		2 명	3.23%

2. 철저한 교육훈련		14 명	22.58%
3. 우수한 물류/유통체계		8 명	12.90%
4. 중간유통, 판매업자들과의 협력관계		31 명	50.00%
5. 기타주관식 내용 참조		7 명	11.29%

|

15. 영업/마케팅

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15-1. 귀사의 영업/마케팅 능력은 경쟁사보다 뛰어납니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		33 명	10.78%
2. 약간 그렇다		64 명	20.92%
3. 보통이다		127 명	41.50%
4. 약간 아니다		54 명	17.65%
5. 매우 아니다		28 명	9.15%

|

15-2. 귀사의 영업/마케팅력 능력이 탁월한 이유는 무엇입니까?			
전체 합계		97 명	100.00%
1. 우수한 인력관리		57 명	58.76%
2. 충분한 투자		6 명	6.19%
3. 외주 마케팅/홍보업체 관리능력		24 명	24.74%
4. 탁월한 인센티브 체계		3 명	3.09%
5. 기타주관식 내용 참조		7 명	7.22%

|

16. 재무/파이낸싱

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16-1. 귀사의 재무/파이낸싱 능력은 경쟁사보다 뛰어납니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		6 명	1.96%
2. 약간 그렇다		28 명	9.15%
3. 보통이다		151 명	49.35%
4. 약간 아니다		80 명	26.14%

5. 매우 아니다		41 명	13.40%

|

16-2. 귀사의 재무/파이낸싱 능력이 탁월한 이유는 무엇입니까?			
전체 합계		34 명	100.00%
1. 탁월한 경영성과		10 명	29.41%
2. 금융/자본시장의 높은 신뢰도		9 명	26.47%
3. 우수한 재무/파이낸싱 체계		8 명	23.53%
4. 높은 자기자본 비율		6 명	17.65%
5. 기타주관식 내용 참조		1 명	2.94%

|

17. 서비스

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17-1. 귀사의 서비스 능력은 경쟁사보다 뛰어납니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		45 명	14.71%

2. 약간 그렇다		116 명	37.91%
3. 보통이다		107 명	34.97%
4. 약간 아니다		32 명	10.46%
5. 매우 아니다		6 명	1.96%

|

17-2. 귀사의 서비스 능력이 탁월한 이유는 무엇입니까?			
전체 합계		161 명	100.00%
1. 우수한 인력		19 명	11.80%
2. 철저한 교육훈련		15 명	9.32%
3. 고객에 대한 이해, 친밀성		109 명	67.70%
4. 양질의 컨텐츠		13 명	8.07%
5. 기타주관식 내용 참조		5 명	3.11%

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18. 외부협력

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18-1. 귀사의 외부와의 협력능력은 경쟁사보다 뛰어납니까?			
전체 합계		306 명	100.00%
1. 매우 그렇다		58 명	18.95%
2. 약간 그렇다		132 명	43.14%
3. 보통이다		102 명	33.33%
4. 약간 아니다		9 명	2.94%
5. 매우 아니다		5 명	1.63%

|

18-2. 귀사의 주요한 외부 협력의 분야는 무엇입니까?			
전체 합계		306 명	100.00%
1. 공동 투자		14 명	4.58%
2. 공동 개발		144 명	47.06%
3. 공동 마케팅		65 명	21.24%
4. 공동 유통		17 명	5.56%
5. 공동 서비스		24 명	7.84%
6. 장기조달계약		24 명	7.84%
7. 기타주관식 내용 참조		18 명	5.88%

|

18-3. 귀사의 주요한 외부 협력기관은 어디입니까?			
전체 합계		306 명	100.00%
1. 대기업		48 명	15.69%
2. 해외 선진기업		11 명	3.59%
3. 해외 현지기업		20 명	6.54%
4. 대학		55 명	17.97%
5. 정부출연연구소		43 명	14.05%
6. 중소기업		114 명	37.25%
7. 기타주관식 내용 참조		15 명	4.90%

|

19. 핵심역량

19-1. 아래의 7대 역량을 중요한 순서대로 번호순으로 선택해 주십시오.

1. 연구개발	2. 생산/제조	3. 물류/유통	4. 영업/마케팅
5. 재무/파이낸싱	6. 상품관련 서비스 (사후관리 등)	7. 외부협력	

Appendix B. Programs for semantic text analysis

```
# -*- coding: 949 -*-
import os
from BeautifulSoup import BeautifulSoup
import nltk

filepath=("D:\Chunk\patent1200")
writepath=("D:\Chunk\\temp")


def htmltotext(path):
files = os.listdir(path)
os.chdir(path)

fp2 = open(writepath+'\\'+'materialtest.txt', 'w')
for each_file in files: #폴더 내의 파일 리스트 부르기
fp = open(each_file, 'r')

soup = BeautifulSoup(fp.read())
fp.close()
```

```
text_parts = soup.findAll(text=True) #html -> text
text = nltk.word_tokenize(''.join(text_parts)) #text -> token
tagged_t = nltk.pos_tag(text) #tagging



cp = nltk.RegexpParser('CHUNK: {<V.*> <DT>? <J.*>? <IN>? <N.*>+}')
#chunk rule

tree = cp.parse(tagged_t)
fp2.write(each_file+'\t')

print each_file
for subtree in tree.subtrees():
if subtree.node == 'CHUNK':
if (
subtree.pprint().count('polyethersulfone') or
subtree.pprint().count('polyvinylidene fluoride')or
subtree.pprint().count('polyethylene')or
subtree.pprint().count('polytetrafluoroethylene')or
subtree.pprint().count('polyamide')or
subtree.pprint().count('cellulose')or
subtree.pprint().count('polypropylene')or
subtree.pprint().count('polyimide')or
subtree.pprint().count('polysulfone')or
```

```
subtree.pprint().count('polycarbonate')or
subtree.pprint().count('polyetherimide') or
subtree.pprint().count('polyvinyl alcohol')or
subtree.pprint().count('polyacrylonitrile')
)!= 0:
print '\t'+subtree.pprint()
fp2.write(subtree.pprint()+', ')
fp2.write('\n')
fp2.close()
if __name__=="__main__":


htmltotext(filepath)
```

초 록

최근 개발도상국뿐 아니라 선진국에서도 국가경제에서 차지하는 중소기업의 위상은 국가 내 기업 수, 고용자 수 및 GDP를 기준으로 절대적인 비중을 차지하고 있다. 미국의 경우 GDP의 50%, 고용자의 절반을 중소기업이 담당하고 있으며 유럽은 전체 고용자의 2/3, 부가가치의 60%가 중소기업에서 창출되고 있다. 한국 내 중소기업의 위상은 흔히 9988로 표현되는데 이는 전체 기업의 99%, 전체 고용자의 88%가 중소기업에 속해 있다는 뜻이다.

이러한 관점에서, 국가차원의 혁신 및 경제 성장 견인을 위해 중소기업의 혁신이 중요하게 다루어져야 한다는 점에는 사회적 합의가 이루어지고 있다. 이를 위한 다양한 형태의 방안이 제시되고 있으나, 중소기업 혁신은 기업의 혁신성 (innovativeness), 다시 말해서 새로운 공정, 제품 및 아이디어를 도입하는 기업의 역량에 좌우된다는 것이 주지의 사실이다.

기업 혁신에 영향을 미치는 핵심요소에 관한 많은 연구가 이루어졌음에도 불구하고, 이론적 차원에서, 혁신성과 관련한 기존 연구가 보완해야 할 점은 다음의 세 가지로 정리된다. 첫째, 기업의 혁신성에 영향을 미치는 혁신요소를 시스템적으로 결합하여 조망하는 부분이 부족하다. 둘째, 같은 맥락에서 시스템적으로 파악된 혁신요소가 시간의 변화에 따라 어떻게 변화하는지에 대한 시각이 부족하다. 마지막으로 기업이 속한 지역에 따른 연구, 특히 한국의 경우에 어떤 양상을 나타나는지 연구된 부분이 부족하다.

다음으로 실무적 방안을 제시하는 차원에서 기업의 혁신성을 강화하는 방안, 즉 새로운 공정, 제품, 아이디어를 탐색하는 방안은 상당한 내부 자원을 필요로 하는 반면, 중소기업은 그 규모의 특성상 제한된 자원으로 인한 어려움이 상존하고 있다.

본 학위 논문은 이러한 문제점을 바탕으로 2개의 모듈을 구성하여 각각의 차원에서 제기된 문제점을 다룬다.

첫 번째 모듈에서는 중소기업에 대한 설문조사를 통해 한국 중소기업의 혁신성 및 혁신성의 변화양상을 연구하여 전반적인 시사점을 도출한다. 구체적으로 다음의 명제를 확인하는 작업을 수행한다. 기존 문헌 연구를 바탕으로 정의된 혁신 요소를 기준으로, 한국 중소기업이 실증적으로 어떻게 유형화되는가, 각 유형별로 혁신성은 어떻게 나타나는가, 마지막으로 각각의 기업 유형이 시간에 따라 어떻게 진화하는가에 대해 파악하도록 한다. 400개 중소기업을 대상으로 한 설문조사를 통하여, 최종적으로 중소기업의 4가지 주요 사업모델이 확인되었으며 각각의 유형은 서로 다른 값을 가진 혁신성 요소로 차별화되었다. 또한 개별 기업의 인터뷰 및 30개 글로벌 강소기업의 추적 조사를 통하여, 파악된 사업 모델으로 연결되는 중소기업의 4가지 사업발전 경로가 제시되었다.

두 번째 모듈에서는 중소기업이 보유한 기술역량을 기반으로 새로운 기술기회를 탐색하는 방법론을 제시하였다. 이는 첫 번째 연구주제에서 각 유형에 속한 중소기업이 다음 단계로 발전하기 위해 필요한 성장 방향을 탐색하는 방법론을 제시하는 것으로서, 기업이 보유한 기술 역량을 구체화하고 특허 정보를 통해 가능한 사업 발전방향을 제시하는 프로세스가 고안되었다.

먼저 중소기업이 보유한 기술을 바탕으로 개발 가능한 응용분야(technology application)을 파악하기 위해, 기업의 기술영역을 대리하는 참조특허집합(reference patent set)을 구성하였다. 그리고 이 참조특허집합을 2차 전방인용(forward citation)하여 확대 특허 집합(expanding patent set)을 구성하였다.

여기서의 가정은 중소기업의 기술역량을 대리하는 참조 특허집합을 전방 인용하는 특허들은 기존의 기술을 활용하는 새로운 응용분야를 내포하고 있다는 것이다. 이후 전문가의 도움

하에 기초 기술응용분야 표를 구성하고 텍스트마이닝을 통해 확장특허집합 내의 특허들을 기술응용분야에 연결하는 과정을 통해 기업의 보유기술에서 파생되는 응용분야를 나타내는 증강된 기술응용분야 표를 제시하는 방법론을 수립하였다.

사례분석으로서 2차전지 분리막을 제조하는 기업을 대상으로 보유기술을 구체화하고 텍스트마이닝을 통해 증강되는 기술응용분야 표를 완성하였으며, 해당 기업의 특허를 표에 투입하여 현재 기술로 접근 가능한 기술응용분야를 복수로 제시하였다. 각각의 경우에 추가로 필요한 연구개발 방향성에 대해서도 기술 키워드를 기준으로 간략하게 제시하였다.

사례 분석 결과, 2차전지 분리막을 제조하는 해당기업의 경우 1차적인 사업확장영역으로서 연료전지 분리막(fuel cell membrane) 응용분야가 제시되었다. 키워드를 기준으로 응용분야로의 진입을 위한 추가 연구개발 방향은 PTFE의 가공과 수소제거기술과 관련한 것으로 나타났다. 다음으로 접근 가능한 유망영역으로는 수처리 분리막, 의료용 혈액투석용 분리막, 의료용 흡수용품(medical absorbent product)의 응용분야가 가능한 것으로 제시되었다.

주요어: 혁신성, 유망기회, 기술기회, 사업 모델, 기술 경영, 중소기업
학 번: 2001-30324