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The study of R&D collaboration, SMEs' survival and growth

: perspective on dynamic capabilities view

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To my mother and my son Hanseung.

Abstract

The study of R&D collaboration, SMEs' survival and growth

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The dynamic capabilities concept has emerged to explain the mechanism of how firms acquire sustainable competitive advantage in a rapidly changing environment. Dynamic capabilities are an important variable that explains the process of translating resources into firm performance (Priem & Butler 2001). Many researchers agree that dynamic capabilities play an important role in transforming a firm's resources into firm performance (Eisenhardt & Martin 2000; Heimeriks & Duysters 2007; Pavlou & El Sawy 2011; Teece, Pisano, & Shuen 1997). However, as the definition of dynamic capabilities is still conceptual, research on the constituents of dynamic capabilities is still underway (Barreto 2010). Empirical research on dynamic capabilities is scant compared with conceptual studies, with sometimes conflicting results among scholars (Zahra, Sapienza, & Davidsson 2006).

The impact of dynamic capabilities on firm performance varies depending on situational factors (Teece et al. 1997), and is both direct and indirect (Protogerou, Caloghirou, & Lioukas 2012). Based on the integrated concept of dynamic capabilities proposed by Teece (2007), this paper compares the direct and indirect impacts of dynamic capabilities on firm performance by analyzing the relationship between dynamic capabilities and R&D collaboration partner selection and the relationship between dynamic capabilities and the performance of firms of different sizes and technological regimes. For an empirical analysis, data from the "2005 SMEs Technology Statistics Survey," published by the Small and Medium Business Administration, was used, and analytical methodologies, such as principal component analysis, probit model with sample selection, and structural equation modeling, were employed.

The relationship between dynamic capabilities and R&D collaboration partner selection was found to be most prominent in seizing capability. As firm size increases, firms are more likely to select market-based R&D partners. This confirms the existence of the disadvantage of "smallness," as firms take market-based R&D partners. The impact of dynamic capabilities was discovered to be greater among larger firms. As for the relationship between dynamic capabilities and R&D collaboration partner selection under different levels of environmental dynamism, the effect of dynamic capabilities was observed in both a relatively stable and rapidly changing environment. This suggests that the impact of dynamic capabilities is not proportional to the rate of change, but depends on the change itself. With regard to the relationship between dynamic capabilities and

firm performance, the impacts of dynamic capabilities on firm survival and firm growth differed only slightly. Dynamic capabilities had a direct impact on firm performance, but their indirect impact was found to be greater.

Keywords: Dynamic capabilities, R&D collaboration partner, firm survival, firm growth, SMEs, technological regime

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Chapter 1. Introduction

1.1 Research background and purpose

As small and medium enterprises make increasing contribution to the job creation and regional development, social and political interest in the SMEs and entrepreneurship are also on the rise (Acs &; Armington 2006; Hoffman, Parejo, Bessant, &; Perren 1998; Zeng, Xie, &; Tam 2010). In particular, as we enter the economy driven by innovation, technology-based SMEs have gained importance as a driver of growth. Firms try to obtain valuable, rare, inimitable, non-substitutable ('VRIN') in order to maintain competitive advantage (Barney 1991). However, SMEs, with disadvantage of smallness and newness, find it difficult to access VRIN resources -- a source of competitive advantage and thus they cannot grow or survive as much as the society expects (Aldrich &; Auster 1986; Stinchcombe 1965).

As product lifecycle is shortened, and complexity of consumer demands increases, the R&D costs are rising, and to cope with uncertainty in markets, firms are increasingly relying on external knowledge and resources (Cefis &; Marsili 2006; Chesbrough 2003; Freeman 1991). Many managers expect a lot of profits from collaboration, and believe that collaboration is the effective strategy to obtain insufficient resources (Aldrich &; Auster 1986; Audretsch &; Feldman 2003; Baum, Calabrese, &; Silverman 2000; Muscio

2007; Staber 1998; Stuart 2000). In particular, R&D collaboration is recognized as an important strategy to enhance professionality of SMEs and secure resources necessary to create innovations (De Jong &; Freel 2010; Edwards, Delbridge, &; Munday 2005; Franco &; Haase 2013; Lin &; Wu 2010; Rothwell &; Dodgson 1994). SMEs can access external resources and knowledge through collaboration, and various external knowledge acquired through collaboration have positive impact on economic and innovative performance of firms (Bougrain &; Haudeville 2002; Gilsing, Nooteboom, Vanhaverbeke, Duysters, &; Van Den Oord 2008; Lin &; Wu 2010) as well as firm survival (Gulati &; Singh 1998; Street &; Cameron 2007). As firms' collaboration increases, the impact of external resources and knowledge on firm performance rises. Accordingly, the strategy to effectively obtain and efficiently utilize external resources and knowledge is gaining importance (Ahuja &; Katila 2001; Cohen &; Levinthal 1990; Laursen &; Salter 2004; Zahra &; George 2002).

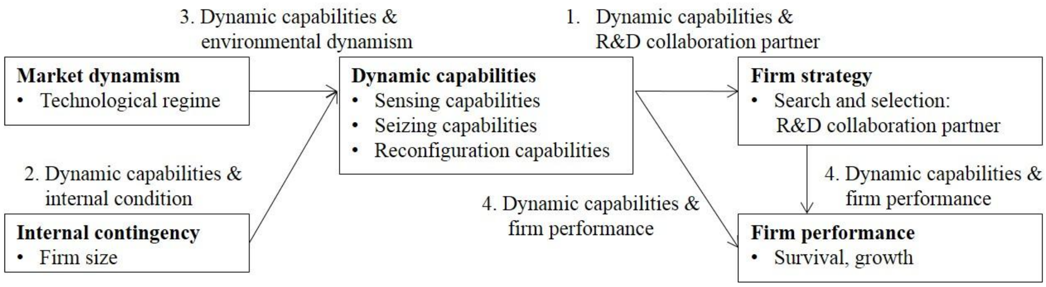
SMEs has flexibility and professionality for innovation creation, but they have limited access to materials (Edwards et al. 2005; Nooteboom 1994; Rothwell &; Dodgson 1994). Hence, the impact of obtaining external resources through collaboration become more significant for smaller firms (Baum et al. 2000; Gilbert, McDougall, &; Audretsch 2006; Rothwell &; Dodgson 1991). At the same time, smaller firms takes more risks associated with R&D collaboration (Lerner &; Merges 1998; Sulej, Stewart, &; Keogh 2001). Therefore, one cannot simply conclude that R&D collaboration by small firms lead to enhancement of firm performance. Performance from R&D collaboration is not generated by simply working together with R&D partners with specific resources. In order to maximize the effect of R&D collaboration, firms should choose the most suitable R&D collaboration partners, and should cultivate internal capabilities to integrate external resources from partners and their own internal resources to create new resources. Teece et al. (1997) defined the internal capability of firms to obtain, integrate, and redeploy resources to survive amid changes of market and technology as "dynamic capabilities", and argued that dynamic capabilities affect firm performance.

The concept of dynamic capabilities has emerged as a mechanism to attain sustainable competitive advantage under a rapidly changing environment that is difficult to grasp with resources and capabilities alone. That is, dynamic capabilities are an important variable that explains the process of connecting resources to firm performance (Priem &; Butler 2001). Many researches have agreed that dynamic capabilities play an important role in converting resources into firm performance (Eisenhardt &; Martin 2000; Heimeriks &; Duysters 2007; Pavlou &; El Sawy 2011; Teece et al. 1997). However, the concept of dynamic capabilities has not been clearly defined. During the last ten years, dynamic capabilities have been called absorptive capability (Cohen &; Levinthal 1990), combinative capability (Kogut &; Zander 1992), or adaptation capability (Lu et al. 2010). Until recently, researches about dynamic capabilities have been largely focused on the definition of dynamic capabilities and on the relationship between dynamic capabilities and firm performance (Barreto 2010). However, they have not been consistent in their outcome and sometimes shown conflicting results among researchers (Zahra et al. 2006).

The impact of dynamic capabilities on firm performance depends on situational factors of firms (Teece et al. 1997), and dynamic capabilities have both direct and indirect impact on firm performance (Protogerou et al. 2012). This paper will define dynamic capabilities by referring to the concept of integrated dynamic capabilities proposed by Teece (2007), and will try to identify the direct and indirect impact of dynamic capabilities on firm performance by testing the relationship between dynamic capabilities and R&D collaboration strategy selection and the relationship between dynamic capabilities and firm performance, while taking into account situational factors such as firm size, age, and technological regime.

1.2 Research range and methods

This study is divided into four categories. First, it is to review the concept of dynamic capabilities by gathering previous literature concerning theories of dynamic capabilities, and to analyze relationship between dynamic capabilities and R&D collaboration strategy selection. Second, it is to classify internal contingency of firms by firm size and to identify conditions where dynamic capabilities can be activated. Third, it is to define external market dynamism of firms by technological regime, and to understand the role of dynamic capabilities depending on market dynamism. Fourth, it is to analyze the relationship between dynamic capabilities and firm performance in the two contexts of "dynamic capabilities – R&D collaboration partner selection – firm performance (*indirect* *effect*)" and "dynamic capabilities – firm performance (d*irect effect*)" (Figure 1).



[Figure 1] Scope of research

This study consists of six chapters. The second chapter comprehensively analyzes and reviews the concept of dynamic capabilities – the key word of this study -- and existing theoretical discussions concerning internal and external conditions of firms and firm performance. The third chapter derives research hypotheses on the impact of dynamic capabilities under different internal and external conditions; on the relationship between dynamic capabilities and R&D collaboration partner selection; and the relationship between dynamic capabilities and firm performance. The fourth chapter explains sample, variables, and empirical analytical methodologies employed in this paper. The fifth chapter looks into the results of empirical analysis. The sixth chapter presents the conclusion of this paper and future direction of research.

1.3 Significance of research

Previous studies of dynamic capabilities have focused on theoretical discussions. In their empirical analyses, sample sizes were relatively small so that it was difficult to generalize the research outcomes. Although researchers have agreed that dynamic capabilities have an impact on firm performance, there have been no consistent explanations on how that works (Helfat et al. 2007). Moreover, dynamic capabilities concept was considered only under a rapidly changing environment (Teece et al. 1997; Teece 2007), and thus discussions on the role of dynamic capabilities under diverse environmental characteristics are scarce. More recently, some researchers argued that the impact of dynamic capabilities on firm performance is affected by firm's internal conditions as well as external environment. This paper expands the range of empirical research of dynamic capabilities by using large sample regarding dynamic capabilities and firm performance, and looks for the finding that the role of dynamic capabilities on firm performance varies across different internal and external conditions of firms. This study investigates a logical linkage between dynamic capabilities and R&D collaboration partner selection, and compares the direct and indirect impacts of dynamic capabilities on firm performance.

This study made three contributions. First, existing researches considered dynamic capabilities, R&D strategy, and firm performance as separate components, not in a single logical sequence context. However, this study considered "dynamic capabilities – R&D collaboration partner selection – firm performance" as a continuous flow, and thus will present a more comprehensive understanding about the relationship between dynamic capabilities and firm performance. In addition, by comparing direct and indirect impacts of dynamic capabilities on firm performance, this paper empirically tests conceptual hypotheses of previous researches concerning dynamic capabilities and firm performance.

Second, in previous literature on dynamic capabilities, environmental change or environmental dynamism was only introduced as a concept. Dynamic capabilities are significant in that, unlike operational capability, dynamic capabilities cope with environmental change. In this study, by considering environmental dynamism in empirical analysis, the impact of environmental dynamism that has been presented only as a concept is empirically confirmed. This paper expects to provide an evidence that can assess the role of dynamic capabilities by environmental dynamism.

Third, this study considered firm size – internal factor of firms to analyze how dynamic capabilities can help resolve the limit of 'smallness' that is difficult to overcome in the short run. This attempt is meaningful as the result can be used to establish a policy to support SMEs such as expansion of opportunities for R&D collaboration.

This study goes beyond limitations of previous researches that have largely focused on the conceptualization of relationship between dynamic capabilities and firm performance by presenting concrete evidence on the relationship between dynamic capabilities and firm performance through empirical analysis, and by understanding that such relationship varies depending on internal and external conditions of firms. I expect this paper to present a comprehensive framework concerning dynamic capabilities and firm performance.

Chapter 2. Theoretical Background

2.1 Firms and resources

2.1.1 Purpose of inter-firm collaboration

Over the last 30 years, inter-firm collaboration has gained steadily increasing attention in terms of socio-economic perspective as well as policy-making. As technological change accelerates, it is impossible for a firm to conduct all necessary processes for innovation (Garavaglia 2006). A firm utilizes collaboration to share, exchange, and internalize external resources (Lavie 2007). Hamel (1991) proposed inter-firm collaboration as a shortcut to accommodate new knowledge. Collaboration is certainly the most effective means to obtain external knowledge (Dussauge et al. 2004; Mowery et al. 1996). Firms can access tangible assets and intangible assets of partners through collaboration (Lavie 2007), and expand innovative capacity (Ahuja 2000), knowledge stocks (Inkpen 2000), and organizational efficiency (Burt 2000). As resources of partners accessible through collaboration are used as complementary assets of a firm (Mowery et al. 2002; Rothaermel 2001), collaboration has a direct impact on firm performance (Barney 1991). In addition, as collaboration gives firms an opportunity to learn resources and capacity of their partners (Doz 1996), it can reinforce internal resources, which have a positive impact on firm performance (Lavie 2006). However, selecting partners with high technological capability does not guarantee access to and use of external knowledge (Dyer and Singh 1998). In order to make use of partner's knowledge efficiently, a firm needs to have a capacity to understand, utilize and absorb the partner's knowledge (Cohen and Levinthal 1990). Although a firm acquired external resources through collaboration, collaboration could lead to a failure unless the firm has a capability to use and internalize external resources within the firm (Hamel et al. 1989; Hitt et al. 2000).

Resource-based view stresses the difference of resources of firms as the source of competitive advantage (Barney 1991). Prahalad and Hamel (1994) argued that different performances produced by firms under the same environment are attributed to internal resources of firms rather than the environment. The competitiveness of a firm is determined by resources which are valuable, rare, and impossible to imitate and substitute (Barney 1991; Conner and Prahalad 1996; Eisenhardt and Martin 2000). Collaboration is one of effective strategies to obtain VRIN (value, rarity, inimitability, non-substitutability) resources necessary for firms.

Firms cooperate with the outside world with a view to entering new market, seize new knowledge, reduce R&D costs and risks (Elmuti and Kathawala 2001). According to Das and Teng (2000), firms choose collaboration because collaboration creates new resources that can maximize firm value by combining external resources with internal resources while firms use VRIN resources held by partners. External collaboration begins with selection of partners (Kanter 1994). Selecting partners that have resources that can strengthen or complement internal resources is the most important factor in achieving success through collaboration (Hamel et al. 1989).

One cannot overemphasize the importance of selection of good partners because the success of collaboration depends on the choice of partners (Hitt et al. 2000; Iyer 2002). CEOs spend a lot of time in searching for potential partners (Kanter 1994). The process of searching for and selecting partners is affected by ‘bounded rationality’ of a firm (Simon 1991). That is, although there is a partner that possesses the very resources needed by a firm, the firm cannot search for all potential partners, and thus it search for partners only within its reach (Oliver 2001). Because the selection of partners is in many cases based on trust and relationship with the partner, rather than on perfect information about the partner (Oliver 1997; Powell 1990). Accordingly, cases of selecting wrong partners due to imperfect information are often found (Lampel and Shapira 2001).

2.1.2 High failure rate of inter-firm collaboration

30 to 70% of collaborations fail (Bamford et al. 2003; Elmuti and Kathawala 2001; Kale and Singh 2007). This suggests that resources acquired through collaboration does not easily translate into an improvement in firm performance. According to previous researches regarding collaboration and firm performance (Gulati and Singh 1998; Hamel et al. 1989; Park et al. 2002; Williamson 1991), firms can reduce costs and risks by accessing resources and core capabilities of partners through collaboration. However,

participation and collaboration do not automatically lead to enhanced performance (Bamford et al. 2003; Bleeke and Ernst 1991; Devlin and Bleackley 1988; Gulati 1998). Firms can lower costs and risks through collaboration, but still they should bear costs of collaboration (Hennart 1991), and earnings from collaboration need to be shared with partners. Hence the net profits earned by a firm are not as significant as expected (Shan 1990). And the choice of improper partners increases risk to a firm (Brouthers et al. 1995).

The causes of failure of collaboration include lack of trust between partners, unclear objectives of collaboration, lack of adjustment and coordination, and difference in method of implementing collaboration (Elmuti and Kathawala 2001). Recent studies on collaboration focus on firms' internal strength by answering to questions: “Why does collaboration fail” or “Why do firms make differential results while all have access to the same resources through collaboration?” (Elmuti and Kathawala 2001; Hoffmann and Schlosser 2001; Shi et al. 2012).

2.1.3 Limits of RBV and emergence of dynamic capabilities view

As external environments of companies change rapidly, some argued that internal resources advocated by the resource-based view does not guarantee competitiveness (Eisenhardt and Martin 2000; Teece et al. 1997). As resources tend to be linked with the environment, they need a lot of time to be able to accommodate changes in the environment. Many firms, despite having sufficient resources, do not make success continuously because the internal resources and capabilities of those firms did not evolve to cope with changes in the environment (O'Reilly III and Tushman 2008). VRIN resources -- the key elements of resource-based view -- improve firm performance at a specific situation and timing, but fail to explain dynamic process of corporate behavior of acquiring and creating new resources to identify and cope with changes in the environment (Teece et al. 1997; Zollo and Winter 2002).

Resource-based view does not explain properly how and why a certain firm, under unpredictable environmental change, was able to achieve a superior performance (Morgan et al. 2009). In addition, the resource-based view does not clarify how resources are translated into performance, and how resources are related to capabilities (Mosakowski and McKelvey 1997; Priem and Butler 2001). To complement this static resource-based view and to explain activities and performance of firms under a changing environment, a new concept of dynamic capabilities view has emerged.

The change of research views on firms with a focus on resources is summarized in Table 1. From the resource-based view, difference of firm performance comes from heterogeneity of resources held by firms (Wernerfelt 1984), and in addition to resources, there are capabilities as determinants of firm performance (Barney 1991). As the focus of research about firms has shifted from "Why is firm performance different?" to "Why is a successful firm different?", some scholars argued that a firm is a combination of resources and capabilities, and researchers began to be more interested in 'capabilities' of firms. In the corporate research literature, types of resources were segmented, and the importance of knowledge as a managerial resource was recognized. Later, researches on "Why are continuously succeeding firms different?" began to introduce the concept of dynamic capabilities to cope with changes in the environment (Teece et al. 1997).

[Table 1] Change of views of researches on resources and firms

Research views	Why are firms different?	Why are successful firms different?	Why are sustainably successful firms different?
Key arguments	A firm are a combination of resources. Difference in firm performance is attributed to difference in resources among firms. Difference in resources held by firms is due to market imperfection	A firm is a combination of resources and capabilities. Performance determinants are divided into resources possession and resources utilization. Resources and capabilities are firm-specific.	A firm is a capability transformation system. Knowledge creation and dynamic capabilities are important to acquire resources and learn capabilities
Theoretical contribution	Defined resources Explained resources with rents. Economic approach to resources	Defined capabilities Expanded economic rents Recognized the importance of knowledge	Defined dynamic capabilities Identified relation between dynamic capabilities and knowledge creation Recognized the importance of change

			in a competitive environment
Scholars	Wernerfelt (1984) Barney (1986)	Barney (1991) Grant (1991) Prahalad and Hamel (1994)	Teece et al. (1997) Eisenhardt and Martin (2000) Makadok (2001)

2.2 Concept of dynamic capabilities

Although a new paradigm of dynamic capabilities emerged from the limitations of the resources-based view, it has locality and cumulativity of learning as attributes of evolutionary economics. Here, locality of learning means the exploration and development of new technology occurs in the neighborhood of technologies already in use. Cumulativity means the present technological development of a firm is based on the past experiences of production and innovations and it continues to progress along the connection line in order to solve a specific problem. According to the theory of evolutionary economics, firms do not take the most optimized alternative to solve problems quickly at a single attempt in order to make decision in a situation with uncertainty and bounded rationality. Rather, firms first choose suitable alternatives and gradually improve and modify them subsequently (Zahra et al. 2006). In particular, in a dynamic and unpredictable environment, firms try to adapt to shifts in business environment by substituting existing process with a new process (March 1991). In order to obtain and maintain competitive advantage, firms build capability to deal with environmental changes by reinforcing knowledge assets they have accumulated (Teece et al. 1997). As changes accelerate in all industries, firms should acquire resources to generate high performance while responding to changes in the environment (Daft 2010).

Dynamic capabilities are classified into the ability to renew existing resources and capabilities, and the ability to create resources and capabilities that they do not own. Teece et al. (1997) proposed that dynamic capabilities build upon process, position, and path. ‘Process’ is a series of methods taken by firms and is represented by coordination, integration, learning, practices, reconfiguration, and transformation. That is, ‘process’ means a firm’s behavioral pattern as in how a firm interacts with external parties, and how a firm acquires and allocates resources. ‘Position’ means the environment in which a firm operates and assets it currently possesses. Competitive environment of a firm is represented by the level of competition within the industry, threats from new entrants, threat from substitutes, and bargaining power of consumers and suppliers. ‘Assets’ comprise technology, financial resources, organization, system, and market capital. ‘Path’ means the scenario of future environment based on the experience of the past and the present.

Dynamic capabilities are defined as an ability to adapt to changes of business environment efficiently and promptly. Teece et al. (1997) defined dynamic capabilities as an ability to integrate, create, and re-configure internal and external resources of the firm in order to respond to rapidly changing external environment. Teece (2007) argued that dynamic capabilities are an inimitable property of a firm to cope with changes of customers and technology. Dynamic capabilities are an ability to redesign a firm in line with changes in the business environment, to develop new products and process, and to reorient and implement major business models. Success and failure of a firm depends on the development and implementation of dynamic capabilities. Dynamic capabilities are a concept that supports an evolutionary adaptability to an environment (Helfat et al. 2007).

Dynamic capabilities are defined in various ways under the basic premise of "response to changes in the environment" (Table 2). Teece et al. (1997) proposed creation of new knowledge and dynamic capabilities through learning in order to obtain competitive advantage and stressed that only firms that cope with rapid changes through a system that adjusts capabilities can continue to grow. Eisenhardt and Martin (2000) defined dynamic capabilities as organizational and strategic routines adopted to integrate new resources. Winter (2003) viewed dynamic capabilities as an ability to expand, modify or recreate specific resources to fit the purpose of the firm, going beyond possession of resources. Zahra et al. (2006) defined dynamic capabilities as a capability to restructure corporate resources and routines in accordance with methods taken by decision makers of the firm. Dynamic capabilities can be understood as a firm-specific capacity, process or routine to modify resources intentionally in order to deal with environmental change (Teece 2007).Dynamic capabilities are basically processes or routines which are internally established and internalized (Makadok 2001), and rely on experiences and resources already held by the firm (Eisenhardt and Martin 2000; Zollo and Winter 2002).

[Table 2] Definition of Dynamic capabilities

Scholars	Definition
Teece and Pisano (1994)	Combination of a firm's ability and capacity to consider development of new product and process in order to respond to shifts in business environment.
Teece et al. (1997)	A firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environment.
Eisenhardt and Martin (2000)	Organizational and strategic routines adopted to integrate new resources in the process of market entrance, collision, split, evolution, and decline, or a clear process of integrating, re-configuring, acquiring or separating resources in response to the changing market conditions
Teece (2000)	Sensibility to capture an opportunity promptly and competently
Zollo and Winter (2002)	Collection of learned and stabilized behavioral patterns a firm chooses in order to build and modify operational routines systematically toward better efficiency
Winter (2003)	Organizational ability to expand, modify, and develop

	capabilities
Zahra et al. (2006)	Ability to reconfigure routines under the judgment of decision makers that it contributes to the future of a firm
Helfat et al. (2007)	An organizational capability to create, expand, modify resources intentionally
Wang and Ahmed (2007)	1) Absorptive capability 2) Innovation capability 3) Adoption capability
Teece (2007)	1) Detection of opportunity and threat 2) Acquisition of opportunities 3) Ability to coordinate and integrate
Barreto (2010)	A firm’s potential and systematic problem-solving capacity; to modify resources base through timely market-oriented decision-making to address opportunities and threats
Weerawardena and Mavondo (2011)	Ability to detect types of opportunities and threats, and to seize opportunities, and to integrate, protect, and enhance resources

Teece (2007) divided dynamic capabilities as 'sensing' capability to detect opportunities and threats, 'seizing' capability to seize the opportunities, and reconfiguration capability to improve, combine, protect, and when necessary, re-configure resources held by a firm. Sensing capability means activities of scanning and monitoring environmental changes, and seizing capability involves creation of product structure and business models toward creativity and innovation, brand management, and structure organization (O'Reilly III and Tushman 2008; Teece 2007). Reconfiguration capability means coordination of resources including redeployment of existing resources, management of complementary assets, and process innovation (Fischer et al. 2010; Grimaldi et al. 2013; Teece 2007). Zott (2003) defined dynamic capabilities as an ability to create new methods of arranging resources through imitations and experimentations and saw redeployment of resources as dynamic capabilities. In addition to resources deployment, dynamic capabilities include attributes such as coordination and integration of resources (Helfat and Raubitschek 2000).

Seizing and capturing an opportunity is affected by proper judgment and implementation (O'Reilly III and Tushman 2008). Seizing capability allows leaders who establish corporate vision and strategy to determine the purpose of collaboration, and to decide resources deployment and its timing. Without seizing capability, it is impossible for a firm to make a timely decision and carry out strategies at the right time even though the firm sensed opportunity and threats. The key to sustainable corporate success is an ability to redeploy resources and readjust corporate structure as market and technology change (Teece 2007). Firms need a leader who is capable of redeploying resources necessary to capture a new opportunity to grow successfully in the long run. Eisenhardt and Martin (2000) maintained that the redeployment of existing resources is necessary for long-term competitive advantage, and that the ability of a manager to establish, integrate, and reconfigure existing internal and external capabilities to address environmental change is the source of a sustainable competitive advantage. The role of an entrepreneur and board of directors in a firm is to integrate internal and external activities, and to change the firm in accordance with changes in market and technology (Kodama 2007). In particular, as strategic management activity of small and medium sized firms is directly controlled by entrepreneurs (or owners) (Mintzberg 1991), the commitment of an entrepreneur to reconfigure resources in a small business is directly linked to resources redeployment capabilities.

2.3 R&D collaboration and dynamic capabilities

Firms are more likely to choose again the strategies that were effective in the past due to their inclination to rely on the past experience and path (Cyert and March 1992; Nelson and Winter 1982; Stuart and Podolny 1996). However, if the environment and landscape of firms changed, then the best practices of the past would be no longer the best (Quinn and Cameron 1983). Firms should adjust the focus of decision-making in accordance with environmental change (Burt 1992). For the successful R&D collaboration, it is necessary to search for potential R&D collaboration partners who can offer complementary resources (Hoffmann and Schlosser 2001).

R&D collaboration offers firms an opportunity to acquire resources of partners (Inkpen and Dinur 1998). To acquire resources of partners, they need an ability to comprehend and internalize resources of partners. As intangible assets such as knowledge, technology, and information gain importance, and a proper response to environmental change and innovative activities is emphasized, dynamic capabilities are drawing attention. In particular, in the sector where technology changes rapidly, knowledge necessary for innovation is widely dispersed. Therefore external knowledge needs to be acquired to achieve sustainable innovation, and dynamic capabilities should be cultivated to recognize external knowledge (Rothaermel 2009).

Dynamic capabilities are distinguished from operational capability to operate firms daily (Winter 2003). Operational capability employs current technology with current methods to offer existing products and services to the same customers (Helfat and Winter 2011). On the other hand, dynamic capabilities have a direct impact on the change of firm strategies, i.e. adjust firm as the environment changes (Zahra et al. 2006). Firms that have developed an advanced level of dynamic capabilities are more prompt in detecting opportunities and threats and can easily adopt suitable strategies to them. Dynamic capabilities help them to take optimal strategies necessary for developing their capabilities, ultimately increasing firm performance (Wang and Ahmed 2007). Searching for wider area help firms access to richer range of knowledge, and thus increases chance of finding solutions to problems faced by firms (March 1991), and chance of creating innovation (Fleming and Sorenson 2001; Nelson and Winter 1982). Firms can be offered new knowledge, and reduce time and costs necessary for technology development through various external sources (Koka and Prescott 2008; Laursen and Salter 2006; Powell et al. 1996; Simard and West 2006). Small and medium sized enterprises are limited in acquiring dynamic capabilities to detect opportunities due to limited internal resources (Laursen and Salter 2004). Firms determine the level of detection of external knowledge and recognize and select proper partners, based on their capabilities to detect (Laursen and Salter 2013; Love et al. 2013). Dynamic capabilities determine the level of recognizing and assessing R&D collaboration partners.

Many empirical studies showed that excellent researchers and latest R&D results at colleges are effective in complementing insufficient resources of firms, and contribute to innovation and growth of firms (Eom and Lee 2010; Lööf and Broström 2008; Mansfield 1997). Researches of colleges led to numerous innovations, and accelerated innovation (Mansfield 1991). Moreover, universities and public research institutes are important sources of ideas that offer innovative ideas to firms (Cohen et al. 2002). Universities are core agents of creating basic knowledge (Simard and West 2006), and make a decisive impact on innovation creation by firms (Zeng et al. 2010). Firms can utilize sophisticated R&D knowledge and human resources through collaboration with universities and public research institutes, and maximize R&D productivity and profits (Barnes et al. 2002; Fey and Birkinshaw 2005; Pekkarinen and Harmaakorpi 2006; Wang and Shapira 2009). They cooperate with universities and public institutes to measure technical and commercial feasibility of a new technology (Mansfield 1991; OECD 2008; Vanhaverbeke 2006). Universities are stable, reliable partners (Ahrweiler et al. 2011). Furthermore, new firms can enhance reliability and reputation in the market through collaboration with universities (Ahrweiler et al. 2011; Oliver and Liebeskind 1997). Because firms do not see universities and public research institutes as competitors, they tend to prefer cooperation with universities (Tidd and Trewhella 1997). Small and medium sized firms partner with universities in order to solve problems of technology (Santoro and Chakrabarti 2002), and to sharpen the edge of core technology (Fukugawa 2005). Particularly, technology intensive firms think highly of partnership with universities (Zucker et al. 2002).

Theories of open innovation view the involvement of external partners such as customers in the process of internal innovation as an important factor of successful innovation (Gassmann 2006). Collaboration with customers promotes development of a new product and creation of innovation by small and medium firms (Kaminski et al. 2008; Kaufmann and Tödtling 2001). Small and medium sized firms often obtain knowledge and ideas about new technology and products through contracts with major customers. Collaboration with customers is the most important part of inter-firm collaboration, and is the source of information for significant innovation, and greatly helps create innovation (Amara and Landry 2005; Robson and Bennett 2000). In particular, on the supply network (vertical network), small and medium sized firms have opportunities to learn organizational structure of larger firms as well as their technology (Dankbaar 1998).

Firms that acquired legitimacy in the market can easily obtain survival, resources, rights and competitiveness (Baum and Oliver 1991). Legitimacy is essential for every firm, and is more important for small firms and new ventures which strive to establish their own business areas (Carroll 1983; Hannan and Freeman 1977). Collaboration is one of the effective means to strengthen a firm’s legitimacy (Eisenhardt and Schoonhoven 1996). Collaboration with partners with high social position helps enhance firm reputation and position (Stuart 2000).

Alliance with large firms having rich physical resources give a positive impact on innovations, growth, and survival of SMEs (Stuart et al. 1999), and also facilitates SMEs’ entry into a new market (Robson and Bennett 2000). According to Rothwell and Dodgson (1991), as large firms have an advantage in terms of physical resources in creating innovation, SMEs can more easily obtain resources through collaboration with larger firms. Collaboration with large firms allow SMEs an access to useful information about new technology, new market, and process improvement, thereby making positive impact on product innovation and process innovation of SMEs (Whitley 2002). In addition, collaboration with large firms increases confidence in products of SMEs (Stuart et al. 1999), helps create new customers, and enhance brand awareness of SMEs (Doz 1987).

2.4 Firm size and R&D

Schumpeter first argued that with the increase of production factors, technological innovation is a main driver of economic growth. He confirmed that the rapid economic growth of the United States in the early 20th century showed that the essence of market in capitalism does not lie in its adjustment function, but in a drive that generates dynamic development. He explained why large firms with monopolistic strength have an advantage in technological innovation as follows. First, technological advancement requires massive R&D investment and financing. Large firms is better positioned to obtain R&D resources. Large firms can enjoy incentives of technological innovation through pricing and monopoly profits based on their monopolistic strength. Moreover, by diversifying the sources of financing, large firms can diversify risks more easily than SMEs. Second, large firms can enjoy scale of economy in employing technological manpower and facilities. Large firms can appoint professional managers to manage their organizations efficiently, utilize various external technological network, use scientific and technological resources and experienced human resources, and access expensive research equipment in their internal research institutes. This shows that at the early phase of technological development, there lie big differences between large firms and SMEs. Third, bigger firms can use the results of technology development more efficiently. Larger firms are in a better position to transform technological development results into products and increase profits. With diverse marketing capability and production activities, large firms can identify customer needs more competently than SMEs, giving them an advantage in product distribution network and services. This strength facilitates their exploration of new markets. Fourth, bigger market share enables firms to enjoy more cost savings. Large firms have a better understanding of the whole process of technological development than SMEs. In fact, large firms can easily adjust unit price in product designing, employment of production processes, and supply of raw materials.

Organizational ecology stressed that the fact that organizations have an inertia is not an absolute proposition but a relative concept in response to environmental change (Hannan and Freeman 1993). That is, firms do not reject changes at all times, but when changes happen rapidly, it is rather difficult for them to predict environmental change and to adapt themselves to and catch up with those changes. Inertia of an organization is proportional to the size of the organization. Generally, larger firms are likely to have greater inertia. The inertia of firms can be changed by dynamic capabilities that predict changes and adjust their resources and capabilities (Day and Wensley 1988; Spanos and Lioukas 2001). When the limitation of smaller firms cause lack of internal recourses and capabilities (Aldrich and Auster 1986; Stinchcombe 1965), collaboration is an effective strategy to obtain insufficient resources (Aldrich and Auster 1986; Audretsch and Feldman 2003; Baum et al. 2000; Muscio 2007; Staber 1998; Stuart 2000). In particular, with increasing R&D costs associated with shorter product cycle and rising complexity of consumer demands as well as climbing uncertainty of market, firms' innovation depends significantly on their ability to acquire external knowledge effectively (Cefis and Marsili 2006; Chesbrough 2003; Freeman 1991). Thus R&D collaboration activity is regarded as an important strategy to acquire resources necessary to strengthen firms' professionalism and to create innovation (De Jong and Freel 2010; Edwards et al. 2005; Franco and Haase 2013; Lin and Wu 2010; Rothwell and Dodgson 1994).

Small firms often have an organic structure that can flexibly respond to dynamic environment. Small firms experience difficulties in growth and survival due to lack of physical resources necessary to innovate, but they are more ready to create innovation because of flexible corporate structure conducive to prompt decision making (Edwards et al. 2005; Nooteboom 1994; Rothwell and Dodgson 1994). An organic organization, unlike a mechanical structure, is a flexible entity with dispersed authorities and open communication. Besides, organic organizations respect autonomy of members, their individual inclinations and attitudes, and tend to be more actively engaged in exchanges with external groups (Mintzberg 1991). On the other hand, bureaucratic and mechanic organizational structures face difficulty in adapting themselves to rapidly changing environment. A flexible, organic organizational structure is more suitable to creative learning process than mechanical organizations, and thus it is better positioned to create innovation (Aiken and Hage 1971; Burns and Stalker 1961) .

2.5 Environmental dynamism and technological regime

In the conceptual research on dynamic capabilities and firm performance, environmental factor is highly emphasized (Eisenhardt and Martin 2000; Teece et al. 1997; Zahra et al. 2006), but there is hardly any empirical research to focus on the impact of environmental factors on the relationship between dynamic capabilities and firm performance. Eisenhardt and Martin (2000) argued that dynamic capabilities are procedure of continuously learning new knowledge to cope with the environment, and firms can continuously achieve high performance through dynamic capabilities in a dynamic environment. And Teece et al. (1997) also argued that in order to cope with non-linear and unpredictable environment promptly, firm's ability to build, integrate, redeploy internal and external capabilities is the source of sustainable competitive advantage, and the core concept of dynamic capabilities is an ability to efficiently and promptly respond to the external environment. Levitt and March (1988) defined learning as the process of encoding inferences from history into routines that guide behavior, and argued that firms with a high level of dynamic capabilities can institutionalize and materialize new knowledge and experience they face in a dynamic environment in a way to raise their competitive advantage swiftly, and thus they can produce higher performance than those with lower level of dynamic capabilities.

Lifecycle of products and cycle of business models have become shorter, and changes in business environment take place incessantly (Hamel 2002). Accordingly, firms have to search for a new opportunity in an uncertain and dynamic environment in order to achieve performance from the current business activity. McArthur and Nystrom (1991) argued that because environmental factors interact with a strategy that affects firm performance, firms should consider environmental dynamism as well as lifecycle of products and level of internal resources when they establish strategies. Technological advancement, and change of consumer desire increase environmental dynamism. Dynamic environment is caused by firms' innovation activities as well. Miller (1987) found that innovative strategy of firms for a new product helps them cope with competitors' innovation, gives them an opportunity for a new competitive advantage, and induces them into a dynamic environment as the new product creates new and highly variable market sector. Highly dynamic environment is an environment where uncertainty about customers and competitors is high and changes in the market are significant, and industrial innovations and R&D activities occur frequently (Miller 1987).

Technological regime -- one of the core concepts of evolutionary economics -- is a core element that determines innovation pattern of an industry, and deals with technological environment of firms where innovation activities take place (Malerba 2004; Malerba and

Orsenigo 1996). Technological regime includes the opportunity of technology, appropriability of innovation, cumulativity of innovation, and knowledge base. Opportunity of technology means a probability of success from the investment of innovation activities. Appropriability of innovation means a probability of protecting innovation from imitation and earning profits from innovative activities. Cumulativity of innovation indicates the extent to which new knowledge creation is based on existing knowledge. Opportunity, appropriabillity, and cumulativity vary across industries, leading to different investment in innovation and chance of innovation across industries. In an industry with low appropriability and cumulativity, entry barrier to innovation is low and the hierarchy of innovation firms is unstable. In this case, innovation intensity is weak and a competitive market structure allowing free entry is formed. Meanwhile, in an industry with high level of appropriability and cumulativity, entry barrier to innovation is high and the hierarchy of innovation firms is stable, and innovation intensity is high, and an oligopolistic market structure is formed (Breschi et al. 2000; Malerba and Orsenigo 1996). Higher opportunity of technology and appropriability of innovation mean more investment on innovation. Lower opportunity and appropriability lead to less investment on innovation. Higher cumulativity - continuity of innovation - increases chance that innovation firms will succeed in subsequent innovations (Breschi et al. 2000). Higher technological opportunity, higher appropriability, and stronger cumulativity of innovation bring about more innovation activities and knowledge creation. Industrial innovation is affected by technological regimes. Industries with higher opportunity, appropriability, and cumulativity tend to have more innovative activities than those with lower opportunity, appropriabililty, and cumulativity.

Industries can be classified into a high-tech industry where technological competition is important and a low-tech industry where competition is not intense. High-tech industries have higher opportunity, appropriability, and cumulativity while low-tech industries have lower opportunity, appropriability, and cumulativity. These differences in technological regime generate difference in innovation activities. That is, variety of innovations flourish in highly competitive high-tech industries whereas innovations are less noticeable in low-tech industries where non-technology competition like prices, brands, or distribution is more relevant than technology competition (Marsili 2002). High-tech firms are devoted to technological innovation to survive while low-tech firms employ innovation as a means of differentiation. Malerba and Orsenigo (1996) showed that different technological regimes lead to difference in technological innovation activities and outcome. Firm's routines of using internal and external knowledge resources vary due to difference of technological regimes of each industry. Hence, R&D collaboration relationship reflects technological regime of each industry. In a high-tech industry, as competitive advantage can be attained through technological innovations, R&D collaboration to acquire and spread technology is active (Lewis 1992).

Many scholars thought that the key to dynamic capability is firm's ability to efficiently and promptly respond to shifts in business environment. Teece et al. (1997) argued that if organizational, technological skills and routines can recognize rapid shifts in markets, and redeploy resources and processes to meet the needs of the environmental change, sustainable competitive advantage can be obtained in a rapidly changing market. This suggests that dynamic capabilities are inimitable corporate capability that is indispensable to cope with technological advancement and customer change (Teece 2007). Success in market depends on a firm's competence in applying experience and knowledge to develop a new product and improve existing products (Christensen et al. 1998). Rapid technological change and fluctuation in customer' tastes call for continued product improvement and new product development. Therefore, firms are more engaged in innovation activities in a variable environment (Jantunen 2005). Because technological regime determines the environment of firms' innovation activities, it can be used as an indicator of environmental dynamism.

2.6 Firm performance and dynamic capabilities

The purpose of researches on dynamic capabilities is to understand how firms cope with environmental changes and sustain competitive advantage (Teece 2007). Leading literatures on dynamic capabilities and firm performance include researches of Teece et al.

(1997), Eisenhardt and Martin (2000), and Teece (2007) (Figure 2). Teece et al. (1997) argued that the past path of a firm determines its current position, and the current position affects firm performance. Teece (2007) suggested that ‘sensing’ capability and ‘seizing’ capability determine a new position and path, and the new position and path affect firm performance. In addition, ‘reconfiguration’ capability determines firm performance and competitive advantage. Eisenhardt and Martin (2000) found that dynamic capabilities to acquire, integrate, and coordinate resources determine new resources and resources deployment, and directly influence firm performance.

Latest studies on dynamic capability and firm performance have not shown consistent results (Zahra et al. 2006). But there are three views on how dynamic capabilities affect firm performance (Barreto 2010). The first view is that dynamic capability have a direct impact on firm performance (Makadok 2001; Teece et al. 1997; Zollo and Winter 2002). The second view is that dynamic capability is indirectly related to firm performance (Kogut and Zander 1992; Zott 2003). The third view is that dynamic capabilities are not related to firm performance, but the effect of new resources deployment through dynamic capabilities or the extent to which managers utilize dynamic capabilities determines firm performance (Eisenhardt and Martin 2000; Helfat et al. 2007).

Earlier propositions regarding dynamic capabilities posited that dynamic capability has a direct relationship with firm performance (Teece et al. 1997). For example, it was found that the ability to extract and integrate external knowledge in a pharmaceutical industry is positively correlated to research productivity (Henderson and Cockburn 1994), or that a new HRM execution to redeploy resources had a positive impact on organizational flexibility (Huang and Cullen 2001), firm performance (Ichniowski et al. 1997), and innovation outcome (Laursen 2002). In addition, Makadok (2001) argued that dynamic capability has a direct influence over corporate profits or profit-making.

As the market gets mature and competition becomes fierce, firms have no choice but to continuously apply, renew, and reconfigure internal resources and capabilities. The past path of firms (i.e. investment made in the past, history of the firm) leads to the present position of the firm (tangible and intangible resources and assets), and this position affects corporate processes.

Dynamic capabilities controlled by those paths, positions, and processes, again affect firm performance, and affect creation of a new position and path of the firm (Teece et al. 1997). Teece (2007) improved logical coherence by repairing connection between process and dynamic capabilities that was disconnected in the research of Teece et al. (1997). Teece (2007) found that dynamic capabilities that confirm opportunity translate into dynamic capabilities that seize the opportunity and decide investment, and this flow is connected to a new path and position, ultimately influencing firm performance such as growth and profits. Furthermore, Jantunen et al. (2005) argued that firms that are devoted to implementing a new strategy and operational method in order to adapt their internal organizations to international business conditions can earn much better outcome than those who are not active in international arena. Redeployment of resource base through dynamic capabilities has a positive impact on firm performance (Fey et al. 2000; Ichniowski et al. 1997; Laursen 2002). Dynamic capabilities have direct relationship with firm survival – long-term performance as well as short-term performance of the firm (Zollo and Winter 2002).

According to Zott (2003), dynamic capabilities have a direct relationship with firm performance by changing resources, practices, and capabilities. Dynamic capabilities contribute to firm performance and performance varies depending on the timing of deployment of resources. Newbert (2008) maintained that dynamic capabilities act as a mediator in transforming firm structure so as to produce better results than rivals in the market. Zahra et al. (2006) argued that the relation between dynamic capabilities and firm performance is indirect in that dynamic capabilities enhance firms' capabilities. Dynamic capabilities create and form firms' capabilities (Kogut and Zander 1992) and practices (Nelson and Winter 1982), which in turn dictate performance. This causal link suggests dynamic capabilities are indirectly related to performance.

Eisenhardt and Martin (2000) suggested that firms having dynamic capabilities generate better performance than those without them. According to their literature, long-term competitive strength does not depend on dynamic capabilities themselves but on deployment of resources driven by dynamic capabilities and on how promptly and appropriately firms utilize dynamic capabilities than rivals. Feldman and Pentland (2003) implied that awareness and judgment of managers about internal and external environment of firms is the most critical element in developing dynamic capabilities, and sometimes manager’s decision does not reflect the environment correctly and, as a result, wrong application of dynamic capabilities will not bring about improved firm performance. How dynamic capabilities affect firm performance can be addressed in the relationship between dynamic capabilities and costs as well. If we define ordinary capabilities as those that permit a firm to make a living in the short term, and dynamic capabilities as those that extend, modify or create such ordinary capabilities, we need a long-term investment to make dynamic capabilities meaningful (Winter 2003). The pursuit of change by means of dynamic capabilities may disturb existing capabilities instead of generating benefits through change, resulting in costs exceeding benefits. For this reason, as the use or development of dynamic capabilities does not necessarily benefit firms, it is necessary to keep the balance between costs and benefits incurred by dynamic capabilities (Winter 2003). Zahra et al. (2006) argued that when dynamic capabilities are employed in a situation where they are not required, dynamic capabilities could do firms harm.

2.7 Theoretical position and contribution of thesis

This paper proposes a research that explains relationship between dynamic capabilities, selection of partners for R&D collaboration, and firm performance, by measuring the impact of dynamic capabilities on R&D collaboration to strengthen internal resources using external resources. Dynamic capabilities are different from capabilities advocated by the resources-based view because dynamic capabilities are capable of coping with environmental changes. However, in the previous research literature on the relationship between dynamic capabilities and firm performance, it is difficult to find researches that tested relationship between dynamic capabilities and firm performance with a focus on environmental factor. This study will identify relationship between dynamic capabilities and firm performance, considering internal and external environmental factors. This paper empirically proves that depending on environmental factors, firms use dynamic capabilities to select R&D collaboration partners, and the strategy adopted by firms affect their short-term and long-term performance.

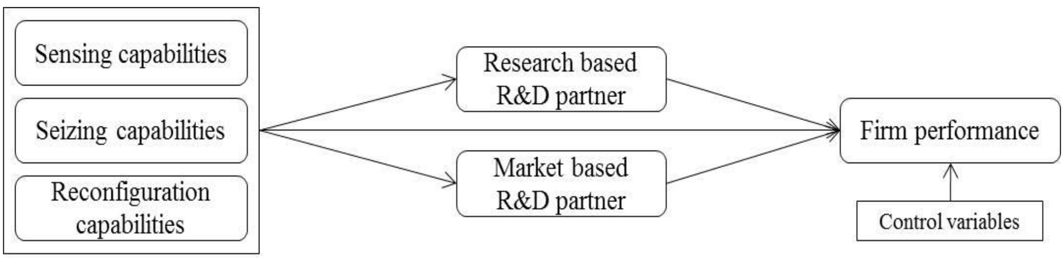
Some critics say that dynamic capabilities view has relatively weak empirical research base (Morgan et al. 2009; Pablo et al. 2007). Most of earlier literature on dynamic capabilities view was the development of a theory based on case studies (Helfat and Peteraf 2009). In addition, as there was not almost no empirical analysis with large samples, it is hard to generalize the results of empirical analysis (Ambrosini and Bowman 2009). Previous empirical researches were focused on specific high-tech industries such as semiconductor and pharmaceutical sectors of the developed countries (Deeds and Decarolis 1999; Macher and Mowery 2009; Madhok and Osegowitsch 2000; Rothaermel and Hess 2007) or new firms and thus they were limited in terms of sampling (McKelvie and Davidsson 2009; Weerawardena et al. 2007). This paper presents an alternative to overcome limitations in conceptual research and case studies through an empirical analysis of about 3,000 firms as a sample.

Although it was agreed that dynamic capabilities affect firm performance, there has been yet no consistent consensus on how that works (Helfat et al. 2007). Moreover, as dynamic capabilities are considered only in a rapidly changing environment (Teece 2007; Teece et al. 1997), discussions on the role of dynamic capabilities under varying environment characteristics have not been made sufficiently. Recent studies found that the impact of dynamic capabilities on firm performance depends on firms' internal conditions as well as external environmental conditions. This study intends to expand the depth of empirical research of dynamic capabilities, using a large sample regarding relationship between dynamic capabilities and firm performance, and to prove that the role of dynamic capabilities on firm performance is affected by both internal and external environments of firms. This paper investigates logical linkage between dynamic capabilities and selection of R&D collaboration partner, test conceptual hypotheses of extant literature by analyzing the direct and indirect impacts of dynamic capabilities on performance, and presents evidence on how the dynamic capabilities view can further develop as a theory.

Chapter 3. Research Model and Hypothesis

3.1 Research Model

This study conducts two empirical analyses to test the relationship among dynamic capability, R&D collaboration partner selection, and firm performance (Figure 2). The first empirical analysis is to test the relationship between dynamic capabilities and R&D collaboration partner selection. R&D collaboration partners are divided into research-based partners and market-based partners, and the analysis is made considering firm size and technological regime. The second analysis is about relationship between dynamic capabilities and firm performance and aims at identifying both direct and indirect impacts of dynamic capabilities on firm performance. Firm performance is divided into firm survival and firm growth, and the impacts of dynamic capabilities on long-term firm performance and short-term performance are compared.



[Figure 2] Research model

In order to analyze relationship among dynamic capabilities, R&D collaboration partner, and firm performance, data of small and medium enterprises technology development survey of 2005 by the SMBA and the business closure information of 2010 by National Tax Service are used. In order to conduct an analysis of dynamic capabilities and R&D collaboration partner selection, principal component analysis, probit model, probit model with sample selection are used. To analyze relationship between dynamic capabilities and firm performance, structural equation modeling (SEM) is employed.

3.2 Research Hypothesis

3.2.1 Type of R&D collaboration partners

As the range of exploration by firms widens, and the amount of accessible knowledge increases, firms are more likely to find solutions to problems facing them (March 1991), and more likely to create new innovation (Fleming and Sorenson 2001; Nelson and Winter 1982). Firms are offered new knowledge through variety of sources of external knowledge, reducing time and costs needed to develop technology (Koka and Prescott 2008; Laursen and Salter 2006; Powell et al. 1996; Simard and West 2006). Dynamic capabilities determine the range of exploration for external knowledge and R&D collaboration partners (Laursen and Salter 2013; Love et al. 2013). Firms with wider range of exploration for external knowledge prefer R&D collaboration with colleges (Fontana et al. 2006; Laursen and Salter 2004), and firms with more internal R&D capabilities are more likely to work with colleges and research institutes (Fontana et al. 2006). Since the level of understanding values of external knowledge and information depend on dynamic capabilities, R&D collaboration partners selected by firms vary (Cohen and Levinthal 1990; Lubatkin et al. 2001; Zahra and George 2002). The selection of proper R&D collaboration partner is affected by dynamic capabilities that can identify resources of partners (De Jong and Freel 2010). Dynamic capabilities allow firms to overview opportunities of technology across industries, and to obtain external knowledge through appropriate R&D collaboration partners in order to catch up with technological level of other firms (Moreira 2009). Hence,

Hypothesis 1. Selection of research-based R&D collaboration partners increases the impact of dynamic capabilities.

3.2.2 **Firm size**

Aldrich and Auster (1986) argued that lack of resources within the firm, high financing costs, non-existence of labor market, and government regulations are factors that constitute disadvantage for small firms. Lack of internal resources and reputation put small firms at a disadvantage when competing with well-established firms. Ahuja (2000) and Lee et al. (2001) showed that resource base of firms can be expanded and innovation performance can be enhanced through technology transfers. Small firms can complement insufficient internal resources by acquiring necessary resources and knowledge through collaboration with external partners (Powell 1998), and small firms can be supplied resources needed to change their strategic position (Eisenhardt and Schoonhoven 1996).

Hannan and Freeman (1983) observed that firms with high reliability and predictability have an advantage in selecting environments. Small firms need to enhance reliability and predictability in order to survive without collapse. Small firms can increase reliability through reinforced collaboration with the external environment, and improve predictability through enhanced technological capabilities (Lee et al. 2001). Jarillo (1989) showed that collaboration is the means that small firms can employ to obtain resources they need to grow. Yet they suffer disadvantage in collaborating with the external world due to lack of experience of such collaboration (Chun and Mun 2012; Rosenbusch et al. 2011). As firms choose strategy to cope with environmental change through dynamic capabilities (Day and Wensley 1988; Spanos and Lioukas 2001), dynamic capabilities moderate disadvantage of small firms in selecting collaboration partners (Borch and Madsen 2007; Carroll and Hannan 2000). Hence,

Hypothesis 2. Smaller firms experience greater impact of dynamic capabilities on R&D collaboration partner selection.

3.2.3 Technological regime

Lewin et al. (1999) showed that firms in an industry where technological innovation activities are intense and technological changes are fast are more likely to engage in collaborated research than those in other industries. Miotti and Sachwald (2003) also showed that in the estimation results using dummy variable in the high-tech industry, firms of the high-tech industry are more involved in collaborative research works. Furthermore, Belderbos et al. (2004) observed that firms in an industry with higher rate of technological development are more likely to engage in collaborative research. Greater technological opportunity and appropriability lead to more innovation activities. Greater technological opportunity and appropriability lead to greater investment in innovations, whereas lower opportunity and appropriability produce less investment in innovation. R&D collaboration depends on characteristics of technological regime. High-tech industry firms with greater opportunity, appropriability, and cumulativity tend to need more R&D collaborations than low-tech industry with lower opportunity, appropriability, and cumulativity (Chesbrough et al. 2006). Technological regime also affects the selection of R&D collaboration partners. Because high-tech industry firms require more knowledge-based resources, they prefer collaboration with technology-based partners, i.e. colleges and research institutes (Santoro and Chakrabarti 2002), while low-tech industry firms are inclined to work with market-based partners – customers and suppliers (Miotti and Sachwald 2003).

Market dynamism is caused by such factors as technological innovation in the industry, regulatory change, and changes in industrial competition (Eisenhardt and Martin 2000). Dynamic capabilities are required in a highly dynamic environment (Teece et al. 1997; Teece 2007). Firms have to create dynamic capabilities to cope with shifts in the market, and more dynamic market calls for higher level of dynamic capabilities (Eisenhardt and Martin 2000; Wang and Ahmed 2007). Hence,

Hypothesis 3. Firms in the high-tech industry experience greater impact of dynamic capabilities on R&D collaboration partner selection.

3.2.4 **Firm performance**

Growing firms have more chance of survival. However, growth of firms does not mean survival, and survival does not mean growth. Firms that achieved good performance in the past or hold sufficient assets may be excluded from the list of environment selection or exit for a considerable period despite worsening performance. Sometimes, a strategy of pursuing fast growth may undermine firm survival (Romanelli 1989). Firm survival and firm growth are not identical concepts, and the relationship between the two performances are highly complicated (Delmar et al. 2003). It is possible to achieve short-term performance with currently available technology. However, without developing new technology, long-term performance is not ensured (Duane Ireland and Webb 2007). To achieve long-term performance, resources should be allocated to keep the balance between use of existing technology and search for a new technology.

Spanos and Lioukas (2001) observed that resources of firms have direct impact on market performance (short-term performance like market share, sales, etc.), but do not have a statistically significant impact on margin (long-term performance like ROE, net profits, etc.). Hannan et al. (1998) proposed that initial conditions, experience, resources, and capabilities of firms are important elements to predict survival. Capabilities to capture and take advantage of opportunities in the market and to adapt internal resources to demands are critical to firm survival (Wang and Ahmed 2007). Firm survival depends on dynamic capabilities that enable firms to maintain a sustainable competitive advantage (Cool et al. 1989). Dynamic capabilities facilitate development of strategies to maintain a long-term competitive advantage under a highly uncertain and variable circumstance, and enhance an ability to tackle crisis (Grewal and Tansuhaj 2001). Hence,

Hypothesis 4a. The impact of dynamic capabilities on firms' survival is more indirect.

Hypothesis 4b. The impact of dynamic capabilities on firms' growth is more indirect.

Chapter 4. Research Method

4.1 Data and sampling

This study used "2005 Survey on Technology of Small and Medium Enterprises" published by the Small and Medium Business Administration (SMBA). The survey is conducted biennially for SMEs with over five to up to 300 employees which has R&D activities. The purpose of the survey is to establish efficient technology policies for SMEs based on the status of technology development of SMEs. The survey investigates R&D collaboration activities, technology organization, human resources management, and sales. To obtain information on firm survival – long-term performance of firms, I checked whether the firms that responded to the survey survive (as of 2010) by using business closure information of 2010 offered by the National Tax Administration. This paper tested research hypotheses using 3,061 small and medium firms established since 1970.

4.2 Variables and basic statistics

R&D collaboration partner type: R&D collaboration partner type is used as a dependent variable in the analysis of factors of R&D collaboration partner selection, and is used as an explanatory variable in the analysis of relation between dynamic capabilities and firm performance. Firms should differentiate among partners that offer insufficient resources (Osborn & Hagedoorn 1997). This study classifies partners into research-based partner and market- based partner according to the type of resources that partners can offer (Miller & Shamsie 1996). R&D collaborations with colleges allow firms access to rare resources such as excellent scientists and latest research facilities and the exploration of new scientific knowledge (Audretsch, Leyden, & Link 2012; Subramanian, Lim, & Soh 2013). Large firms are important customers of SMEs, and R&D collaboration with large firms gives SMEs new ideas about innovation, and innovations based on this collaboration are more likely to succeed in the market (Tether 2002; Von Hippel 1998). Hagedoorn and Schakenraad (1994) found that the characteristics of partner, rather than the amount of collaboration have greater impact on firm performance. The performance of collaboration relies on the type of resources offered by partners (Nieto & Santamaria 2007).

R&D collaboration can be divided into ‘exploration collaboration’ and ‘exploitation collaboration’ according to the characteristics of resources firms wish to acquire through collaboration (Rothaermel & Deeds 2004). Exploration collaboration is to search for newness and focuses on “R (research)” in R&D (Koza & Lewin 1998). Exploration collaboration is uncertain and highly variable, and the performance of collaboration is invisible or sometimes negative. Generally, exploration collaboration is largely made between firms and colleges (Rothaermel & Deeds 2004). On the other hand, exploitation collaboration is to enhance the efficiency of existing products or services, or to commercialize prototype products invented through exploration collaboration. Exploitation collaboration focuses on “D (development)” in R&D (Koza & Lewin 1998), and is often realized between demand firms and supply firms on the value chain (Rothaermel & Deeds 2004). This paper also found that exploration collaboration occurs with research-based partners (Table 3).

The success of collaboration is greatly affected by the characteristics of partners selected (Saxton 1997). Resources held by firms are limited, and in order to capture sustainable competitive advantage, additional resources are needed. Thus, firms choose partners that own specific resources (Hitt et al. 2000). SMEs are actively cooperating and exploring knowledge to acquire resources for innovation they lack internally (Baum et al. 2000; Levinthal & March 1993). However, as the risk of collaboration is more on relatively smaller participants, smaller firms experience disadvantage (Lerner & Merges 1998; Sulej et al. 2001).

In this study, colleges and public research institutes are defined as research-based partners and demand firms and supply firms are defined as market-based partners. Research-based partner variable and market-based partner variable are dummy variables. When a firm has the experience of collaboration with each partner type, it is indicated as (1), and when not, as (0). 41% of the total sample has experience of R&D collaboration, and 82% of those firms who had R&D collaboration selected research-based partners as R&D partners, and 45% of firms who selected R&D collaboration used market-based partners as co-research partners.

[Table 3] Type of partners according to the purpose of R&D

R&D investment area	Sample mean	Non-research-based partners	Research-based partners	t-statistics
Exploration R&D	0.66 (0.47)	0.61 (0.49)	0.67 (0.47)	-1.66* (0.09)
Sample size	1,244	255	1,019	

Note: Figure in parenthesis below mean indicates standard deviation, and figure in parenthesis below t-statistics is *p-value.*

Firm survival: In this study, firm survival was used as a long-term firm performance variable (*Survival*). For SMEs which intrinsically stand a low chance of survival, survival itself is much more important than any other performance (Audretsch & Mahmood 1994). Firms listed on the business closure register of 2010 of the National Tax Service are defined as exit firms, and those not listed are defined as survival firm. Firms with R&D collaboration have a better chance of survival than those without R&D collaboration, but the difference is not statistically significant (Table 4).

[Table 4] R&D collaboration and firm survival

Variable name	Sample mean	Non-R&D collaboration firms mean	R&D collaboration firms mean	t-statistics
Firm survival	0.85 (0.36)	0.84 (0.37)	0.85 (0.37)	-0.96
Sample size	3,061	1,244	1,817	

Note: Figures in parenthesis below mean indicates standard deviation, and figure in parenthesis below t-statistics is *p-value.*

Firm Growth: In this study, increase of sales is used as firms' short-term performance variable. By comparing sales of 2002 and 2003, existence of increased sales is indicted as (1), and otherwise as (0). The chance of growth for firms with R&D collaboration is higher than those without R&D collaboration, but the difference is not statistically significant (Table 5).

[Table 5] R&D collaboration and firm growth

Variable name	Sample mean	Non-R&D collaboration firms mean	R&D collaboration firms mean	t-statistics
Firm growth	0.74	0.73	0.75	-0.96

	(0.44)	(0.44)	(0.43)
Sample size	3,061	1,244	1,817

Note: Figures in parenthesis below mean indicates standard deviation, and figure in parenthesis below t-statistics is *p-value*.

Firm Size: Firm size means the influence of firms in the market, and affects the opportunity to select R&D collaboration partners (Hitt et al. 2000). Larger firm size means greater R&D collaboration activities, and more chance of collaboration with colleges (Mohnen & Hoareau 2003). And firms with higher level of understanding of knowledge (absorptive capability, or learning capacity) and capacity to use knowledge are more likely to collaborate with colleges – knowledge-based partner (Fontana, Geuna, & Matt 2003). Large firms and new firms are more likely to gain benefits through R&D collaboration with colleges (Fontana et al. 2006). Table 6 shows the characteristics of firms according to firm size. As for the firm size variable *(Size*), firms were classified into four groups according to the number of full time employees (5~19, 20~49, 50~99, 100~299). The group with employees over 20 less than 50 represented the most with 31%. The absolute size of R&D investment is proportional to firm size, but the share of R&D investment out of sales or share of innovation products out of sales is inversely proportional to firm size. As for the firm group with employees of over 100, firms with R&D collaboration were more than those without R&D collaboration (Table 20). This confirms the previous research finding that larger firms with over 100 employees prefer R&D collaboration (Chun & Mun 2012). When the analysis of determinants of R&D partner selection is done only for firms that had R&D collaboration, most observations in the sample are likely to be large firms since majority of firms with over 100 employees took R&D collaboration.

[Table 6] Characteristics of firm according to firm size

Category	Sample size (firm)	Employee[1] (person)	Age (year)	R&D size (million won)	R&D Invest / sales (%)	Innovation products / sales (%)
5≤size<20	707 (23.10 %)	13	12	178.22	19.35	43.30
20≤size<50	939 (30.68)	33	15	321.42	5.14	32.88
50≤size<100	701 (22.90)	70	18	519.95	2.86	28.70
100≤size<300	714 (23.33)	170	21	1031.28	1.60	29.85
Total	3,061	69	16	499.39	7.07	33.62

[1] Employees means full-time employees, rounded off to the nearest whole number.

Firm Age : Firm age is used as an important explanatory variable along with firm size (Hannan & Freeman 1983). As for the firm age variable (*age*), firm age was calculated by deducting the year of firm establishment from 2005 – the year of the survey. The proportion of firms with age over 10 years less than 20 years was the most with 43%, and the proportion of firms with age less than 5 years was the least with around 2%. The share of R&D investment out of sales for firms with age less than 10 ranged from 10 to 12%, a very high level. As the age increases, firm size and absolute size of R&D rose while the relative R&D size (R&D investment over sales) is inversely proportional to the age (Table 7). Because correlation between new firms (age less than 5 years) and small firms (less than 20 employees) was not high (Pearson correlation coefficient 0.18), new firms cannot be identified as small firms. As for firms aged over 20, the number of firms with R&D collaboration was greater than the number of those without R&D collaboration. That is, as the firm gets older, they tend to prefer R&D collaboration.

[Table 7] Firm characteristics according to firm age

Category	Sample size (firm)	Employee[2] (person)	R&D size (million won)	R&D/sales (%)
Age≤5	47 (1.54 %)	33	334.68	9.91

[2] Employees means full-time employees, rounded off to the nearest whole number.

5<Age≤10	924 (30.19)	44	382.28	12.11
10<Age≤20	1,316 (42.99)	65	534.18	6.40
20<Age≤40	774 (25.29)	107	590.04	2.04
Total	3,061	69	499.39	7.07

Technological Regime: With regard to technological regime classification, 22 industries in manufacturing sector were divided into high-tech industry (high-tech industry, mid and high-tech industry), and low-tech industry (low-tech industry, mid and low-tech industry) according to the OECD guideline (2001). Additionally, four service industries of the knowledge and service sector were classified as high-tech industry. High-tech industry firms were 1,789, accounting for 58% of the total sample. In the high-tech industry that offers technological opportunity and innovation appropriability, incentive for innovation activities is high, and thus there is more likelihood of R&D collaboration for innovation (Belderbos et al. 2004; Miotti & Sachwald 2003). In the high-tech industry, due to technological opportunity and innovation appropriability, it takes longer to imitate innovation, and the lifecycle of innovative technology is longer. Moreover, as innovation activities are intense, R&D intensity and the share of innovation products out of sales are higher than in low-tech industry. In addition, high innovation cumulativity creates difference in the size of knowledge assets held by firms (Table 8). Because of technological opportunity, and innovation appropriability and cumulativity, technological regimes of high-tech industry and low-tech industry are clearly different. This suggests the difference in environmental dynamism between high-tech industry and low-tech industry.

[Table 8] Characteristics of environment according to technological regime

Characteristics	Sample mean	Low-tech industry firm mean	High-tech industry firm mean	t-statistics
Time to imitate technology[3]	3.81 (1.41)	3.70 (1.48)	3.88 (1.35)	-3.42*** (0.00)
Product lifecycle[4]	5.81 (2.87)	5.65 (2.95)	5.92 (2.82)	-2.59*** (0.00)

3 Time to imitate innovation means the duration it takes for rivals to develop imitation of main products of a firm. It was divided into ① up to 3 months ② 3 to less than 6 months ③ 6 months to less than 1 year ④ 1 year to 1.5 years ⑤ 1.5 years to less than 2 years, and ⑥ over 2 years, meaning the larger the value, the greater duration to imitate.

4 Product lifecycle is the lifetime of a main product from its launching in market to declining period. It was divided into six months, ranging from less than six months to over 10 years, with bigger value meaning longer lifetime of the product.

R&D intensity	2.57	2.43	2.67	-6.84***
	(0.96)	(0.97)	(0.94)	(0.00)
Knowledge asset size[5]	1.69	1.57	1.77	-4.29***
	(1.27)	(1.30)	(1.24)	(0.00)
Share of innovation product / sales	0.34	0.31	0.36	-4.18***
	(0.34)	(0.34)	(0.34)	(0.00)
Use of R&D collaboration	0.41	0.38	0.43	-2.84***
	(0.49)	(0.48)	(0.49)	(0.00)
Sample size	3,061	1,272	1,789	

Note: Figures in parenthesis below mean indicates standard deviation, and figure in parenthesis below t-statistics is *p-value.*

Dynamic capabilities : As for the dynamic capabilities variable, according to the definition of Teece (2007), sensing capability was defined by the range of exploration (Danneels 2008; Jantunen 2005) and internal resources of firms that can explore (Grimaldi et al. 2013). Utilization and importance of 15 external knowledge sources was used as a proxy for sensing capability (*Sense1-15*). Table 9 shows the utilization of external knowledge sources. Most of firms used exhibitions and fairs as the source of external knowledge, and regarded other divisions within the firm and customers as the

[5] Knowledge asset size is the logarithm of the size of patents and trademark rights held by firms.

most important source of external knowledge.

[Table 9] Utilization of external knowledge sources

External knowledge source		# of firms (firm)	Importance level (5- point scale)
Sesnse1	Exhibitions, fairs	1,748	3.39
Sesnse2	Within the firm (other divisions)	1,719	3.72
Sesnse3	Internet	1,424	3.41
Sesnse4	Competitors in the same industry	1,307	3.25
Sesnse5	Literature related to technology and patents	1,172	3.44
Sesnse6	Technology research clubs and seminars	1,170	3.39
Sesnse7	Customers	946	3.59
Sesnse8	Newspapers, magazines	810	3.13
Sesnse9	Colleges	763	3.31
Sesnse10	Suppliers of materials, parts	689	3.21
Sesnse11	Public research institutes	644	3.41
Sesnse12	Suppliers of machines,	485	3.13

	equipment		
Sesnse13	Professional R&D firms	410	3.13
Sesnse14	Consulting firms	345	2.92
Sesnse15	Private research institutes	289	2.90

Seizing capability is related to "implementation" to respond to opportunities and risks firms detected (O'Reilly III & Tushman 2008). Seizing capability is about firms' implementation of strategies, and a quick and appropriate decision to address sensed changes should be made (Eisenhardt & Martin 2000; Grimaldi et al. 2013; Jantunen 2005). According to the characteristics of knowledge that firms wish to get through collaboration, collaborations are classified into exploration collaboration and exploitation collaboration (Rothaermel & Deeds 2004). In this paper, the purpose and performance of R&D was used as a proxy for seizing capability (*Seize1-10*). Table 10 shows the purposes of R&D for firms. Most firms chose sales increase as the purpose of R&D, and performance of R&D was found to be the highest in sales increase.

[Table 10] Purpose of R&D

R&D purpose		# of firms (firm)	Performance (5 points)
Seize1	Sales increase	2,604	3.11

Seize2	Exports expansion	1,336	1.55
Seize3	Import substitution (localization)	1,308	1.60
Seize4	Job increase	1,169	1.25
Seize5	Cost reduction (except personnel expenses)	1,281	1.42
Seize6	Personnel expense reduction	817	0.84
Seize7	Production period reduction	942	1.06
Seize8	Product quality improvement	2,112	2.66
Seize9	Production process improvement	1,218	1.45
Seize10	Entering new business area	1,448	1.76

Reconfiguration capability is the capability to redeploy resources and adjust corporate structure in response to shifts in technology and market (Teece 2007). Entrepreneurs and board of directors integrate internal and external activities, and modify firms to address changes in market and technology (Kodama 2007). Resources are redeployed, integrated, and coordinated to be combined with an organization's activity, leading to creation of dynamic capabilities that is hard to be imitated by competitors (Akwei 2007). Increase of R&D investment is the result of redeployment of resources. In this study, by comparing investments of 2003 and 2004, R&D investment increase is indicated as (1), and staying the same or decrease as (0). R&D investment was divided into internal use, joint development, commissioned development, technology introduction, and other external use. R&D investment was used as a proxy for reconfiguration capability (*Reconfiguration1-5*). Table 11 shows firms' R&D investment. Internal use was found to be the most important, and joint development was the most significant among external uses.

[Table 11] R&D investment

R&D investment		Mean	S.D.
Recon1	Internal use	0.65	0.48
Recon2	Joint development	0.21	0.41
Recon3	Outsourced development	0.08	0.27
Recon4	Technology introduction	0.06	0.23
Recon5	Other external use	0.03	0.16

4.3 Analysis Method

4.3.1 Principal Component Analysis

Principal component analysis (PCA) is one of factor analyses that derive factor structure that can represent the values of original variables, based on correlation. Principal component analysis compounds multivariate data into a few variates and then analyzes data based on those variates. The most important characteristics of PCA is to identify a few new factors that represent original variables while minimizing loss of information that was contained in the original variables. The new factors satisfy uncorrelation between independent variables. In order to understand characteristics of each data, PCA looks for perspective making the largest variance and analyzes data based on that. Finding the position of identifying attributes of data is to find composition variables that maximize variance. Principal components briefly summarize the characteristics of the entire data.

There is no absolute standard as to the number of principal components, but generally it is determined using absolute eigenvalues, scree test, and maximum percent of variables. The eigenvalue – the size of variance explained by a factor -- should be over 1. This means that factors should be extracted so that they can explain more than variates explained by one original variable. To conduct scree test, eigenvalues of extracted factors are put into table. Scree test is a method to determine the number of factors at the position where trend changes from a sharp fall to a slow fall after eigenvalues fell. Maximum percent of variables is a method to extract the number of factors that can explain part of necessary variables and usually determines the number of factors that can explain over 75~85% of variables. The interpretation of principal components extracted through principal component analysis is done for variables with factor loadings.

Variables used as proxies for dynamic capabilities in the previous researches are shown in Table 12. This study divided dynamic capabilities as sensing capability, seizing capability and reconfiguration capability, according to the definition of Teece (2007). Sensing capability is related to scanning of the external world (Danneels 2008; Ellonen, Wikström, & Jantunen 2009; Jantunen 2005; Wilden, Gudergan, Nielsen, & Lings 2013), seizing capability is linked to utilization of knowledge (Ellonen et al. 2009; Jantunen 2005; Wilden et al. 2013). Reconfiguration capability is related to new management method and business process change (Jantunen et al. 2005; Lin & Wu 2014; Wilden et al. 2013). Factors of the three capabilities derived through the Principal Component Analysis are used as variable for model to determine R&D collaboration partners.

[Table 12] Proxies for dynamic capabilities

Dynamic capabilities	Range of proxies

Sensing capability	Professional consultative activities Detection of change of demand in target markets and customers Observation of external R&D performance utilization process and best practices Collection of information about competitors and external environment
Seizing capability	Decision making process Selection of business areas and investment Adoption (application) of best practices Collection of opinions from customers and within the firm
Reconfiguration capability	New management strategy establishment (marketing, production strategy, etc.) New production facilities and manufacturing process Resource redeployment process

4.3.2 **Probit Model and Probit Model with sample selection**

Many researches that analyzed the determinants of R&D collaboration partners by firms conducted empirical analysis using firms that performed R&D collaboration in the sample (Veugelers & Cassiman 2005). Because R&D collaboration partner can only be selected by firms that select R&D collaboration, if analysis is done only for firms that perform R&D collaboration, sample selection bias happens. This study used probit model with sample selection to empirically analyze the determinant of R&D collaboration partner by firms.

I will explain about the probit model briefly before explaining about the probit model with sample selection. In this study, R&D collaboration partners were classified into colleges and research institutes that can offer exploration-focused knowledge and customers and suppliers that can offer exploitation-focused knowledge. Dependent variable (y) is a dummy variable that indicates the existence of R&D collaboration partners. If colleges and research institutes (or customers or suppliers) were chosen as R&D collaboration partners, that is indicated as (1), and otherwise as (0). If the probability that firms select R&D collaboration partners is determined by a series of explanatory variable (X), the relationship can be expressed as eq.1.

$$P(y=1|X)=\Phi(X\beta)$$
$$P(y=0|X)=1-\Phi(X\beta) \qquad \text{Eq. (1)}$$

In the Equation (1), P is probability, Φ is cumulative normal distribution function, β is parameter. In the above equation, the probability that R&D collaboration partner is selected $P(y=1)$ is a non-linear function of $X\beta$. Unlike a linear function, coefficient β to be estimated in the Equation (1) represents the impact of the change of X on probability that R&D collaboration partner will be selected. Probit Model can get estimate of β, by maximizing logarithm likelihood function using maximum likelihood estimation. Logarithm likelihood function of Probit Model is in eq.2. Here n indicates the total number of firms in the sample.

$$\ln L = \sum_{i=1}^{n} \left\{ y_i \ln \Phi(X_i \beta) + (1 - y_i) \ln[1 - \Phi(X_i \beta)] \right\} \qquad \text{Eq. (2)}$$

R&D collaboration partner cannot be defined for firms which do not participate in R&D collaboration activities. That is, R&D collaboration partner variable is not observed in the whole sample, but only in part of the sample, showing characteristics of censored data. In particular, if such censoring occurred randomly in the sample, estimation results from sample of firms that have R&D collaboration partners would not be biased.

However, because firms' R&D collaboration selection and R&D collaboration partner selection are related to each other, estimation results of Probit Model about determination of R&D collaboration partner using only firms that conducted R&D collaboration activities would be biased due to sample selection.

In order to correct the bias that would occur due to censoring of sample, this study will use Probit Model with bivariate sample selection. The model includes two dependent variables -- R&D collaboration partner (y_1) and R&D collaboration (y_2). With regard to

R&D collaboration partner variable, if there exist partners selected by firms for R&D collaboration (in this study, research-based partners and market-based partners), it is indicated as (1), and otherwise as (0). R&D collaboration variable is a variable indicating whether firms are engaged in R&D collaboration activities. If there exists R&D collaboration activity, it is indicated as (1), and otherwise (0). (eq.3).

$$y_1^* = \begin{cases} 1 & \text{if } X_1 b_1 + u_1 > 0 \\ 0 & \text{if } X_1 b_1 + u_1 \leq 0 \end{cases}$$

$$y_2^* = \begin{cases} 1 & \text{if } X_2 b_2 + u_2 > 0 \\ 0 & \text{if } X_2 b_2 + u_2 \leq 0 \end{cases} \qquad \text{Eq. (3)}$$

$$\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \sim \mathrm{N}\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right]$$

Probit model with sample selection has two probit equations to explain two dependent variables. Dependent variable of the first equation is R&D collaboration partner (y_1), and dependent variable for the second equation is the existence of R&D collaboration (y_2). Probit model with sample selection is expressed in Equation (3). In the Equation (3), disturbance terms (u_1, u_2), which are related to each other, follow a bivariate standard normal distribution, and correlation coefficient is ρ . In the Equation (3), R&D

collaboration partner variable (y_1) is observed only among firms that selected R&D collaboration ($y_2 = 1$), and R&D collaboration variable, unlike R&D collaboration partner variable, is defined for all firms.

Observations in the whole sample are classified into three cases: the case of performing both R&D collaboration selection (y_2) and R&D collaboration partner selection (y_1) ($y_1 = 1, y_2 = 1$); the case of performing R&D collaboration activities, but not selecting colleges and research institutes (or demand firms and supply firms) as R&D collaboration partners ($y_1 = 0, y_2 = 1$); and the case of not performing R&D collaboration ($y_2 = 0$) (eq.4).

$$
\begin{aligned}
& = \mathrm{Prob}[y_1 = 1 \mid y_2 = 1] * \mathrm{Prob}[y_2 = 1] && (y_1 = 1, y_2 = 1) \\
f(y_1, y_2) \quad & = \mathrm{Prob}[y_1 = 0 \mid y_2 = 1] * \mathrm{Prob}[y_2 = 1] && (y_1 = 0, y_2 = 1) \qquad \text{Eq. (4)} \\
& = \mathrm{Prob}[y_2 = 0] && (y_1 = 0)
\end{aligned}
$$

Accordingly, logarithm likelihood function is in eq. 5.

$$\ln L = \sum_{i=1}^{n} [y_{1i} y_{2i} \ln \Phi_2 (X_{1i}\beta_1, X_{2i}\beta_2) + y_{1i}(1 - y_{2i}) \ln \Phi_2 (X_{1i}\beta_1, -X_{2i}\beta_2) + (1 - y_{1i}) \ln \Phi(-X_{1i}\beta_1)] \quad \text{Eq. (5)}$$

In the above logarithm likelihood function, Φ_2 is a bivariate standard normal cumulative distribution function. As in the probit model mentioned earlier, using maximum likelihood estimation, consistent estimators of parameters (β_1, β_2, ρ) can be obtained. If the two equations are not related to each other ($\rho = 0$), even as the two equations are estimated through each probit model, bias does not occur. However, if the correlation coefficient is not “0”, estimating the equation for R&D collaboration partner selection with only firms that perform R&D collaboration activities would incur bias of sample selection.

4.3.3 **Structural Equation Model**

In literature of empirical analysis of dynamic capabilities and firm performance, structural equation model is widely used (Table 13). This is an attempt to establish and specify the concept of dynamic capabilities in order to cure the weakness of dynamic capabilities – that the definition of dynamic capabilities is conceptual and based on surveys – through causal relationship analysis among variables. Structural Equation Model (SEM) is a combination of regression analysis and factor analysis, and is effective in explaining the concept that is hard to observe directly (Acock 2013).

[Table 13] Empirical research regarding dynamic capabilities

Researcher	Sample size and analytical model
King and Tucci (2002)	174 (Disk drive industry, 1967-1995) Heckman 2-stage model
Jantunen (2005)	217 / OLS
Døving and Gooderham (2008)	254 (small firms) / OLS
Protogerou et al. (2012)	271 / SEM
Wilden et al. (2013)	91 / SEM
Lin and Wu (2014)	20 / SEM

Structural equation modeling is a statistical method that enables an inference about causal relationship among variables in a situation where research through experiment is difficult or impossible. Every phenomenon consists of various factors, and concrete emergence of effects by these factors is an observed phenomenon. Dynamic capabilities, -- sensing capability, seizing capability, and reconfiguration capability are latent variables that are not directly observed, and proxy variables observed through surveys are measured variables. To measure how well proxy variables (observed variable) of dynamic capabilities can explain dynamic capabilities variables, error variance of observed variables is estimated through reliability coefficient of observed variables. Reliability coefficient is the extent of test scores' freedom from measurement error that occurs randomly. Based on information on reliability coefficient of observed variables, measurement error, i.e. error variance of observed variables can be indirectly estimated. Error variance can be estimated by deducting reliability coefficient from 1 (the perfect level of reliability coefficient of observed variable). This value represents the unreliable portion in the observed variable. The unreliable portion of observed variable multiplied by variance of observed variable is error variance. This estimate is called reliability coefficient. Reliability coefficient – ratio of variance -- ranges from 0 to 1 theoretically. As the reliability coefficient approaches "0", observed scores are only numbers assigned at random, meaning that the measured values are difficult to rely on.

In this study, to confirm internally consistent reliability of proxies for dynamic capabilities, Cronbach's alpha (α) is used. Generally, reliability coefficient of over 70 is evaluated as appropriate (Acock 2013). Moreover, to evaluate model, this paper used model chi-square test, RMSEA (root mean square error of approximation), CFI (comparative fit index), and SRMR (standardized root mean square residual) (Boomsma 2000; McDonald & Ho 2002). Generally, when RMSEA is less than or equal to 0.05, goodness of fit is considered as very appropriate, and when RMSEA is 0.05 to 0.08, level of approximation error is deemed as appropriate (Browne & Cudeck 1992). When CFI is over 0.90, goodness of fit for research model is considered as good (Hu & Bentler 1999). When SRMR is less than 0.1, goodness of fit is considered as good (Acock 2013).

Chapter 5. Empirical Analysis Result

5.1 Factor Analysis of Dynamic Capabilities

To select proxies for sensing capability, principal component analysis was conducted for 15 technological information source items used by firms to search for technological information. Among the derived 15 factors, Factor 1, Factor 2, and Factor 3, whose eigenvalues were greater than 1 (see Table 14) were selected as proxies for sensing capability (Table 15).

[Table 14] Result of principal component analysis for sensing capability

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	4.241	2.901	0.283	0.283
Factor2	1.340	0.157	0.089	0.372
Factor3	1.183	0.190	0.079	0.451
Factor4	0.993	0.153	0.066	0.517
Factor5	0.839	0.061	0.056	0.573
Factor6	0.779	0.005	0.052	0.625

Factor7	0.774	0.057	0.052	0.677
Factor8	0.717	0.033	0.048	0.724
Factor9	0.684	0.027	0.046	0.770
Factor10	0.657	0.045	0.044	0.814
Factor11	0.612	0.030	0.041	0.854
Factor12	0.581	0.026	0.039	0.893
Factor13	0.556	0.011	0.037	0.930
Factor14	0.544	0.041	0.036	0.967
Factor15	0.503	.	0.034	1.000

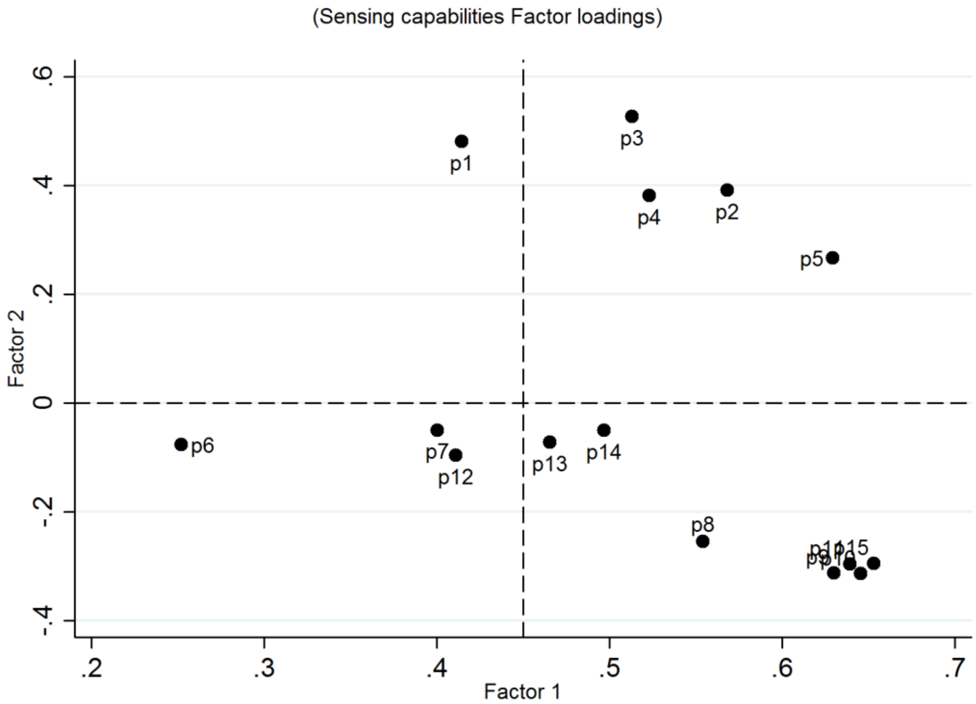
Table 15 shows correlation coefficients between Factor 1, Factor 2, and Factor 3 and original variables. All figures in the component matrix of Factor 1 have positive values, and values of Factor 1 are proportional to all variables. Hence, Factor 1 is a variable that indicates firm's openness to external information (*openness*). Factor 2 has a positive value when technological information sources have no physical entities (e.g. exhibitions, seminars, and Internet), and it has a negative value when information sources are external partners that firms can establish a direct relationship with (e.g. within the firm, rivals in the same industry, raw materials and parts suppliers). Based on this, Factor 2 is defined as a variable that indicates the attributes of external partners with 'anonymity' and 'specificity' (*ad-hoc partner*). Firms with larger value of Factor 2 prefer external information source with anonymity, whereas firms with smaller value of Factor 2 prefer partners with whom they can establish direct cooperative relationship as they have physical entities. Factor 3 has a negative value for technological research meeting and seminars, literature on technology and patents, and R&D professional companies, while it has a positive value for domestic and international exhibitions and fairs, Internet, and domestic and international newspapers and magazines. Hence Factor 3 is interpreted as a variable that indicates attributes of external partners as generality and professionality (*general partner*). Firms with smaller Factor 3 value were found to prefer partners which hold a high level of professionalism in a specific field.

[Table 15] Sensing capability variables and component matrix of principal component analysis

	External information source	Factor1	Factor2	Factor3
p1	Domestic and international exhibitions and fairs	0.415	0.481	0.175
p2	Technological research meetings and seminars	0.568	0.391	-0.194
p3	Internet	0.513	0.527	0.101

p4	Literature on technology and patents	0.523	0.382	-0.140
p5	Domestic and international newspapers and magazines	0.629	0.267	0.113
p6	Within the firm	0.252	-0.077	0.239
p7	Rivals in the same industry	0.401	-0.050	0.487
p8	Raw material and parts suppliers	0.554	-0.254	0.215
p9	Machinery and equipment suppliers	0.630	-0.313	0.112
p10	Professional R&D firms	0.645	-0.314	-0.068
p11	Consulting firms	0.639	-0.296	-0.049
p12	Customers	0.411	-0.096	0.453
p13	Colleges	0.466	-0.073	-0.480
p14	National & public research institutes	0.497	-0.050	-0.506
p15	Private research institutes	0.653	-0.295	-0.142

Figure 3 is a scatterplot of principal component scores of sensing capability with Factor 1 (*openness*) and Factor 2 (*ad-hoc partner*) set as horizontal axis and vertical axis respectively. Internet, literature on technology and patents, and technological research meetings and seminars are virtual partner with high openness, while raw material and parts suppliers, machinery and equipment suppliers, colleges and national and public research institutes are specific partners with high openness. Firms that acquire external information through their customers have intermediate level of openness, prefer specific partners, and are likely to use competitors in the same industry as source of external information.



[Figure 3] Scatterplot of principal component scores for sensing capability variable

Principal component analysis of seizing capability was conducted for 10 items of R&D investment purpose (Table 16). Among 10 derived factors, two factors whose eigenvalues are greater than 1 were chosen as proxies for seizing capability (Table 17).

[Table 16] Result of principal component analysis of seizing capability variable

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	3.502	2.167	0.350	0.350
Factor2	1.335	0.383	0.134	0.484
Factor3	0.952	0.172	0.095	0.579
Factor4	0.780	0.047	0.078	0.657
Factor5	0.733	0.083	0.073	0.730
Factor6	0.650	0.035	0.065	0.795
Factor7	0.615	0.065	0.062	0.857
Factor8	0.550	0.077	0.055	0.912
Factor9	0.473	0.063	0.047	0.959
Factor10	0.410	.	0.041	1.000

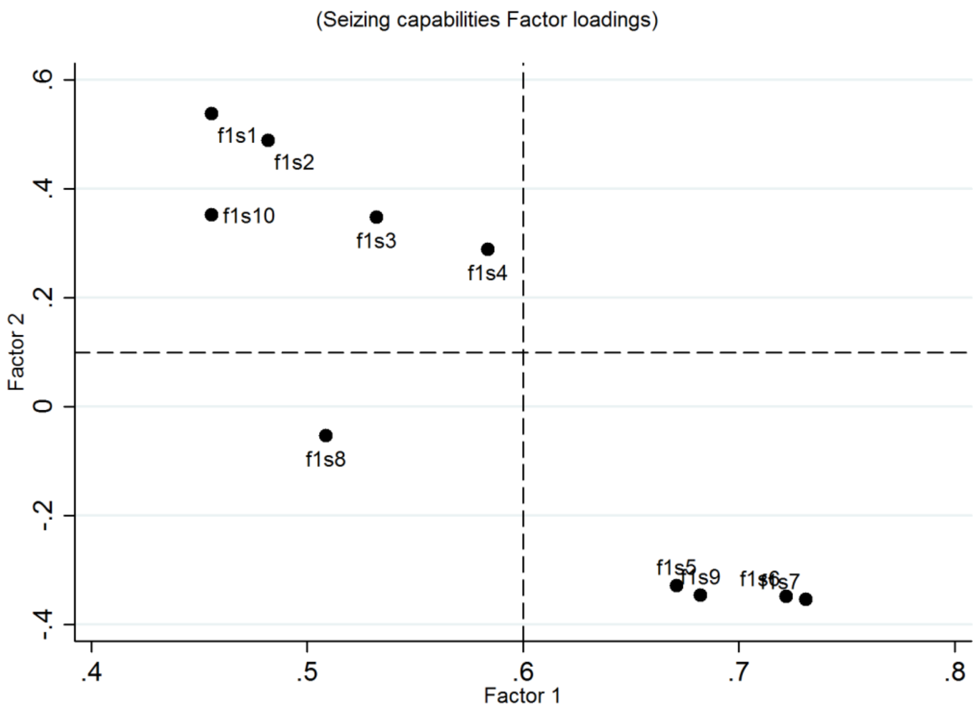
Table 17 shows correlation coefficient (component matrix) between Factor 1, Factor 2 and original variables. Component matrix of Factor 1 has positive values. Based on the finding that Factor 1 values are proportional to 10 variables of seizing capability, Factor 1 was defined as a variable whose R&D investment purpose is innovation (*innovation*). Factor 2 has positive values for variables related to product innovation such as 'sales increase', 'exports increase', but has negative values for variables related to process innovation such as 'cost reduction', 'personnel expense reduction', and 'production period reduction.' Based on this, Factor 2 was defined as a variable whose R&D investment purpose is product innovation (*product innovation*).

[Table 17] Seizing capability variable and component matrix of principal component analysis

	R&D investment purpose	Factor 1	Factor 2
s1	Sales increase	0.456	0.538
s2	Exports increase	0.482	0.489
s3	Imports substitution (localization)	0.532	0.348
s4	Employment increase	0.584	0.289
s5	Cost reduction (except personnel expenses)	0.671	-0.329
s6	Personnel expenses reduction	0.722	-0.348

s7	Production period reduction	0.731	-0.354
s8	Product quality improvement	0.509	-0.054
s9	Production process improvement	0.682	-0.347
s10	Entering new business area	0.456	0.352

Figure 4 is a scatterplot of principal component scores of seizing capability with Factor 1 (*innovation*) and Factor 2 (*product innovation*) set as horizontal axis and vertical axis. Sales increase (s1), entering new business area (s10) is the purpose of R&D investment at its early stage, while the effects of personnel expenses reduction (s6), and production period reduction (s7) can be generated when R&D investment has been made continuously. This result shows that R&D investment happens first in areas of product innovation, followed by process innovation which takes long time (Utterback & Abernathy 1975). Firms with higher R&D investment for product innovation saw significant effects of sales increase (s1) and exports increase (s2), while firms with higher R&D investment for process innovation experienced greater effects of production period reduction (s7), and personnel expenses reduction (s6).



[Figure 4] Scatterplot of principal component scores for seizing capability variable

Principal component analysis of Reconfiguration capability was conducted for five items that indicate change in R&D investment (Table 18). Two factors with eigenvalue exceeding 1 were chosen as proxies for reconfiguration capability (Table 19).

[Table 18] Results of principal component analysis of reconfiguration capability variable

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	1.223	0.181	0.245	0.245

Factor2	1.042	0.090	0.208	0.453
Factor3	0.952	0.054	0.190	0.643
Factor4	0.898	0.011	0.180	0.823
Factor5	0.886	.	0.177	1.000

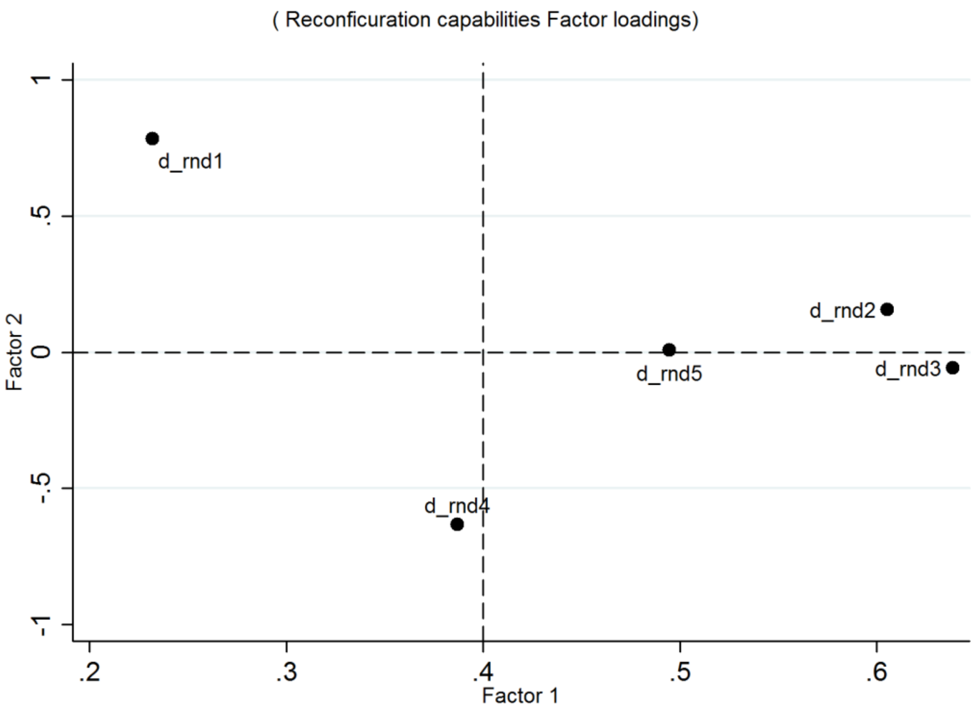
Table 19 shows coefficient of correlation between Factor 1, and Factor 2, and five variables of reconfiguration capability. Component matrix of Factor 1 have all positive values. Accordingly, if all variables become larger, Factor 1 value gets larger, and if all variables become smaller, Factor 1 value gets smaller. Based on this, Factor 1 is defined as R&D investment increase (*R&D increase*). As for Factor 2, variables such as 'own use' and 'joint development' - firms directly participate in R&D - have positive values, and variables such as 'outsourced development' and 'technology introduction' – exploitation of R&D completed by others -- have negative values. Based on this finding, Factor 2 is regarded as a variable representing firms' participation in R&D (*direct R&D*).

[Table 19] Reconfiguration capability and component matrix of principal component analysis

	Variable (R&D investment change)	Factor1	Factor2
d_rnd1	Own use (internal use)	0.232	0.783

d_rnd2	Joint development	0.605	0.157
d_rnd3	Outsourced development	0.639	-0.057
d_rnd4	Technology introduction	0.387	-0.633
d_rnd5	Others	0.495	0.009

Figure 5 is a scatterplot of principal component scores of reconfiguration capability with Factor 1 (*R&D increase*) and Factor 2 (*direct R&D*) set as horizontal axis and vertical axis respectively. The first R&D activity affected by the R&D investment increase is ‘internal R&D activity’ (d_rnd1), followed by ‘technology introduction’ (d_rnd4), ‘joint development’ (d_rnd2), and ‘outsourced development’ (d_rnd3). It was found that firms with less R&D investment increase either develop technology on their own or introduce technology with a high level of sophistication.



[Figure 5] Scatterplot of principal component scores of reconfiguration capability variable

Statistics of variables including principal component factors of dynamic capabilities are in Table 20. Firm size and firm age are not greatly related to the existence of R&D collaboration. However, in the largest firm size and oldest age group (100≤firm size<300, 20<firm age≤40), firms with R&D collaboration showed higher means. As for the dynamic capabilities, difference between firms with R&D collaboration and firms without R&D collaboration were statistically significant, and the means of firms with R&D

collaboration were greater than those of firms without R&D collaboration. With regard to obstacles to R&D, firms with R&D collaboration showed higher means. In terms of infrastructure, technology, and costs (except manpower), firms with R&D collaboration showed higher means.

[Table 20] Summary statistics of sample

Variable name	Sample mean	Firms without R&D collaboration mean	Firms with R&D collaboration mean	t-statistics
R&D collaboration partner				
Research-based partner	N/A	N/A	0.82	N/A
			(0.39)	
Market-based partner			0.45	
			(0.50)	
Firm size dummy				
Firm size< 20	0.23	0.23	0.23	0.55
	(0.42)	(0.42)	(0.42)	(0.58)
20≤firm size<50	0.31	0.32	0.29	1.57
	(0.46)	(0.47)	(0.45)	(0.12)
50≤firm size<100	0.23	0.24	0.22	1.22
	(0.42)	(0.43)	(0.41)	(0.22)
100≤firm size<300	0.23	0.21	0.27	-3.47***
	(0.42)	(0.41)	(0.44)	(0.00)

(Continued Table 20)

Firm age dummy				
Firm age≤5	0.02	0.02	0.02	0.03
	(0.13)	(0.12)	(0.12)	(0.98)
5<firm age≤10	0.30	0.31	0.29	1.40
	(0.46)	(0.46)	(0.45)	(0.16)
10<firm age≤20	0.43	0.43	0.43	0.28
	(0.50)	(0.50)	(0.49)	(0.78)
20<firm age≤40	0.25	0.24	0.27	-1.82*
	(0.43)	(0.43)	(0.44)	(0.06)
Sensing capability				
openness	4.0e-10	-0.06	0.09	-3.92***
	(1.0)	(1.03)	(0.95)	(0.00)
ad-hoc partner	-3.14e-10	-0.07	0.11	-4.84***
	(1.00)	(0.98)	(1.02)	(0.00)
general partner	-5.70e-10	0.17	-0.24	11.33***
	(1.00)	(0.89)	(1.10)	(0.00)
Seizing capability				
innovation	1.13e-09	-0.05	0.08	-3.55***
	(1.00)	(1.01)	(0.98)	(0.00)
product innovation	1.99e-10	-0.06	0.09	-4.09***
	(1.00)	(0.98)	(1.03)	(0.00)
Reconfiguration capability				
R&D increase	3.02e-10	-0.32	0.47	-23.51***
	(1.00)	(0.69)	(1.17)	(0.00)
direct R&D	-3.74e-09	-0.04	0.05	-2.47**

	(1.00)	(0.95)	(1.06)	(0.01)
Obstacles to R&D				
human resources	0.61	0.62	0.60	0.92
	(0.49)	(0.49)	(0.49)	(0.36)
infrastructure	0.41	0.39	0.44	-2.86***
	(0.49)	(0.49)	(0.50)	(0.00)
technology	0.53	0.54	0.52	-1.05
	(0.51)	(0.50)	(0.51)	(0.29)
cost	0.60	0.59	0.62	-1.85*
	(0.49)	(0.49)	(0.49)	(0.06)
Sample size	3,061	1,817	1,244	

Note: Figures in parentheses below means are standard deviation, and those in parentheses below t-statistics are *p-value*. *** is significant at 1%, ** at 5%, and * at 10%.

5.2 Selection of R&D collaboration partners

Table 21 shows the result of analysis of determinants of research-based R&D partners. For firms to maintain sustainable competitive advantage with limited resources, it is very important to search for partners holding specific resources (Franco & Haase 2013; Hitt et al. 2000; Ritala, Hallikas, & Sissonen 2008; Saxton 1997; Shah & Swaminathan 2008). Firms use sensing capability to select partners (Laursen & Salter 2004), and select the most suitable partner among potential partners (Stiglitz 2002). Greater sensing capability means availability of richer resources and knowledge for selection, and thus enhances chance of finding appropriate solutions to problems (March 1991). Furthermore, as the range of exploration widens, chance of innovation creation increases (Fleming & Sorenson 2001; Nelson & Winter 1982). Access to various sources of external knowledge sources broadens the range of exploration, and thus facilitates firm's selection of suitable R&D collaboration partners (Laursen & Salter 2013; Love et al. 2013). *Openness* variable of sensing capability is positively related to research-based R&D collaboration partners, which is in line with the argument of Laursen and Salter (2004). *Ad-hoc partner* variable did not show statistically significance, and *general partner* variable was negatively related to research-based R&D collaboration partners. This can be interpreted as the fact that firms prefer research-based R&D partners when they require concrete, professional R&D resources.

According to March (1991), exploration is related to detection, variation, high risks, experiment, discovery, and innovation, while exploitation is related to reinforcement, production, materialization, and realization. Exploration collaboration aims at finding new knowledge, while exploitation focuses on the utilization or development of existing knowledge (Koza & Lewin 1998). Research-based R&D partner represents exploration collaboration partner (Rothaermel & Deeds 2004). It is more likely that dynamic capabilities prefer collaboration with research-based partners, as R&D results are more unpredictable.

Seizing capability's *innovation* variable did not have statistically significant values, while *product innovation* variable was positively related to research-based R&D collaboration partners. Firms prefer research-based R&D partners for product innovation. Research-based R&D collaboration partners are the most important source of innovative ideas to firms (Cohen et al. 2002), and colleges, in particular, are core drivers of basic knowledge creation (Simard & West 2006) and play a decisive role in creating new products (Zeng et al. 2010).

Reconfiguration capability's *R&D increase* variable is positively related to research-based R&D collaboration partners, but without statistical significance. Reconfiguration capability's *direct R&D* variable is negatively related to research-based R&D collaboration partners. This suggests that as firms are more directly involved with R&D, they are less likely to engage in R&D collaboration. And this means firms use R&D collaboration as an alternative to internal R&D activities. In terms of knowledge management, as both internal R&D and R&D collaboration increases at the same time, it could incur unintended knowledge overlapping, raise management costs, and thus decrease the efficiency of R&D activity (Lavie & Drori 2012; Rothaermel & Hess 2007; Soh & Subramanian 2013). Firms wish to enhance productivity of R&D by working together with partners which hold resources that may create synergy with their internal resources (Das, Sen, & Sengupta 1998). The negative relationship between direct R&D variable and research-based R&D collaboration partners found in this research may suggest that firms begin to opt for R&D collaboration as an alternative to their direct

R&D activities as they reach the limit of R&D resources and capabilities.

Firm size is an important determinant of R&D collaboration (Fontana et al. 2003; Mohnen & Hoareau 2003). This study found that smaller firms are more likely to prefer research-based R&D partners (Link & Rees 1990). Small firms with less visibility in the market can strengthen trust and reputation as well as obtain R&D resources through alliance with colleges (Ahrweiler et al. 2011; Oliver & Liebeskind 1997). In the result of R&D collaboration selection equation, it was found that firms with larger size are more likely to take R&D collaboration. This may suggest that small firms face disadvantage of "smallness" in R&D collaboration, and difficulty in winning an opportunity to R&D collaboration. Firm age variable did not show statistically significance, but firms with older age are more likely to prefer research-based R&D partners.

Firms' lack of infrastructure and technology and high costs of R&D were found to increase R&D collaboration. This is in line with the finding of Belderbos et al. (2004) that firms collaborate with research institutes to share costs. Lack of internal resources of firms is the major reason for firms' decision toward R&D collaboration (Hagedoorn & Schakenraad 1994). Firms can access complementary knowledge through R&D collaboration, as well as share the high costs and risks of R&D (Hagedoorn 1993). In particular, small innovative firms have serious constraints on R&D investment such as insufficient internal funds and difficulty of access to credit market (Freel 2007; Hall 2002). SMEs are more active in R&D collaboration to solve shortage of funds necessary for innovation creation (Baum et al. 2000). Through R&D collaboration, SMEs can approach credit market successfully as well as reduce R&D costs (Piga & Atzeni 2007).

[Table 21] Determinants of research-based R&D partner selection: Probit model with sample selection

	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.161*** (0.057)	0.035*** (0.012)	0.113*** (0.043)	0.016*** (0.006)	
ad hoc partner	0.058 (0.048)	0.013 (0.010)	0.056 (0.036)	0.008 (0.005)	
general partner	-0.404*** (0.049)	-0.087*** (0.010)	-0.308*** (0.042)	-0.043*** (0.007)	
innovation	0.043 (0.051)	0.009 (0.011)	0.035 (0.037)	0.005 (0.005)	
product innovation	0.107** (0.047)	0.023** (0.010)	0.077** (0.034)	0.011** (0.005)	
R&D increase	0.025 (0.041)	0.005 (0.009)	0.022 (0.030)	0.003 (0.004)	
direct R&D	-0.033 (0.045)	-0.007 (0.010)	-0.031 (0.033)	-0.004 (0.005)	

size2	0.009	0.002	-0.017	-0.002	0.008
	(0.135)	(0.029)	(0.103)	(0.015)	(0.066)
size3	0.032	0.007	0.005	0.001	-0.006
	(0.154)	(0.033)	(0.116)	(0.016)	(0.074)
size4	-0.236	-0.054	-0.302***	-0.048**	0.214***
	(0.152)	(0.037)	(0.112)	(0.020)	(0.078)
age2	0.201	0.041	0.093	0.013	-0.094
	(0.358)	(0.070)	(0.281)	(0.038)	(0.192)
age3	0.276	0.058	0.162	0.022	-0.084
	(0.358)	(0.074)	(0.281)	(0.038)	(0.192)
age4	0.576	0.107*	0.386	0.048	-0.076
	(0.368)	(0.058)	(0.289)	(0.031)	(0.197)
human resources	0.231**	0.051**			0.079
	(0.103)	(0.023)			(0.048)
infrastructure	0.126	0.027			0.125***
	(0.100)	(0.021)			(0.048)
technology	-0.058	-0.012			0.121**
	(0.105)	(0.023)			(0.050)
cost	0.183*	0.040*			0.198***
	(0.106)	(0.024)			(0.050)
industry			(included)		
LR test of rho = 0:			-0.866***		
rho			[18.99]		
[Chi-squared(1)]					

Log likelihood	-489.61	-2534.74
Sample size	1,239	3,061

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** 5%, and * at 10%.

Firms decide to have R&D collaboration, and then select R&D collaboration partners. Based on this sequence of decision-making, R&D collaboration partner selection is possible only for firms which decided to have R&D collaboration, and thus randomness of sampling is not guaranteed. According to Table 21 and Table 22, there exists correlation between disturbance terms of collaborative R&D equation and collaborative R&D partner equation, and using probit model with sample selection, due to selection bias, consistent estimator is obtained.

Sensing capability's *openness* variable is positively related to market-based R&D collaboration partners, which is identical to relationship of the research-based R&D collaboration to openness. Openness to external technology and information is positively related to R&D collaboration partners regardless of their type, and thus openness is not significant as determinant of R&D collaboration partners. *Ad-hoc partner* variable is negatively related to market-based R&D partners, but without statistical significance. *General partner* variable is positively related to market-based R&D partners with statistical significance. This is opposite to research-based R&D partner selection which is negatively related. When firms need market-based R&D resources, they prefer general partners having rich resources rather than specific and professional partners. Seizing capability variables as they become larger, are more likely not to prefer market-based R&D partners. Reconfiguration capability variables did not have statistically significant values. Hypothesis 1 that research-based R&D collaboration partner increases the impact of dynamic capabilities is most prominently observed in seizing capability. Sensing capability plays an important role in exploring suitable partners, but the selection of R&D collaboration partners after R&D investment decision is more affected by seizing capability.

As the firm size increase, firms prefer working with market-based R&D collaboration partners. Based on this finding, it is confirmed that small firms face limit of smallness when they try to select market-based R&D collaboration partners. Firm size is critical in case of collaboration with market-based R&D partner.

[Table 22] Determinants of market-based R&D partners: Probit model with sample selection

	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.136*** (0.041)	0.054*** (0.016)	0.077*** (0.021)	0.016*** (0.006)	
ad hoc partner	-0.020 (0.037)	-0.008 (0.015)	-0.021 (0.020)	0.008 (0.005)	

general partner	0.218***	0.086***	0.123***	-0.043***	
	(0.036)	(0.014)	(0.021)	(0.007)	
innovation	-0.024	-0.010	-0.020	0.005	
	(0.041)	(0.016)	(0.023)	(0.005)	
product innovation	-0.016	-0.006	-0.002	0.011**	
	(0.038)	(0.015)	(0.021)	(0.005)	
R&D increase	-0.009	-0.003	0.002	0.003	
	(0.032)	(0.013)	(0.019)	(0.004)	
direct R&D	-0.021	-0.008	-0.012	-0.004	
	(0.036)	(0.014)	(0.020)	(0.005)	
size2	0.072	0.029	0.010	-0.002	0.020***
	(0.109)	(0.043)	(0.075)	(0.015)	(0.006)
size3	0.089	0.035	-0.017	0.001	-0.005
	(0.124)	(0.049)	(0.085)	(0.016)	(0.005)
size4	0.381***	0.151***	0.286***	-0.048**	0.033***
	(0.127)	(0.050)	(0.085)	(0.020)	(0.006)
age2	0.000	0.000	-0.030	0.013	-0.005
	(0.308)	(0.122)	(0.217)	(0.038)	(0.006)
age3	-0.161	-0.063	-0.112	0.022	0.000
	(0.306)	(0.121)	(0.216)	(0.038)	(0.006)
age4	-0.314	-0.122	-0.256	0.048	0.001
	(0.312)	(0.121)	(0.221)	(0.031)	(0.005)
Human resources	-0.115	-0.045			-0.003
	(0.083)	(0.033)			(0.005)

infrastructure	0.041 (0.081)	0.016 (0.032)		0.003 (0.020)
technology	0.042 (0.085)	0.017 (0.034)		-0.004 (0.023)
cost	0.023 (0.087)	0.009 (0.034)		0.081*** (0.026)
industry			(included)	
LR test of rho = 0: rho [Chi-squared(1)]			0.992*** [26.34]	
Log likelihood	-782.70		-2820.41	
Sample size	1,244		3,061	

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

5.3 Firm Size

Table 23 and Table 24 are results of analysis of determinants of research-based R&D collaboration partners according to firm size. In order to analyze the impact of dynamic capabilities on the selection of R&D collaboration partners by firm size, samples were divided into small firms (5 ≤ firm size < 20) and large firms with more than 20 employees. *Openness* variable, regardless of firm size, was positively related to research-based R&D collaboration partners with statistical significance.

[Table 23] Determinants of research-based R&D partner by firm size (5 ≤ Size < 20)

	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.081 (0.058)	0.028 (0.020)	0.342** (0.153)	0.041** (0.018)	
ad hoc partner	0.166*** (0.055)	0.058*** (0.019)	0.046 (0.091)	0.006 (0.011)	
general partner	-0.291*** (0.056)	-0.102*** (0.020)	-0.240*** (0.089)	-0.029** (0.012)	
innovation	0.019 (0.056)	0.007 (0.020)	-0.013 (0.084)	-0.002 (0.010)	
product innovation	0.046 (0.058)	0.016 (0.020)	-0.062 (0.076)	-0.007 (0.009)	
R&D increase	0.410*** (0.061)	0.144*** (0.022)	0.119 (0.087)	0.014 (0.011)	
direct R&D	0.055 (0.058)	0.019 (0.020)	-0.130 (0.097)	-0.016 (0.012)	
age2	-0.305 (0.307)	-0.108 (0.109)	-0.428 (0.505)		0.073 (0.283)
age3	-0.195 (0.313)	-0.068 (0.106)	-0.479 (0.512)		0.083 (0.289)

age4	-0.114	-0.039	0.293	-0.111
	(0.363)	(0.121)	(0.667)	(0.341)
Human resources	0.210*	0.073*	0.342**	0.156
	(0.121)	(0.042)	(0.153)	(0.106)
Infrastructure	0.119	0.042	0.046	0.101
	(0.122)	(0.043)	(0.091)	(0.111)
technology	0.275**	0.097**	-0.240***	0.227**
	(0.125)	(0.045)	(0.089)	(0.109)
cost	0.216	0.073	-0.013	0.201
	(0.150)	(0.049)	(0.084)	(0.130)
industry			(included)	
LR test of rho = 0:			-0.819***	
rho			[11.54]	
[Chi-squared(1)]				
Log likelihood	-365.73		-2820.41	
Sample size	249		707	

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

Among small firms (less than 20 employees), unlike larger firms, *innovation* variable and *product innovation* variable were negatively related to research-based R&D collaboration partners. This implies that small firms do not collaborate with research-based R&D partners just for technological innovation. They use R&D collaboration to strengthen legitimacy and visibility as well as to deal with lack of resources for innovation (Doz 1996; Stuart 2000). Because small firms focus on specific areas for innovation, they are highly professional in specific areas. Accordingly, small firms are less likely to work with research-based R&D partners having professional knowledge for innovation (Soh & Subramanian 2013). The impact of sensing capability on research-based R&D partner selection does not vary depending on firm size, while seizing capability does vary. Hypothesis 2 that smaller firms have greater impact of dynamic capabilities cannot be adopted in the selection of research-based R&D partners.

[Table 24] Determinants of research-based R&D partner by firm size (20 ≤ Size)

	(1)Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.084*** (0.030)		0.085* (0.046)	0.012* (0.007)	
ad hoc partner	0.099*** (0.029)		0.051 (0.041)	0.008 (0.006)	
general partner	-0.335*** (0.031)		-0.358*** (0.054)	-0.053*** (0.010)	
innovation	0.049 (0.032)		0.039 (0.043)	0.006 (0.006)	
product innovation	0.112***		0.116***	0.017***	

	(0.031)	(0.041)	(0.006)	
R&D increase	0.440***	0.003	0.000	
	(0.030)	(0.034)	(0.005)	
direct R&D	0.049*	-0.012	-0.002	
	(0.028)	(0.037)	(0.005)	
age2	0.060	0.455	0.056	-0.233
	(0.296)	(0.372)	(0.039)	(0.269)
age3	0.167	0.541	0.077	-0.208
	(0.293)	(0.368)	(0.052)	(0.267)
age4	0.314	0.666*	0.083**	-0.138
	(0.296)	(0.372)	(0.040)	(0.269)
human resources	0.053			0.050
	(0.064)			(0.055)
infrastructure	0.090			0.127**
	(0.063)			(0.054)
technology	0.046			0.092
	(0.067)			(0.058)
cost	0.147**			0.169***
	(0.064)			(0.055)
industry		(included)		
LR test of rho = 0:		-0.819***		
rho		[11.54]		
[Chi-squared(1)]				
Log likelihood	-382.901	-1964.26		

Sample size	960	2,354

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

Table 25 and Table 26 show the results of market-based R&D partner selection according to firm size. In the selection of market-based R&D partner, the impact of sensing capability varies according to firm size. As for firms with over 20 employees, firms with more openness to external knowledge, and with more specificity of partners, are more likely to prefer market-based R&D partners. The impact of seizing capability on market-based R&D partners did not vary according to firm size, but without statistical significance. Reconfiguration capability did not have statistically significant impact on market-based R&D partners. Again, in the result of analysis of determinants of market-based R&D partners, Hypothesis 2 that the impact of dynamic capabilities becomes greater as the firm size gets smaller cannot be accepted. In order for dynamic capabilities to become meaningful capabilities, a long-term investment is needed and the pursuit of change through dynamic capabilities could incur additional costs by disturbing existing capabilities rather than creating benefits through such change. (Winter 2003). Hence, firms that can maintain the balance between costs and benefits caused by dynamic capabilities, i.e. firms whose size exceeds a certain level would experience greater impact of dynamic capabilities.

[Table 25] Determinants of market-based R&D partner by firm size (5 ≤ Size < 20)

	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.026 (0.070)	0.006 (0.016)	0.037 (0.072)	0.010 (0.530)	
ad hoc partner	0.193*** (0.062)	0.044*** (0.014)	0.092 (0.061)	0.025 (1.370)	
general partner	0.000 (0.062)	0.000 (0.014)	0.174** (0.078)	0.047* (1.720)	
innovation	-0.010 (0.065)	-0.002 (0.015)	-0.080 (0.063)	-0.021 (-1.180)	
product innovation	0.071 (0.063)	0.016 (0.014)	0.000 (0.055)	0.000 (0.000)	
R&D increase	0.235*** (0.058)	0.054*** (0.013)	-0.028 (0.051)	-0.007 (-0.530)	
direct R&D	0.045 (0.065)	0.010 (0.015)	-0.036 (0.059)	-0.010 (-0.600)	
age2	-0.154 (0.336)	-0.036 (0.078)	0.053 (0.357)	0.014 (0.150)	0.063 (0.284)
age3	-0.184 (0.342)	-0.041 (0.074)	-0.107 (0.371)	-0.028 (-0.290)	0.053 (0.290)

age4	-0.727	-0.116**	-0.658	-0.132	-0.152
	(0.453)	(0.045)	(0.493)	(-1.610)	(0.342)
Human resources	-0.171	-0.040			0.190*
	(0.136)	(0.032)			(0.101)
infrastructure	0.064	0.015			0.044
	(0.136)	(0.032)			(0.098)
technology	0.150	0.035			0.169
	(0.139)	(0.033)			(0.103)
cost	0.176	0.038			0.083
	(0.170)	(0.035)			(0.116)
industry			(included)		
LR test of rho = 0: rho [Chi-squared(1)]			0.884** [4.57]		
Log likelihood	-285.382		-623.488		
Sample size	281		707		

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

The results of Table 25 and Table 26 showed that the purpose of R&D collaboration varies depending on the firm size. Firms with less than 20 employees use R&D collaboration when they lack R&D manpower, whereas those with over 20 employees participate in R&D collaboration to reduce the R&D costs.

[Table 26] Determinants of market-based R&D partner by firm size (20 ≤ Size)

	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.114***	0.029***	0.076***	0.021***	
	(0.031)	(0.008)	(0.022)	(0.006)	
ad hoc partner	0.018	0.005	-0.039*	-0.011*	
	(0.031)	(0.008)	(0.023)	(0.006)	
general partner	0.034	0.009	0.123***	0.033***	
	(0.032)	(0.008)	(0.024)	(0.007)	
innovation	0.031	0.008	-0.007	-0.002	
	(0.034)	(0.009)	(0.025)	(0.007)	
product innovation	0.044	0.011	0.003	0.001	
	(0.032)	(0.008)	(0.025)	(0.007)	
R&D increase	0.300***	0.077***	0.015	0.004	
	(0.029)	(0.007)	(0.022)	(0.006)	
direct R&D	0.024	0.006	-0.007	-0.002	
	(0.030)	(0.008)	(0.022)	(0.006)	
age2	0.012	0.003	-0.112	-0.029	-0.229
	(0.308)	(0.079)	(0.305)	(0.078)	(0.270)
age3	0.022	0.006	-0.145	-0.039	-0.209
	(0.305)	(0.078)	(0.301)	(0.081)	(0.268)

age4	0.063	0.016	-0.200	-0.052	-0.151
	(0.308)	(0.081)	(0.303)	(0.077)	(0.269)
human resources	-0.046	-0.012			0.029
	(0.068)	(0.018)			(0.046)
infrastructure	0.081	0.021			0.076
	(0.068)	(0.018)			(0.047)
technology	0.083	0.021			0.066
	(0.072)	(0.018)			(0.048)
cost	0.065	0.016			0.117**
	(0.069)	(0.018)			(0.047)
industry			(included)		
LR test of rho = 0: rho [Chi-squared(1)]			0.992*** [20.43]		
Log likelihood	-1048.949		-2184.937		
Sample size	963		2,354		

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

5.4 Technological Regime

Table 27 shows the result of analysis of determinants of research-based R&D collaboration partners according to technological regime. Openness to external information was positively related to research-based R&D partners in both high-tech industry and low-tech industry, but statistical significance existed only in the high-tech industry. ‘Anonymity of partners’, ‘professionality of partners’ and ‘investment in innovation’ were favored when research-based R&D partners were selected by the low-tech industry. This result does not support Hypothesis 3 that the impact of dynamic capabilities is more prominent in high-tech industry. This suggests that regardless of environmental dynamism, dynamic capabilities is positively related to R&D collaboration selection.

[Table 27] Determinants of research-based R&D partners according to technological regime (high-tech industry)

	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.071** (0.033)	0.026** (0.012)	0.165*** (0.058)	0.023*** (0.008)	
ad hoc partner	0.118*** (0.033)	0.043*** (0.012)	0.026 (0.046)	0.004 (0.006)	
general partner	-0.299*** (0.034)	-0.109*** (0.012)	-0.274*** (0.050)	- 0.038*** (0.007)	
innovation	0.001 (0.034)	0.000 (0.012)	-0.043 (0.045)	-0.006 (0.006)	

product innovation	0.067**	0.024**	0.081*	0.011*	
	(0.033)	(0.012)	(0.043)	(0.006)	
R&D increase	0.422***	0.154***	0.062	0.009	
	(0.033)	(0.012)	(0.039)	(0.006)	
direct R&D	0.054*	0.020*	-0.059	-0.008	
	(0.032)	(0.012)	(0.044)	(0.006)	
size2	-0.026	-0.009	0.099	0.013	-0.053
	(0.094)	(0.034)	(0.136)	(0.018)	(0.086)
size3	-0.056	-0.020	-0.028	-0.004	-0.009
	(0.104)	(0.037)	(0.146)	(0.021)	(0.095)
size4	-0.015	-0.006	-0.335**	-0.052**	0.181*
	(0.108)	(0.039)	(0.139)	(0.024)	(0.098)
age2	-0.045	-0.016	0.034	0.005	-0.046
	(0.281)	(0.101)	(0.386)	(0.052)	(0.260)
age3	-0.018	-0.007	0.055	0.008	-0.079
	(0.280)	(0.102)	(0.385)	(0.053)	(0.259)
age4	0.087	0.032	0.327	0.041	-0.106
	(0.285)	(0.105)	(0.394)	(0.044)	(0.264)
human resources	-0.004	-0.001			0.024
	(0.071)	(0.026)			(0.062)
Infrastructure	0.006	0.002			0.037
	(0.071)	(0.026)			(0.062)
Technology	0.012	0.004			0.040
	(0.076)	(0.028)			(0.065)

Cost	0.147* (0.076)	0.053* (0.027)		0.150** (0.066)
Industry			(included)	
LR test of rho = 0: rho [Chi-squared(1)]			-0.891*** [10.87]	
Log likelihood	-932.60		-1520.53	
Sample size	765		1,789	

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

Some researchers argued dynamic capabilities are necessary for firms to attain sustainable competitive advantage in a rapidly changing environment (Teece et al. 1997; Teece 2007). Previous empirical literature regarding environmental dynamism were largely focused on high-tech industry such as bio industry (Madhok & Osegowitsch 2000). However, the effect of dynamic capabilities can be activated in a less dynamic environment as well as in a rapidly changing environment (Eisenhardt & Martin 2000). Protogerou et al. (2012) proved that in Greek manufacturing industry, dynamic capabilities affect firm performance, regardless of level of environmental dynamism. Ambrosini and Bowman (2009) argued that because dynamic capabilities can be effective under a relatively stable environment, the term “dynamic” should not be construed as “environmental dynamism.” This study also found that dynamic capabilities are affecting firms’ choice of strategy in a less variable environment as well as in a rapidly changing environment. This implies that dynamic capabilities help firms respond to changes, sense environmental change, and choose strategy to cope with such change, irrespective of the speed of the change.

[Table 28] Determinants of market-based R&D partners according to technological regime (low-tech industry)

	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.100** (0.044)	0.033** (0.014)	0.048 (0.068)	0.006 (0.009)	
ad hoc partner	0.101** (0.041)	0.033** (0.014)	0.108* (0.063)	0.015 (0.009)	
general partner	-0.354*** (0.044)	-0.117*** (0.015)	-0.397*** (0.087)	- 0.054*** (0.016)	
innovation	0.122*** (0.045)	0.040*** (0.015)	0.184** (0.072)	0.025** (0.011)	
product innovation	0.151*** (0.045)	0.050*** (0.015)	0.057 (0.059)	0.008 (0.008)	
R&D increase	0.457*** (0.046)	0.151*** (0.015)	-0.067 (0.052)	-0.009 (0.007)	

direct R&D	0.047	0.015	0.018	0.002	
	(0.043)	(0.014)	(0.054)	(0.007)	
size2	-0.002	-0.001	-0.139	-0.019	0.109
	(0.118)	(0.039)	(0.167)	(0.025)	(0.104)
size3	-0.134	-0.043	0.073	0.010	0.003
	(0.135)	(0.042)	(0.198)	(0.025)	(0.119)
size4	-0.004	-0.001	-0.209	-0.031	0.277**
	(0.148)	(0.049)	(0.194)	(0.032)	(0.130)
age2	-0.194	-0.063	0.092	0.012	-0.102
	(0.318)	(0.100)	(0.434)	(0.056)	(0.287)
age3	0.053	0.018	0.175	0.023	-0.030
	(0.316)	(0.105)	(0.430)	(0.057)	(0.287)
age4	0.287	0.099	0.318	0.038	0.053
	(0.329)	(0.118)	(0.446)	(0.047)	(0.298)
human resources	0.232**	0.075**			0.165**
	(0.091)	(0.029)			(0.078)
infrastructure	0.204**	0.068**			0.257***
	(0.090)	(0.031)			(0.078)
technology	0.209**	0.069**			0.238***
	(0.095)	(0.031)			(0.080)
cost	0.176*	0.057*			0.254***
	(0.095)	(0.031)			(0.080)
industry			(included)		
LR test of rho = 0:			-0.830***		

rho [Chi-squared(1)]		[6.66]	
Log likelihood	-614.62	-998.39	
Sample size	479	1,789	

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

Table 29 is the result of analysis of determinants of market-based R&D partners according to technological regime. Among determinants, 'product innovation' variable showed significant difference depending on technological regime. High-tech industry firms do not favor market-based R&D collaboration partners when they intend to do R&D for product innovation, whereas low-tech industry firms prefer market-based partners for product innovation. Low-tech industry's product innovation is focused on non-technological factors such as price, brand, and distribution, rather than technological aspects (Marsili 2002). Low-tech industry firms use product innovation as a means to differentiate. In the analysis of determinants of market-based R&D collaboration partners, dynamic capabilities have an impact in the low-tech industry.

[Table 29] Determinants of market-based R&D partners according to technological regime (high-tech industry)

	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.081**	0.021**	0.076***	0.021***	

	(0.036)	(0.009)	(0.028)	(0.008)	
ad hoc partner	0.061*	0.016*	-0.005	-0.001	
	(0.036)	(0.009)	(0.028)	(0.008)	
general partner	0.004	0.001	0.116***	0.032***	
	(0.035)	(0.009)	(0.027)	(0.007)	
innovation	0.010	0.003	0.006	0.002	
	(0.037)	(0.010)	(0.030)	(0.008)	
product innovation	-0.023	-0.006	-0.052*	-0.014*	
	(0.035)	(0.009)	(0.028)	(0.008)	
R&D increase	0.266***	0.069***	-0.002	0.000	
	(0.032)	(0.008)	(0.025)	(0.007)	
direct R&D	0.030	0.008	-0.022	-0.006	
	(0.034)	(0.009)	(0.026)	(0.007)	
size2	-0.040	-0.010	-0.041	-0.011	-0.050
	(0.104)	(0.026)	(0.100)	(0.027)	(0.086)
size3	-0.015	-0.004	-0.035	-0.010	-0.019
	(0.116)	(0.030)	(0.110)	(0.030)	(0.095)
size4	0.313***	0.086**	0.324***	0.094***	0.157
	(0.116)	(0.034)	(0.107)	(0.033)	(0.096)
age2	0.038	0.010	-0.001	0.000	-0.080
	(0.295)	(0.077)	(0.294)	(0.080)	(0.260)
age3	-0.023	-0.006	-0.131	-0.036	-0.106
	(0.295)	(0.076)	(0.293)	(0.079)	(0.259)
age4	-0.087	-0.022	-0.266	-0.069	-0.140

	(0.301)	(0.075)	(0.298)	(0.073)	(0.263)
human resources	-0.074	-0.019			0.020
	(0.078)	(0.020)			(0.053)
infrastructure	0.006	0.002			0.022
	(0.077)	(0.020)			(0.053)
technology	0.042	0.011			0.027
	(0.082)	(0.021)			(0.056)
cost	0.108	0.028			0.100*
	(0.083)	(0.021)			(0.055)
industry			(included)		
LR test of rho = 0: rho			0.999***		
[Chi-squared(1)]			[24.35]		
Log likelihood	-810.14		-1695.63		
Sample size	765		1,789		

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

Purpose of R&D collaboration varies depending on technological regime. High-tech industry firms use R&D collaboration to reduce the burden of R&D costs, while low-tech industry firms participate in R&D to tackle issues such as manpower, infrastructure, technology, and costs. This may suggest that as low-tech industry firms concentrate on acquiring non-technological competitiveness, they rely on external sources to get resources necessary for R&D.

[Table 30] Determinants of market-based R&D partners according to technological regime (high-tech industry) (low-tech industry)

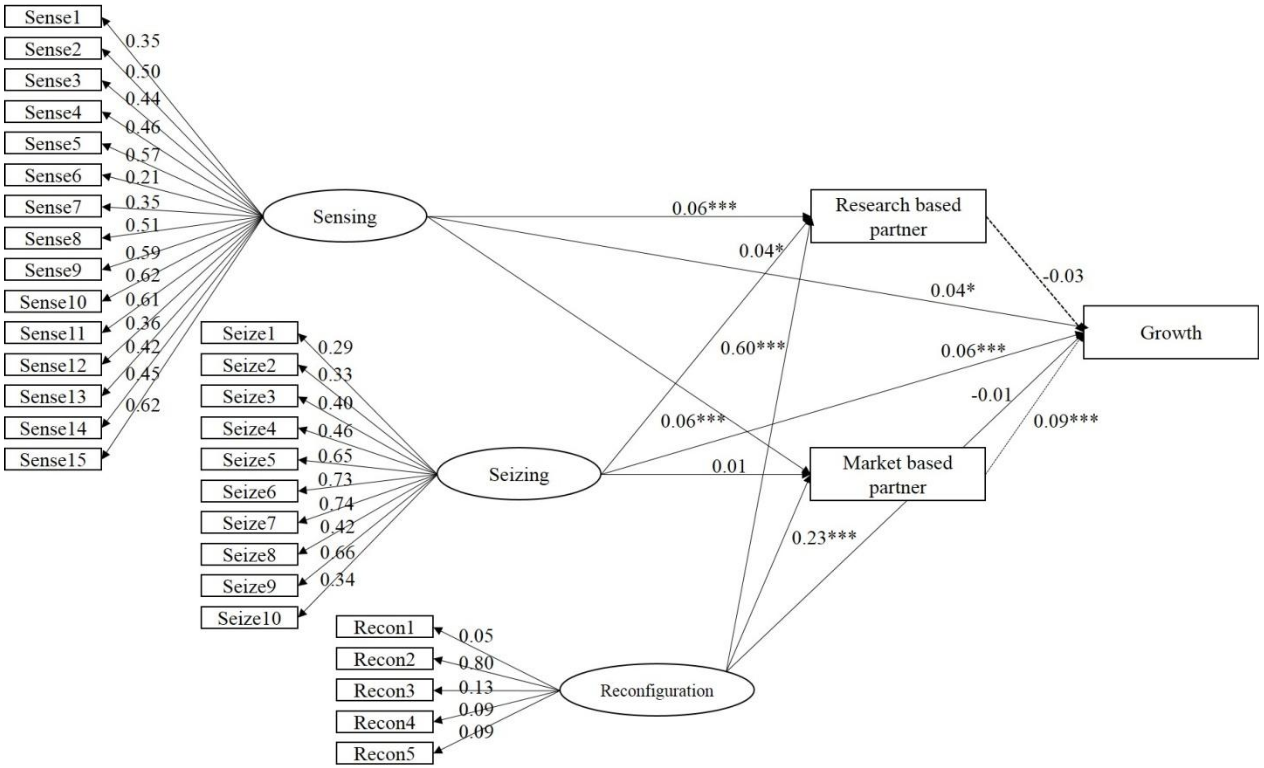
	(1) Probit model		(2) Sample selection model		
	R&D partner equation		R&D partner equation		Collaborative R&D equation
	Coefficient	Marginal effect	Coefficient	Marginal effect	
openness	0.137*** (0.046)	0.032*** (0.011)	0.116* (0.060)	0.039* (0.023)	
ad hoc partner	0.027 (0.044)	0.006 (0.010)	-0.046 (0.052)	-0.015 (0.018)	
general partner	0.066 (0.046)	0.015 (0.011)	0.224*** (0.070)	0.074** (0.036)	
innovation	0.017 (0.050)	0.004 (0.012)	-0.084 (0.060)	-0.028 (0.022)	
product innovation	0.157*** (0.047)	0.037*** (0.011)	0.134** (0.061)	0.045* (0.026)	
increasing R&D	0.326*** (0.045)	0.076*** (0.011)	0.003 (0.048)	0.001 (0.016)	
direct R&D	0.013 (0.045)	0.003 (0.010)	-0.011 (0.052)	-0.004 (0.017)	
size2	0.132 (0.126)	0.032 (0.031)	0.117 (0.157)	0.039 (0.055)	0.089 (0.104)
size3	-0.006 (0.147)	-0.001 (0.034)	0.099 (0.178)	0.033 (0.062)	-0.023 (0.119)

size4	0.198	0.049	0.252	0.087	0.239*
	(0.157)	(0.041)	(0.181)	(0.067)	(0.130)
age2	-0.075	-0.017	0.117	0.039	-0.105
	(0.349)	(0.079)	(0.446)	(0.153)	(0.287)
age3	-0.021	-0.005	-0.025	-0.008	-0.043
	(0.348)	(0.081)	(0.438)	(0.145)	(0.287)
age4	-0.032	-0.007	-0.268	-0.085	0.000
	(0.361)	(0.083)	(0.454)	(0.140)	(0.299)
human resources	-0.051	-0.012			0.137*
	(0.097)	(0.023)			(0.080)
infrastructure	0.170*	0.040*			0.233***
	(0.097)	(0.024)			(0.084)
technology	0.154	0.036			0.237***
	(0.100)	(0.023)			(0.082)
cost	0.099	0.023			0.225***
	(0.102)	(0.023)			(0.083)
industry			(included)		
LR test of rho = 0:			0.591*		
rho			[2.07]		
[Chi-squared(1)]					
Log likelihood	-527.39		-1110.52		
Sample size	479		1,789		

Note: Figures in parentheses are standard errors. *** is significant at 1%, ** at 5%, and * at 10%.

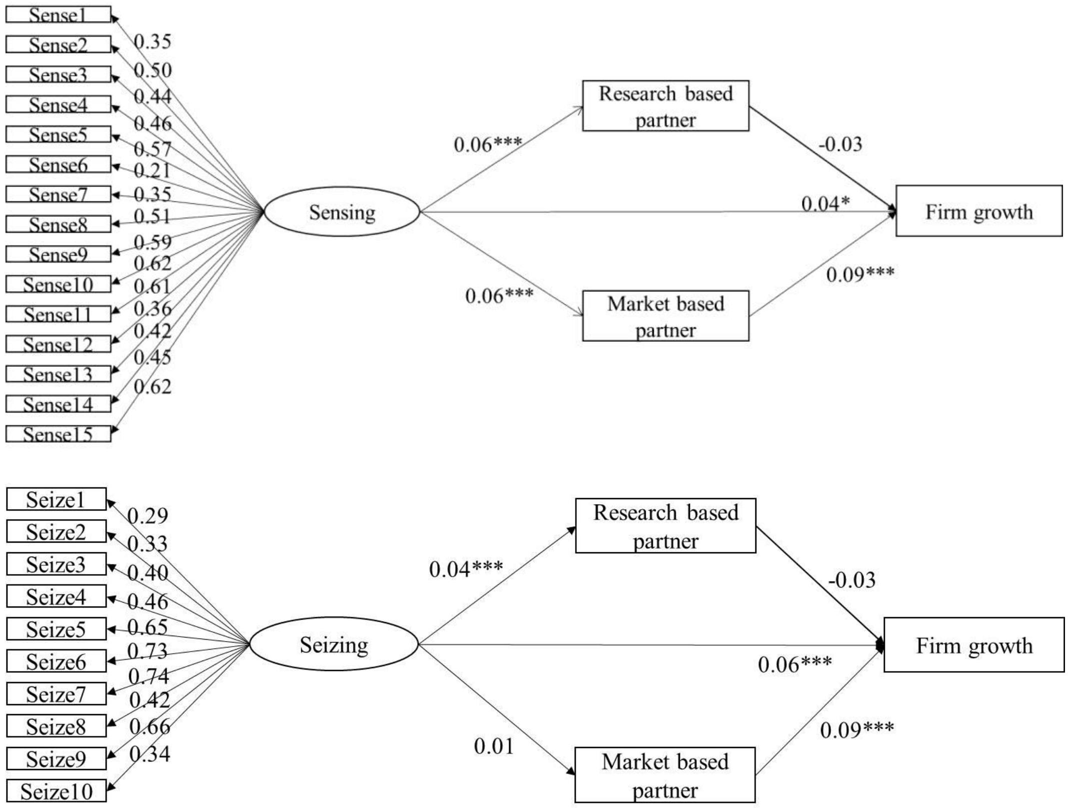
5.5 Firm Performance

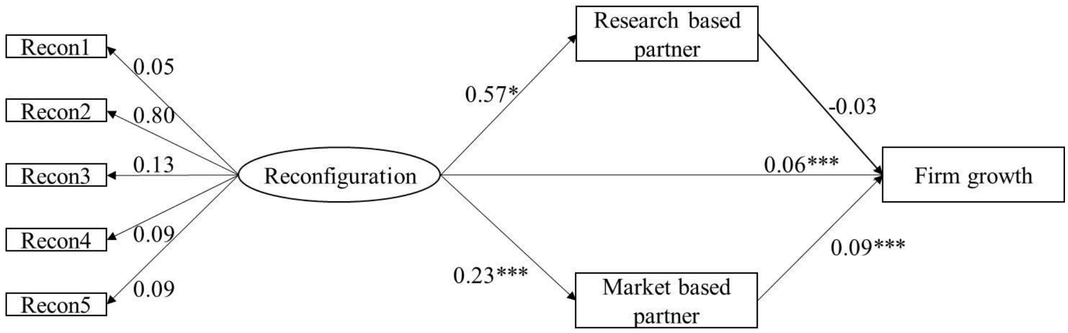
Figure 6 shows the result of path analysis of structural equation that analyzed the impact of dynamic capabilities on R&D partners and firm performance. Based on these results, we can compare the direct impact of sensing capability, seizing capability, and reconfiguration capability on firm growth with their indirect impact on firm growth through selection of R&D partners. Latent variables and observed variables of dynamic capabilities include statistically significant path ($p < 0.01$). Sensing capability and seizing capability have direct, positive impact on firm performance. This finding conforms to the observation of Teece et al. (1997), Teece (2007). However, reconfiguration capability is not directly related to firm growth. Relationship between dynamic capabilities and R&D partners are statistically significant, except for relation between seizing capability and market-based R&D partner. With respect to relationship between R&D partner and firm growth, only market-based R&D partner is related to firm growth with statistical significance. Because the relationship between research-based R&D partners and firm growth is not statistically significant, it is difficult to compare direct and indirect impacts of dynamic capabilities on firm growth through research-based R&D partners. In addition, seizing capability is not related to market-based R&D partner with statistical significance, it is difficult to compare the direct and indirect impacts of seizing capability on firm growth.



[Figure 6] Path analysis of relationship between dynamic capabilities and firm growth

According to Figure 7, with respect to market-based R&D partners, sensing capability had a statistically significant impact on the selection of market-based R&D partners, and the impact of market-based R&D partners on firm growth was statistically significant. Sensing capability's indirect impact on firms growth through market-based R&D partners was found to have greater explanatory power than its direct impact (0.09*** > 0.04*). Path analysis between sensing capability and firm growth supports Hypothesis 4a. that the indirect impact of dynamic capabilities on firm growth is greater than its direct impact. Research-based R&D partners have a negative impact on firm growth while market-based R&D partners have a positive impact on firm growth with statistical significance. This suggests that collaboration with market-based R&D partners is more effective in achieving short-term performance.





[Figure 7] Results of path analysis of dynamic capabilities and firm growth

Table 31 is the result of analysis of dynamic capabilities on firms' market performance. Sensing capability has statistically significant impact on firm growth (0.04, $p < 0.1$). Sensing capability has indirect impact on firm growth through research-based R&D partners and market-based R&D partners. Sensing capability is positively related to both type of R&D partners, but the relation between research-based R&D partner and firm growth is not statistically significant. On the other hand, market-based partner is positively related to firm growth with statistical significance. Generally, firms collaborate with research-based R&D partners at the early phase of R&D, and cooperate with market-based partners in the phase of R&D commercialization. Hence research-based partners often do not generate sales -- firms' visible short-term performance. On the other hand, when they work with market-based partners in the commercialization phase to produce market performance from R&D, market-based partners have a positive impact on short-term performance. Through path analysis of relation between sensing capability and firm growth, indirect impact of sensing capability on firm growth through market-based R&D partners is found to be greater than its direct impact on firm growth.

Coefficient of direct path from seizing capability to firm growth was positive with statistical significance (0.06, $p < 0.01$). The path from seizing capability to research-based partners had a positive value, with statistical significance (0.04, $p < 0.1$). However, the relationship between research-based partner selection and firm growth was not statistically significant, making it difficult to explain the indirect effect of seizing capability on firm growth.

Direct impact of reconfiguration capability on firm growth had a negative value without statistical significance. The impact of reconfiguration capability on selection of the two types of R&D partners had a positive value. The impact of market-based R&D partner on firm growth had a positive value with statistical significance. Thus indirect impact of reconfiguration capability on firm growth is greater than its direct impact. The indirect impact of dynamic capabilities on firm growth was found to be more prominent through market-based R&D partners rather than through research-based R&D partners. This research finding is consistent with the argument that dynamic capabilities are indirectly related to firm growth (Kogut & Zander 1992; Zott 2003).

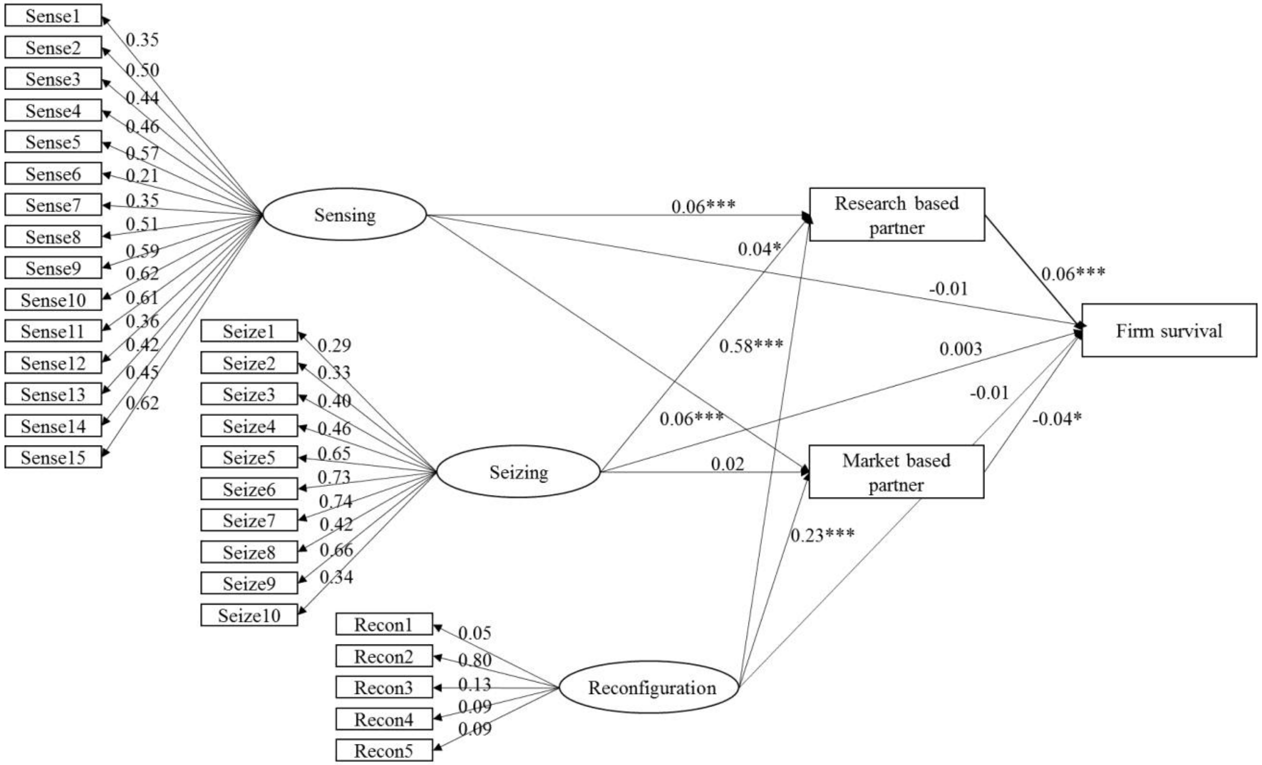
[Table 31] The impact of dynamic capabilities on firm growth

Parameter	Direct effect	Indirect effect
Sensing capabilities → Research based R&D partner		0.06***
Sensing capabilities → Market based R&D partner		0.06***
Sensing capabilities → Sales	0.04*	
Research based R&D partner → Sales		-0.03
Market based R&D partner → Sales		0.09***
Seizing capabilities → Research based R&D partner		0.04*
Seizing capabilities → Market based R&D partner		0.01
Seizing capabilities → Sales	0.06***	
Reconfiguration capabilities → Research based R&D partner		0.57***

Reconfiguration capabilities → Market based R&D partner	0.23***
Reconfiguration capabilities → Sales	-0.01
Goodness of fit statistics	
χ^2 (df)	χ^2 (585)=4038.41(p < 0.00)
RMSEA	0.044
CFI	0.905
SRMR	0.053

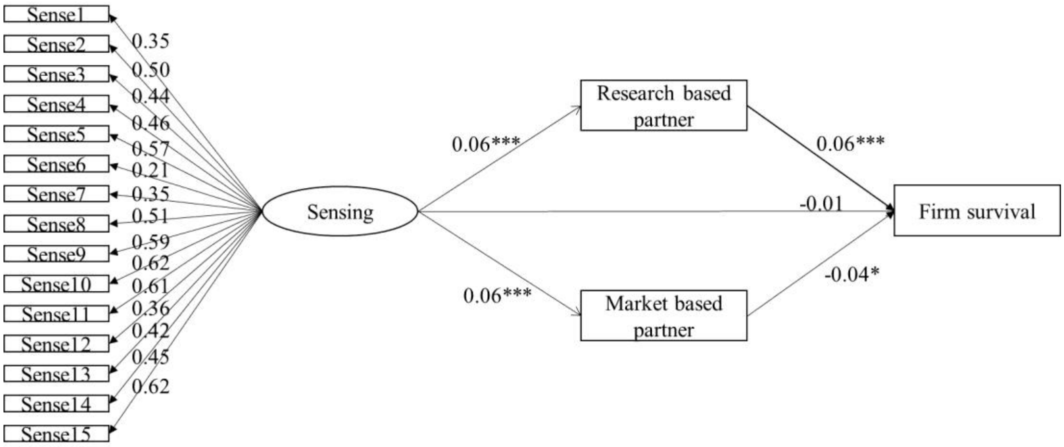
Note: *** is significant at 1%, ** at 5%, and * at 10%.

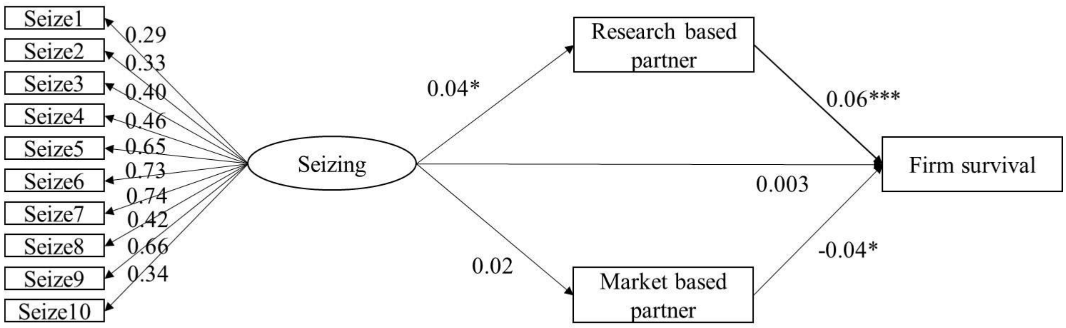
Figure 8 shows the result of path analysis of the impact of dynamic capabilities on R&D partners and firm survival. Based on the results, we can compare the direct impact of sensing capability, seizing capability, and reconfiguration capability on firm survival and the indirect impact of them on firm survival through selection of R&D partners. Both latent variables and observed variables of dynamic capabilities include statistically significant path ($p < 0.01$). Three dynamic capabilities do not have direct impact on firm survival. This outcome is in line with the argument of Eisenhardt and Martin (2000) that dynamic capabilities do not directly affect firm's performance improvement.

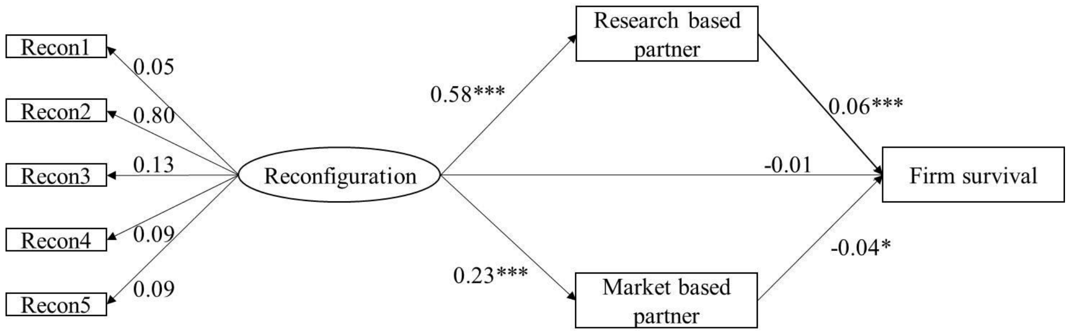


[Figure 8] Result of path analysis of relationship between dynamic capabilities and firm survival

Relationship between dynamic capabilities and R&D partners is statistically significant except relationship between seizing capability and market-based R&D partners. Research-based R&D partner is positively related to firm survival while it is negatively related to market-based R&D partners. Research-based R&D partner does not have any significant impact on short-term performance, but plays an important role in long-term performance improvement (Figure 9).







[Figure 9] Result of path analysis of dynamic capabilities and firm survival

Dynamic capabilities - sensing and seizing opportunities in the early phase of the market and redeploying internal resources to meet external demands - are very critical to firm evolution and survival (Wang & Ahmed 2007). Firm survival depends on the ability of firms to create dynamic capabilities that enable firms to have a competitive advantage (Cool et al. 1989). Firm survival is the representative long-term performance of firms, and dynamic capabilities facilitate firm survival (Zahra & George 2002). Table 32 is the result of path analysis on dynamic capabilities – R&D collaboration partner selection – firm survival. The impact of sensing capability, seizing capability and reconfiguration capability on firm survival is not statistically significant, but indirect path through R&D partner selection is positive with statistical significance. With regard to R&D partners, research-based partners have a positive impact on firm survival, but market-based partners have a negative impact. Firms' R&D activities have impact on both short-term and long-term performances. Research-based R&D partner is selected to solve problems that take long time such as development of new technology and process, and thus does not make any tangible impact on firms' current sales. But it still affects long-term sales of firms, and is positively related with statistical significance to firm survival – firms' long-term performance. On the other hand, market-based R&D partner is negatively related to firm survival with statistical significance, unlike sales. So it was founded that R&D partners, depending on their type, have different impact on firms' short-term and long-term performance.

Firm survival, like sales, is more indirectly than directly affected by dynamic capabilities. Dynamic capabilities sense internal and external opportunities and threats to firms, change firms' operational capabilities to cope with them, thereby affecting firm performance. Accordingly, indirect impact of dynamic capabilities on firm performance is greater than direct impact. This implies that indirect impact of dynamic capabilities is more important to firm survival (Kogut & Zander 1992; Zott 2003).

[Table 32] Impact of dynamic capabilities on firm survival

Parameter	Direct effect	Indirect effect
Sensing capabilities → Research based R&D partner		0.06***
Sensing capabilities → Market based R&D partner		0.06***
Sensing capabilities → Survival	-0.01	
Research based R&D partner → Survival		0.06***
Market based R&D partner → Survival		-0.04*
Seizing capabilities → Research based R&D partner		0.04*
Seizing capabilities → Market based R&D partner		0.02
Seizing capabilities → Survival	0.003	
Reconfiguration capabilities → Research based R&D partner		0.58***
Reconfiguration capabilities → Market based R&D partner		0.23***
Reconfiguration capabilities → Survival	-0.01	
Goodness of fit statistics		

χ^2 (df)	χ^2 (486)=4226.32, ($p < 0.00$)
RMSEA	0.05
CFI	0.89
SRMR	0.054

Note: *** is significant at 1%, ** at 5%, and * at 10%.

Table 33 shows the results of analysis of relationship between dynamic capabilities and market performance of firms according to firm size. As for the determinants of R&D partners, larger firms prefer market-based partners, and smaller firms prefer research-based partners. In the small firms with less than 20 employees, sensing capability and seizing capability are negatively related to market-based partner, while reconfiguration capability is positively related to market-based partner with statistical significance. When small firms collaborate with market-based R&D partners in order to enter new market through commercialization, they need reconfiguration capability among dynamic capabilities.

[Table 33] Impact of dynamic capabilities on firm growth according to firm size

Parameter	Less than 20	Over 20
Sensing capabilities → Research based R&D partner	0.05	0.06***
Sensing capabilities → Market based R&D partner	-0.004	0.08***
Sensing capabilities → Sales	-0.06*	0.03
Research based R&D partner → Sales	-0.07*	-0.03
Market based R&D partner → Sales	0.05	0.10***
Seizing capabilities → Research based R&D partner	0.02	0.05**
Seizing capabilities → Market based R&D partner	-0.06	0.03
Seizing capabilities → Sales	0.04	0.06***
Reconfiguration capabilities → Research based R&D	0.55***	0.59***

partner		
Reconfiguration capabilities → Market based R&D partner	0.24***	0.24***
Reconfiguration capabilities → Sales	0.04	-0.02

Note: *** is significant at 1%, ** at 5%, and * at 10%.

Table 34 is the result of analysis between dynamic capabilities and firms' market performance according to technological regime. Some of previous researches argued that dynamic capabilities play a role only under a highly dynamic environment (Teece et al. 1997; Teece 2007). However, according to this study, it would be difficult to argue that the impact of dynamic capabilities on firm performance varies depending on the level of environmental dynamism. That is, dynamic capabilities have impact on the selection of R&D partners and market performance, even under a less dynamic environment. Both sensing capability and reconfiguration capability are positively related to R&D collaboration partner selection in both high-tech and low-tech industries regardless of environmental dynamism measured by technological regime.

[Table 34] Impact of dynamic capabilities on firm growth according to technological regime

Parameter	High-tech industry	Low-tech industry
Sensing capabilities → Research based R&D partner	0.06**	0.07**
Sensing capabilities → Market based R&D partner	0.06**	0.06*
Sensing capabilities → Sales	0.06**	0.01
Research based R&D partner → Sales	-0.06**	0.01
Market based R&D partner → Sales	0.12***	0.05
Seizing capabilities → Research based R&D partner	0.04	0.05
Seizing capabilities → Market based R&D partner	0.05**	-0.06
Seizing capabilities → Sales	0.09***	0.01
Reconfiguration capabilities → Research based R&D partner	0.58***	0.58***

Reconfiguration capabilities → Market based R&D partner	0.22***	0.24***
Reconfiguration capabilities → Sales	-0.007	-0.02

Note: *** is significant at 1%, ** at 5%, and * at 10%.

Chapter 6. Conclusion

6.1 Summary of research results and suggestions

This study looked into how dynamic capabilities affect R&D collaboration partner selection, and which discriminating factors exist under different internal and external conditions by analyzing the relationship between dynamic capabilities and R&D collaboration partner selection. Dynamic capabilities are segmented into sensing capability, seizing capability, and reconfiguration capability (Teece 2007). According to the result of this study, the impact of dynamic capabilities on determinants of research-based R&D partners are discriminating, compared with market-based partners

In this study, firm size was considered as it is one of the internal conditions of firms that affect the relationship between dynamic capabilities and R&D activities. Small firms may anticipate much from R&D collaboration due to relatively insufficient internal resources, but they face constraint in R&D collaboration due to a disadvantage of smallness. For research-based partner selection, such disadvantage of small firm size was found to be less visible. However, in the selection of market-based R&D collaboration partner, disadvantage of smallness does exist because larger firms are more likely to capture opportunities for R&D collaboration. Dynamic capabilities are the ability to sense environmental change, to adjust strategy and redeploy resources, and to cope with the change. Dynamic capabilities, unlike operational capabilities, requires long-term investment, and may incur costs as they disturb existing operational capabilities (Winter 2003). For dynamic capabilities to play a role as determinant of R&D collaboration partners, firms should be able to bear the burden of costs associated with dynamic capabilities. Hence, dynamic capabilities are more effective for larger firms with a certain size than small firms.

As dynamic capabilities are more active for firms with a certain size than smaller firms, the use or development of dynamic capabilities by small firms does not necessarily give benefits to them. As the response to environmental change in small firms is decided by a few managers, such decision may not reflect the environment correctly and thus dynamic capabilities are not applied properly, which is not likely to lead to any real improvement in firm performance. Therefore, small firms need to collaborate with external professional institutions that offer access to various information necessary for decision-making in order to allow dynamic capabilities to function fully.

In the low-tech industry as well as the high-tech industry, dynamic capabilities play an important role in selecting R&D collaboration partners. As for the relationship between dynamic capabilities and R&D partner selection under different level of environmental dynamism, dynamic capabilities operate in a relatively stable environment as well as in a rapidly changing environment. This suggests that the impact of dynamic capabilities is not proportional to the rate of change, but relies on the change itself.

Dynamic capabilities affect firm growth and survival directly, but their indirect impact is greater. Firm survival and growth are not affected by dynamic capabilities themselves, but by redeployment of resources rendered by dynamic capabilities, and by whether dynamic capabilities are employed more promptly and properly than competitors.

6.2 Significance and limits of Research, and future direction for research

The significance of this research can be divided into the followings:

First, this study aims at presenting a more integrated view of the relationship between dynamic capabilities and firm performance by considering relationship between internal and external conditions of firms and dynamic capabilities – R&D collaboration partner selection – firm performance. Most of researches on dynamic capabilities and firm performance argued that dynamic capabilities affect firm performance *directly*. This study is meaningful in that unlike previous researches, it tested empirically the *indirect* impact of dynamic capabilities -- where dynamic capabilities affect R&D collaboration partner selection, and adopted strategy influences firm performance.

Second, dynamic capabilities are the ability to cope with environmental change in market and technology efficiently and promptly. Previous researches have argued that dynamic capabilities function under a rapidly changing environment. However, this study empirically proved that dynamic capabilities affect firm strategy and performance in a relatively stable environment as well as in a rapidly changing environment. This suggests that dynamic capabilities are not responding to the rate of change, but to change itself.

Third, the common criticism about dynamic capabilities is that there are not sufficient empirical analyses compared with many conceptual researches, and that empirical researches were done largely as case studies and with a small sample size, making it difficult to allow empirical results to be generalized with reliability. According to Wang and Ahmed (2007), most of empirical researches on dynamic capabilities from 1997 to 2008 had a sample of less than 100 observations and with one case study (Gilbert et al. 2006), with the largest sample having 466 observations (Song, Droge, Hanvanich, & Calantone 2005). This study used a large sample with 3,061 firms to analyze the relationship between dynamic capabilities and firm performance, enabling a more complete understanding of dynamic capabilities.

Yet this study has several limitations although it is a meaningful empirical research on dynamic capabilities, using a large sample.

First, this study used cross-sectional data, and the results represent dynamic capabilities at a specific point of time. Yet reconfiguration capability is not a decision made at one specific time, but occurs within consecutive activities i.e. “sensing-seizing-reconfiguration.” With a cross-sectional data, it is difficult to identify linkage of all related variables.

Second, organizational changes, redeployment and integration of resources, and the impact of new capabilities on firm performance take place at intervals. In particular, capabilities adsorbed through inter-firm collaboration require a considerable time to adjust to market conditions and commercialize. Hence, the present firm performance is the result of dynamic capabilities applied at a certain point of time in the past. However, it is difficult to know exactly at which point of time dynamic capabilities affected the present result. This paper analyzed firm survival as a long-term performance, given the duration aspect of performance, but it is limited because it had only one point of time to observe dynamic capabilities affecting firm performance.

Third, dynamic capabilities are characterized by acquisition, development, and promotion of new knowledge, and the important means of achieving this is inter-firm collaboration. This study performed an empirical study confined to R&D collaboration. In order to generalize the effects of dynamic capabilities, various types of collaboration should be included to produce more complete research.

Fourth, besides the resource-based view and evolutionary theory of firms, which provided the basis for the dynamic capabilities view, other views need to be considered. By taking diverse theories and perspectives into consideration, more realistic integrated understanding of dynamic capabilities can be obtained.

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Abstract (Korean)

동적역량은 변화하는 환경 속에서 기업이 지속적으로 경쟁력을 확보하는 매커니즘을 설명하기 위해 대두되었다. 동적역량은 기업이 보유한 자원과 성과가 연결되는 과정을 설명해 주는 중요한 역할 변수이다 (Priem & Butler 2001). 많은 연구에서 동적역량이 기업의 자원을 성과로 바꾸는데 있어 중요한 역할을 담당한다는 것에는 이견이 없다 (Eisenhardt & Martin 2000; Heimeriks & Duysters 2007; Pavlou & El Sawy 2011; Teece, Pisano, & Shuen 1997). 하지만 동적역량의 정의는 매우 개념적이어서 최근까지 동적역량은 무엇인가에 대한 연구가 꾸준히 이루어지고 있다 (Barreto 2010). 동적역량에 대한 실증연구는 개념연구에 비해 그 수가 매우 부족하고, 연구자에 따라 상반된 결과를 보이기도 한다 (Zahra, Sapienza, & Davidsson 2006).

동적역량이 기업성과에 미치는 영향은 기업의 상황적 요소에 따라 달라지며 (Teece et al. 1997), 동적역량은 기업성과에 직접적인 영향은 물론 간접적으로 영향을 미친다 (Protogerou, Caloghirou, & Lioukas 2012). 본 연구는 Teece (2007)가 제시한 통합적인 동적역량의 개념을 활용하고, 기업규모와 기술체제를 고려하여 동적역량과 R&D협력파트너 선택의 관계, 동적역량과 기업성과의 관계를 분석하여 동적역량이 직·간접적으로 기업성과에 미치는 효과를 비교하였다. 본 논문에서는 실증분석을 위해 중소기업청의 “2005년 중소기업기술통계조사”를 활용하였고, 방법론으로 주성분분석, 표본선택 프로빗모형과 구조방정식모형을 적용하였다.

R&D협력파트너 선택에 미치는 차이는 seizing 역량에서 가장 뚜렷한 차이를 나타낸다. 기업규모가 증가할수록 시장기반 R&D협력파트너와 협력 확률이 증가한다. 이는 시장기반 R&D협력파트너 선택 시에 소규모의 한계가 존재함을 확인할 수 있다. 소규모 이상의 기업에서 동적역량의 영향이 더 크게 나타났

다. 환경의 동태성에 따른 동적역량과 R&D협력파트너 선택의 관계에서는 동적역량이 변화의 속도가 빠른 환경뿐만 아니라 변화의 속도가 적어 비교적 안정적인 환경에서도 나타남을 확인할 수 있다. 이는 동적역량의 효과는 변화의 속도에 비례하는 것이 아니라 변화 그 자체가 중요한 것임을 나타낸다. 동적역량과 기업성과의 관계는 기업의 생존과 성장에 따라 미치는 영향이 크게 다르지 않았다. 동적역량이 기업성과에 직접적인 영향을 주지만 간접적 효과가 더 크게 작용하고 있음을 확인할 수 있었다.

주요어 : 동적역량, R&D협력파트너, 기업생존, 기업성장, 중소기업, 기술체제
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