ISSN: 2288-2766 © 2018 EABEA. http://eajbe.jams.or.kr
doi: http://dx.doi.org/10.20498/eajbe.2018.6.4.13

The External Knowledge Utilization and Radical Innovation in Korea Electronic Industry

Youngwoo Lee[1], Jae-Jin Kim[2], Sul-Ki Chang[3]

1 First Author Assistant Professor, Department of Business Administration, Daegu University, Daegu, Korea
E-mail: lee3992@deagu.ac.kr

2 Corresponding Author Assistant Professor, Department of Business Administration, Hoseo University, Cheonan, Korea
E-mail: jkim@hoseo.edu

3 Co-Author Costco Wholesale, Gwangmyeong, Korea.
E-mail: sulkichang@gmail.com

Received: November 14, 2018. Revised: December 15, 2018. Accepted: December 20, 2018.

Abstract

Purpose – This study investigates the moderation effect of internal factor, a firms size, on the external knowledge sourcing strategy and its effectiveness in generating radical innovation. We incorporate concepts of breadth and depth as two measures to gauge the degree of openness in firms external search

Research design and methodology – The dependent variable in the regression model is the percentage of innovative sales and therefore, Tobit regression is employed for estimating significant factors affecting on the ratio of first-to-market by breadth and depth in external knowledge, internationalization, and size.

Results – The results show that the external knowledge, in terms of both breadth and depth, has a positive relationship with radical innovation. However internationalization as external knowledge resources is not statistically accepted. Firm size has moderating effect on innovation negatively only in case of using external knowledge resources to a high degree.

Conclusions – Firms obtain external information mostly from customers, competitors, and suppliers etc. empirical knowledge in terms of scope and intensity is an important contributor to innovation. And intensity use of external knowledge and information resources can work in favor of smaller firms rather than larger ones. Internationalization seems to have little effect on innovation but it requires further researches with clear criteria and more data.

Keywords: Radical Innovation, External knowledge, Breadth, Depth, Internationalization, Firm Size.

JEL Classification Code: O32, F23.

1. Introduction

Scholars of business administration, economists, and policy makers have shown interest in innovation as an essential element for sustainable growth and survival for a firm in todays dynamic environment (Mowery and Rosenberg, 1979; Becheikh et al., 2006; Onetti et al., 2012; Bae and Lee, 2013). Innovation in general can be classified into radical innovation and incremental innovation based on the different levels of novelty of the knowledge created as a result of innovation processes (Ettle et al., 1984; Laursen and Salter, 2006). Radical innovation is defined as "fundamental changes that represent revolutionary changes in technology. On the other hand, incremental innovation is defined as "minor improvements or simple adjustments in current technology (Dewar and Dutton, 1986). Radical innovations include fundamental shifts to new technological trajectories that are new to the firm and/or industry, and thus have greater potential to bring substantial customer value, potentially creating new market or new customer demand (Atuahene-Gima, 2005). Enhanced competition, combined with globalization and shortened product cycles, has put increased pressure on contemporary firms to continuously generate radical innovation in order to prosper or to survive (Golovko & Valentini, 2011). However, its success rate of is very low as radical innovation activities entail different types of learning and substantial amounts of resources and uncertainty.

Most of the earlier studies on innovation have focused on internal R&D to create new innovation. (van de Vrande et al., 2009). They consider that the accumulation of intellectual assets within a firms internal research and development (R&D) labs can give rise to innovation and provide an entry barriers for potential barriers. Other internal factors that are also mentioned to enable firms to generate new knowledge are firm size, age, turnover, R&D investment, and overseas exports (Adams and Jaffe, 1996; Calantone et al., 2002; Bae and Lee, 2013). This process in which firms discover and develop innovation internally has been labeled as closed innovation model (Chesbrough, 2003). However, research on corporate innovation has recently focused more on "open innovation – the active use of external knowledge – rather than the spillover effect – passive exposure to external knowledge. This model highlights the interactions with a range of institutions inside the innovation system as well as customers and suppliers to create new knowledge (Brown and Eisenhardt, 1995). They argue that the advantages the firms gain from internal R&D expenditure have declined, while open innovation model in which firms employ both internal and external channels to exploit technologies and acquire outside knowledge (Chesbrough, 2003). Because valuable knowledge required for creating innovation are dispersed across the globe due to labor mobility, firms can no longer afford to innovate on their own (van de Vrade et al., 2009).

In the open innovation model, the ability of exploit external knowledge and impact of external knowledge source on innovation performance has gained much scholarly attention in recent studies. Laursen and Salter (2006) found that a firms efforts to seek broad as well as in-depth knowledge from outside led to positive results on innovation. EnKel et al. (2009) and Moon (2011) concluded that the active application of external knowledge could facilitate innovation. Previous studies have concluded that external network allow enterprises to rapidly fill in specific knowledge without having to spend significant amount of investment to develop that knowledge internally or acquire it through vertical integration (van de Vrade et al., 2009). However, not much is known what internal factors affect the effectiveness of acquiring external knowledge from external network. In an attempt to build and maintain connection with external network of social capital, firm with high reputation or formalized structure could have more advantages to access and assimilate external knowledge. It is known that innovation processes of large firms are typically structured and formalized with more specialized workers and procedures. Also, internal R&D labs of large firms present extended R&D capabilities, which confer ability to critically evaluate and assimilate the outside partner's technological knowledge. At the same time, however, large sized firms are exposed to greater risks if the external partners behave opportunistically and expropriate firms' core information (Lee et al, 2004; Chesbrough, 2006; West and Callagher, 2006). Furthermore, the Not Invented Here (NIH) syndrome suggests that greater attention to external source may confront internal resistance when a firm has relatively abundant technological knowledge as well as complementary assets such as large firms. It may lead large firms to reject external knowledge as well as activities of seeking knowledge from external network, while emphasizing internal R&D efforts. As such, we have limited understanding from the literature how firm size influence external knowledge seeking mechanism and its impact on innovation performance

Another limitation in the open innovation literature is on the fact that previous studies have not dealt with the importance of the active use of external knowledge which lies outside of national borders. According to existing research on international business, valuable knowledge that confer a firm competitive advantage often resides in overseas markets (Johanson and Vahlne, 1977; Hitt et al., 1994, Onetti et al., 2012; Yang, 2012). These knowledge and information acquired in overseas markets cannot be easily copied by other firms and have potential to enhance corporate competitiveness and financial performance (Kotabe et al., 2002; Kuemmeral, 2002; Kafouros et al., 2008;

Onetti et al., 2012). However, there is little research that examines internationalization as a potential source external knowledge for radical innovation (Onetti et al., 2012; Laursen and Salter, 2006).

In order to fill this research gap, this study focuses on the moderation effect of internal factor, a firms size, on the external knowledge sourcing strategy and its effectiveness in generating radical innovation. We incorporate concepts of breadth and depth as two measures to gauge the degree of openness in firms external search following Laursen and Salter (2006). We attempt to contribute to literature by adding internalization variable to examine whether foreign knowledge absorbed from exporting may contribute to a firms innovation performance by using data from 500 Korean manufacturing firms. This study proceeds in the following sequence. First, it provides a literature review on open innovation. Next, it establishes a hypothesis and tests the hypothesis through a Tobit analysis of the 500 firms. Finally, it presents conclusions and suggestions.

2. Literature Review

2.1. Open Innovation

Open innovation is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation respectively (Chesbrough, 2006). Open innovation assumes that the identification and commercialization of external ideas, rather than internal ideas, can develop corporate innovative capabilities efficiently.

Prior to the research of Chesbrough (2003), studies on firms use of external resources had already existed, but these were largely about how to improve innovation internally using corporate exploration and exploitation capabilities within internal alliances and networks, instead of tapping various, wide-ranging external resources (Lavie and Rosenkopf, 2006). For instance, Asheim and Coenen (2005) argued that the networking of small- and medium-sized (SMEs) companies within a geographic cluster accelerates the growth of a regional economy, and in order to step up innovation, government should try to link corporations with research institutes or colleges. In similar research, Carayannis et al. (1998) found that the characteristics of the founder of a firm and level of innovation in the region are very critical to the establishment of a high technology company. Rogers et al. (2001) argued that advanced innovative capability in the region and excellent technology personnel are essential to the dissemination and development of intellectual assets within a region.

Penin (2008) saw the research of Chesbrough as an integration of research on various topics such as "disintegrated innovation, "modular innovation, "distributed innovation, and "dispersed innovation. However, recent growing interest in the research of Chesbrough (2003) suggests that the benefits of using extensive external knowledge have been ignored by firms, even until recently (Bianchi et al., 2010). Before the world economy growth slowed, it was believed that the launch of innovative products as the result of internal R&D, earlier than competitors, would guarantee a firm a leading position in the market, higher market share, and larger earnings. Furthermore, in order to enjoy a continuous competitive advantage, it was regarded as critical that a firm develop intellectual property on its own. As a result, there was more research on the development of corporate inner strength, rather than on the use of external resources. However, despite the market leadership of a product, as the technology life cycle becomes gradually shorter, the time available to recover the high R&D investment cost in developing the product decreases. Additionally, the creation of start-ups and the migration of key engineers, or researchers working in large corporate R&D centers, suggest that key research results, where huge financial resources have already been invested, could easily land in the hands of competitors. Hence, questions were raised as to the efficiency and profitability of the in-house R&D center: so-called "closed innovations (Chesbrough, 2003; Chesbrough and Crowther, 2006).

Open innovation allows firms, without a large, internal R&D center, to access and utilize necessary knowledge from other firms, colleges, research institutes, and scientists at a lower cost. Yet, open innovation includes the risk of core corporate secrets being leaked during the process of technology development through collaboration with other institutions or firms. In particular, small- and medium-sized companies should be careful because they may lose their best proprietary ideas and technologies without compensation while working with large businesses (Chesbrough, 2006). Lee et al., (2004) pointed out that due to worries about technology outflow, firms involved in joint development projects are less willing to open up their own resources. These firms wish to acquire knowledge with the least amount of R&D investment, making collaborative research projects difficult. In particular, firms with excellent technology are less inclined to participate in joint research due to concern about technology leakage (Kim, 2010).

2.2. Firm Size

Previous studies have found that there is a great deal of differences between small and large firms in terms of the innovation strategies. Larger firms tend to adopt more structured and formalized process of innovation. Not only larger firms have formal procedures in recruiting specialized workers, licensing IP, and building external networks, but their larger size also enables them to spred innovation risks by diversifying innovation portfolio. Furthermore, large firms may have better position to exploit external knowledge than smaller firms. Complementary assets, which are highly likely to be hold by large incumbents in markets, can be used as "leverage to access and assimilate external ideas for commercialization (Teece, 1986). Also, large firms traditionally relied on internal R&D activities to create new products by having large internal R&D labs. Extended R&D capabilities as well as complementary assets may of larger firms induce them to actively seek external knowledge with a higher capability to exploit a host of external channels in terms of breadth and depth.

2.3. Internationalization and Innovation

In general, there are many studies on innovation that have mentioned investment as a key factor of innovation. R&D investment helps identify new technology and efficient production methods or leads to new products, and such innovative results will ultimately become competitive assets of a firm and positively affect performance (Adams and Jaffe, 1996; Calantone et al., 2002; Bae and Lee, 2013). Still, some other studies argue that as long as investment in corporate innovation remains within the network or region with the technology knowledge, it could adversely affect management performance. This emphasizes the importance of external technological knowledge in addition to efforts to achieve innovation internally (Chesbrough, 2006; Kafouros et al., 2008; EnKel et al., 2009). Therefore, in order for firms to absorb external knowledge effectively beyond a narrow local technology level, internationalization is indispensable to them (Kafouros et al., 2008). Onetti et al. (2012) proved that internationalization, innovation, and entrepreneurship are essential elements for strategic decision-making and growth of new technology-based firms as the market and industrial environment become more complicated. They also argued that through internationalization, firms can pursue growth by moving to a place suitable to the growth of their core industry, going beyond geographical limitations, and that challenge and opportunity in the global market would help them make strategic corporate decisions. They also found that easier access to new technology resources would help strengthen corporate capabilities. Furthermore, through internationalization, firms can be exposed to the diverse needs of more customers in a new overseas market, and while meeting those needs, they can earn and grow (Bell, 1995; Bell and Young, 2004; Onetti et al., 2012). Previous studies have proved that knowledge and information found in overseas markets have a positive influence on corporate innovation and financial performance (Kotabe et al., 2002; Kuemmeral, 2002; Kafouros et al., 2008; Onetti et al., 2012).

Hitt et al. (1994) revealed that as firms pursue internationalization in order to overcome differences in culture and economic regimes and use their corporate resources to exploit knowledge in overseas markets effectively, these activities have a positive impact on innovation. Similarly, Kotabe et al. (2002) revealed that although investment in internal corporate innovation seems effective, a strategy that absorbs innovative resources through an international business strategy should also be considered. In the same study, Kotabe et al. (2002) found that internationalization can positively control the impact of R&D and marketing capabilities on the financial and operational performance of firms.

3. Hypothesis

Holding all the resources and technology necessary for innovation within a firm is a big burden in terms of cost. Thus, because technology becomes complex, and technology life cycle becomes shorter and shorter, firms should pay increasing attention to employing open innovation strategies (Bianchi, 2010), and through that process, innovation resources should be found and utilized (Van de Vrande et al., 2009). Laursen and Salter (2006), in researching U.K. manufacturing firms, analyzed the relationship between openness and corporate innovation and concluded that finding necessary resources outside of a firm is more effective for innovation. Moreover, Ahuja (2000), Choi (2010) showed that seeking external resources and building a collaborative relationship with companies outside the firm are closely related to corporate innovation. Katila (2002) found that building partnerships with many external firms as well as extremely close cooperation has a positive impact on innovation as well. Based on the research on the scope of firms use of external resources and the intensity of cooperation, Laursen and Salter (2006) suggested "external search breadth (scope) and "external search depth (intensity) as concepts to

measure firm openness. The former is defined as "the number of external sources or search channels that firms rely upon in their innovative activities, while the latter is defined as "the extent to which firms draw deeply from the different external sources or search channels. In addition, "external search scope and "external search intensity are, in terms of external knowledge utilization, similar to "knowledge exploration, and "knowledge exploitation, respectively (Laursen and Salter, 2006; Martini et al., 2012). Lee et al. (2010) explained that with regard to the use of external knowledge, "knowledge exploration is an activity looking for technology and partners, while "knowledge exploitation means the process of commercializing technology through cooperation with external firms.

Laursen and Salter (2006) surveyed small- and medium-sized firms in the U.K. and discovered that these concepts, openness scope and intensity, had a significant impact on innovation. The U.K. small- and medium-sized firms collected innovative ideas largely from suppliers of equipment, materials, and components or software as well as their customers. The study of Korean small- and medium-sized companies by Lee et al. (2010) revealed that while both scope and intensity of external resources had a positive impact on innovation, the explanatory power of scope was larger than that of intensity. Korean firms obtained information mainly from customers and users, competitors, and affiliates. Martini et al. (2012), in his study of Italian medium-sized high-tech firms, found that "openness intensity had a positive impact on innovation. Li and Jifei (2009), in their study of Chinese firms, showed that both scope and intensity had a positive impact on innovation. Given the aforementioned, in order to measure the impact of the use of external information on innovation, both the scope and intensity of using information need to be analyzed. Hence, this paper presents the following hypotheses.

H1a: The breadth of the use of external information has a positive impact on radical innovation.

H1b: The depth of the use of external information has a positive impact on radical innovation.

Internationalization provides firms with global networks of researchers, venture capitalists, global customers, and suppliers. Hence, the diverse knowledge and information that firms absorb in domestic and overseas markets become a firms assets and thus have a positive impact on innovation (Kuemmerle, 2002; Onetti et al., 2012). However, few have researched the use of the external knowledge of Korean manufacturing firms in domestic and international markets and the effect of the internationalization activities of such firms on corporate innovation performance. Kuemmerle (2002) argued that for firms that have just started internationalization, the acquisition of information in overseas market is more important than business activities, and that newly acquired knowledge accelerates innovation. Kafouros (2006) and Kafouros et al. (2008) proved that the more actively firms are engaged in many countries, the more innovation they achieve. This is because a higher degree of internationalization leads to better product quality and more sensitivity to the needs and changes in requirements of customers.

The experience and knowledge acquired in overseas markets allow firms to obtain and adopt technology suitable to the needs of these respective local markets, and thus to ultimately have an opportunity to succeed overseas. Hence, as a higher degree of internationalization gives firms access to new resources, ideas, and technology in overseas markets, internationalization becomes an important competitive advantage for firms (Kafouros et al., 2008). Objective knowledge can be learned easily, but knowledge acquired through experience can only be obtained through individual experience (Yang, 2012). In particular, firms that intend to operate in overseas markets can acquire useful experience and knowledge by entering those markets themselves (Johanson and Vahlne, 1977; Yang, 2012). In the same vein, Hitt et al. (1997) also stressed the usefulness of diverse empirical knowledge acquired through internationalization, and argued that the absorption of knowledge through internationalization creates a positive cyclical effect on innovation.

They also emphasized that internationalization is about learning how to capture numerous business opportunities in various markets with different cultural, social, and political backgrounds. Hence, as a firm becomes more internationalized, it accumulates diverse knowledge and experience, which encourages innovation. Particularly, since radical innovation means the development of products that are fundamentally different from previous products from a technological aspect, the acquisition of overseas knowledge through internationalization may be even more important. In summary, internationalization allows firms to seize opportunities in overseas markets as well as an opportunity to absorb necessary technology at a lower cost, thereby having a positive impact on innovation. Accordingly, the following hypothesis is established.

H2: Internationalization has a positive impact on radical innovation.

Large firms tend to have formal structures and complementary assets, which provide the advantages in forming network with external partners (Teece, 1986). As innovation processes of large firms are more structured and formalized in terms of rules and procedures, making it easy to engage in knowledge exchange with external participants. Also, large firms have more financial resources and larger specialized workforce. As a result, large firms could outperform open innovation activities of SMEs by better acquiring and maintaining external network, including individuals and organizations (Chesbrough et al., 2006). Networks allow enterprises to rapidly fill in specific knowledge needs without having to spend enormous amounts of time and money to develop that knowledge internally or acquire it through vertical integration. Large firms could better form both formal collaborative projects and more general and informal networking activities, exploiting external knowledge sources for developing radical innovation. Taken together, we expect that large firms with high levels of R&D intensity and more formalized innovation procedures are better able to exploit a host of search channels in terms of breadth and depth.

H3a: Firm size will positively moderate the relationship between the external search breadth and radical innovation performance.

H3b: Firm size will positively moderate the relationship between the external search depth and radical innovation performance.

H3c: Firm size will positively moderate the relationship between the internationalization and radical innovation performance.

4. Methodology

4.1. Samples and Measurements

This paper uses the data of the Korea Innovation Survey (KIS) of Korean manufacturing firms conducted in 2010. The purpose of the 2010 KIS was to investigate the status of technological innovation at Korean firms, and to support the government policy of promoting technological innovation and strengthening national competitiveness. The survey was conducted by the Science and Technology Policy Institute (STEPI), a government institution. The questionnaire was designed based on the Oslo Manual developed by the OECD and the Community Innovation Survey (CIS) of the Eurostat. Therefore, the survey was accepted as highly reliable and suitable (Moon, 2011).

The parent sample group included manufacturing firms established before 2007 with ten employees or more, selected according to the company register prepared after the 2008 nationwide corporate survey by Statistics Korea. The 2010 KIS survey was conducted from May 2010 to October 2010, with a response rate of 51.03%. The final sample number was 3,925 firms (Ha et al., 2010). From this sample, this paper selected a total of 377 firms engaged in the manufacturing of electronic components, computers, imaging machines, audio and telecommunication equipment, medical precision devices, optical instruments, clocks, and electric devices according to the 9th edition of the Korea Standard Industrial Classification (KSIC). Among these 377 firms: 136 firms (30% of the total) were manufacturers of electronic components, computers, radio, television and communication equipment and apparatuses; 106 firms (28%) were manufacturers of medical, precision and optical instruments, watches, and clocks; and, 136 firms (36%) were manufacturers of electrical equipment.

According to Noh (2010), Hatzichronoglou (1997) classified 22 manufacturing industries into four categories by level of technology intensity, using R&D data from ten OECD countries. High technology industries include: Aircraft and spacecraft; Pharmaceuticals; Office, accounting, and computing machinery; Radio, TV, and communications equipment; Medical, precision, and optical instruments. Medium-high technology industries include: Electrical machinery and apparatus; Motor vehicles, trailers, and semi-trailers; Chemicals, excluding pharmaceuticals; Railroad equipment and transport equipment; Machinery and equipment. Medium-low technology industries include: Building and repairing of ships and boats; Rubber and plastics products; Coke, refined petroleum products, and nuclear fuel; Other non-metallic mineral products; Basic metals and fabricated metal products. Low-technology industries include: Manufacturing and Recycling; Wood, pulp, paper products, printing, and publishing; Food products, beverages, and tobacco; Textiles and textile products; and Leather and footwear. According to this classification, the 377 firms used in this study belong to the high technology or medium-high technology categories.

4.2. Dependent Variable

The 2010 KIS classified innovation into radical innovation and incremental innovation using a ratio of innovative product sales to total sales. Radical innovation is measured by a ratio of first-to-market product sales to total sales during the period 2007 to 2009, with 2009 as base year. Incremental innovation is measured by a ratio of innovative products developed internally by a firm to total sales, albeit not first-to-market, during the period 2007 to 2009. Laursen and Salter (2006) and Li and Jifei (2009) divided the innovation performance into radical and incremental innovation performances. This paper adopted radical innovation as a dependent variable, being expressed as the ratio of innovative product sales to total sales. That is because a market-leading innovation of an electronics manufacturer strongly affects the innovation of followers, and has a greater social impact than the internal innovation of a firm. Shin (2013) argued that the electric and electronics industry was very important because it represents and leads the development of high technology and brings about convergence with other industries. Hence, external resources should be used to develop the innovative first-to-market products, not just to develop one first-to-market new product. Radical innovation at a firm leads to fundamental and innovative changes in technology (Dewar and Dutton, 1986).

4.3. Independent Variable

4.3.1. External Search

Laursen and Salter (2006) and Moon (2011) classified external search into “openness breadth (scope) and “openness depth (intensity). The use of external knowledge as an independent variable here is the same as in the work of Laursen and Salter (2006) and Moon (2011). First, the sources of external information in the present paper include a total of 11 categories: (1) affiliates, (2) suppliers (of raw material, parts, software), (3) corporate customers, (4) competitors and other firms within the same industry, (5) external gatherings such as associations and unions, (6) newly recruited employees, (7) private service providers (consulting firms and private research institutes), (8) universities, (9) government-sponsored and national research institutions, (10) conferences, exhibitions, and (11) specialized cable channels and books. With regard to measuring “openness scope, the value equals 1 when categories are used, and zero (0) when they are not used. Hence, if a firm exploits all sources of external knowledge, the value will be 11, and when none of the external sources are searched for, the value will be zero (0). With regard to “openness intensity, it measures the extent to which firms draw intensively from different search channels or sources of innovative ideas. Each of the 11 sources are coded with 1 when the firm in question reports that it uses the source to a high degree (4 or higher) and 0 in the case of no, low, medium use of the given source. The result is the sum of these values. For example, if all of 11 sources of external knowledge are used in a scale of four or higher for each source, the final value will be 11, meaning that the firm deeply exploits each of the 11 sources of information. The variable for external search was converted into a binary variable.

4.3.2. Internationalization:

In this paper, as a variable to measure internationalization, exports and foreign direct investment (FDI) were considered. Exports, regarded as “the dominant mode of entry into a foreign market, have been used as a measure of internationalization in much literature (Reid, 1981; Bell, 1995). Johanson and Vhlne (1977, 1990) and many scholars found that in the process of exporting, one of the phases of internationalization, empirical knowledge about overseas markets is accumulated. Additionally, FDI can be considered another important measure of internationalization (Lu and Beamish, 2001; Helpman et al., 2004, Cassiman and Golovko, 2011). Helpman et al. (2004) explained that FDI reduces trade costs associated with entry into different markets, and that firms should balance the proper amount of exports and FDI by considering related costs in order to achieve internationalization. In this paper, as a dummy variable to measure the level of internationalization, if either export or FDI occurred during 2007 to 2009, the value is 1, and if neither was executed, the value is 0. Cassiman and Golovko (2011), in their research of internationalization and innovation using data from Spanish manufacturing firms, used export as a dummy variable to measure the level of internationalization. Majocchi and Zucchella (2003) treated FDI as a dummy variable to measure the level of internationalization in their study of internationalization and management performance at small- and medium-sized Italian companies.

4.4. Control Variables

The control variables in this paper are “firm size, “firm age, “R&D intensity, and “industry dummy. The firm size is estimated by the logarithm of the average number of employees for three years (2008 to 2010). The number

of employees is one of a firms important resources and capabilities, and represents the firms size (Bstieler and Hemmert, 2010). The firm size may have a direct impact on firm innovation (Montoya and Calantone, 1994; Cassiman and Golovko, 2011). The firm age was estimated by subtracting the year of incorporation from 2014 (Lucier, 2009). It is generally known that an older firm owns more knowledge and resources, which helps innovation (Autio et al, 2000). R&D cost is one of a firms competitive advantages, and hence one of the significant factors affecting innovation (Kafouros et al., 2008). This paper uses the ratio of internal R&D cost to sales. The last control variable is industry dummy. In this paper, electronics manufacturing industries are classified into three categories according to the KSIC: (1) electronic components, computer, radio, and television and communication equipment and apparatuses; (2) medical, precision and optical instruments, watches, and clocks; (3) and, electrical equipment (Lichtenthaler, 2008).

5. Results

4.1. Samples and Measurements

<Table 1> shows the mean, standard deviation, and minimum and maximum values of each variable. Radical innovation or first-to-market innovation accounted for an average of 14% of sales in 2009. Firms used an average of seven external resources and 64% had exports or attracted FDI. The average age of the 377 firms was 20 years, ranging from the youngest firm of 8 years to the oldest of 81 years.

Table 1: Descriptive Statistics and Correlation

Variables	Mean	S.D.	1	2	3	4
1. Radical innovation	1.06	1.46				
2. Breadth	7.60	3.24	0.13*			
3. Depth	2.54	2.41	0.12*	0.50*		
4. Internationalization	0.67	0.47	0.07*	0.21*	0.15**	
5. Firm size	4.71	1.40	0.03	0.33*	0.24*	0.36*

Note. * p<.05; n=377

<Table 2> shows the results of the Tobit regression. Openness scope is the range of external knowledge use; meaning that the firms use of external knowledge through more diverse channels has a positive impact on radical innovation performance. Accordingly, H1a was accepted. External knowledge used most came from: corporate customers, competitors, and other firms in the same industry, suppliers, conferences, fairs, exhibitions, professional journals and books, newly recruited employees, external gatherings such as associations and unions, universities, government-sponsored and national research institutes, private consulting firms, research institutes, and affiliates. Another aspect of knowledge acquisition, hypothesis 2, was also supported, suggesting that the intensity of using a specific external knowledge source also does affect first-to-market innovation. Therefore, it is proved that the value of “openness scope and “openness intensity were statistically significant. However, it was found that knowledge acquired through internationalization contributes to first-to-market innovation (H2) was not accepted.

This study sets hypothesis 3 with the expectation that firm size will have a role of a positive moderator in the relationship between radical innovation and knowledge acquisition. Its result can be shown in the part of Moderating effect in the Table 2. The results of the analysis are quite interesting, which only depth variable shows statistically negative significant with firm size in the modeling effect. Breadth and internationalization variables show the positive effect but do not have any statistically significant. It means that the openness intensity from external knowledge is more effective to smaller organizations rather than larger ones. Hence H3a, H3b and H3c were not accepted.

Table 2: Tobit regression model

	Model 1		Model 2		Model 3	
Control variables						
Firm age	0.01	(0.78)	0.01	(0.69)	0.01	(0.65)
R&D intensity	0.16*	(1.77)	0.01	(1.16)	0.01	(1.26)
Firm sale	0.04	(1.13)	-0.07	(-0.93)	-0.09	(-1.12)
Industry dummies		Included		Included		Included
Main effects						
Breadth of external sourcing			0.05	(2.32)**	0.04	(2.01)**
Depth of external sourcing			0.07	(2.55)**	0.10	(3.22)***
Internationalization			0.07	(0.51)	0.08	(0.56)
Firm size			0.08	(0.71)	0.09	(0.80)
Moderating effect						
Breadth x Size					0.03	(1.85)*
Depth x Size					-0.04	(-2.22)**
Internationalization x Size					0.01	(0.06)
Chi-square		33.26***		33.77***		39.68***
Log likelihood		-1120.12		-1119.86		-1116.91

Note. * p<.05; ** p<.01; *** p<.001; t-statistics in parentheses; n=377.

6. Conclusion and Limitation

Using 377 Korean electronics manufacturers belonging to high- or medium-tech industries, this paper showed how the use of various external resources, as suggested by open innovation, affects firm innovation, and how the use of diverse external breadth and depth information resources have a positive impact on the development of first-to-market products. In particular, it was found that firms obtain external information mostly from customers, competitors, and suppliers etc. empirical knowledge is an important contributor to innovation. The most of the external information sources used by Korean electronics firms were corporate customers, competitors and other companies within the same industry, and suppliers. This finding is similar to that of Moon (2006) whose research on the determinants of radical innovation for Korean firms, found that it was very important to reflect external knowledge and opinions collected from customers and suppliers in new product development. He added that new products that reflected the views of customers and suppliers were likely to succeed in the market, and would help firms survive in the current uncertain market environment. This finding is also similar to that of Lee et al. (2010) who confirmed that competitors as well as customers and suppliers are important external resources.

As the product life cycle gets shorter gradually and the world economy faces difficulties, an open innovation strategy that focuses on searching for optimal external resources and profiting from them at a low cost will definitely

help firms. However, the outflow of core intellectual property associated with open innovation strategy is still a problem. Accordingly, while each firm adopts a proper open innovation strategy suitable to them, they should look for appropriate partners and devise strategies to protect their core resources effectively.

Interestingly, the use of external knowledge and information resources may vary depending on the size of the firms. Especially the intensity use of external knowledge and information resources can work in favor of smaller firms rather than larger ones. It dose strategically mean that larger firms may have an advantage of utilizing their scale for innovation. Their larger scale can be useful to acquire various knowledge or information from their external boundary. On the other hand, smaller firms have an advantage of focusing on specific areas for innovation.

In this study, we failed to prove that a internationalization focusing on a specific external resource contributes to radical innovation. However, internationalization may be a significant source of external knowledge when customer demands and exploration of new markets are absorbed as knowledge acquired through experience. Therefore, it cannot tell that in new product development overseas market information collected by international business divisions within a firm is not important. It should be particularly noted that it is essential to incorporate various customer needs from different overseas markets even in the initial phase of product development.

This research used data from firms in the electronics industry. However, depending on which industry category a firm belongs to, its level of use of external information will be different, and thus the research results will be different as well. Hence, further research using data from firms in more diverse industry groups needs to follow (e.g., Laursen and Salter, 2006; Martini, 2012). Additionally, although internationalization is not accepted related to radical innovation, this research was done only looking at exports and FDI volume. Thus, future research should focus on identifying specifically what other empirical internationalization knowledge influence innovation.

Reference

Adams, J. D. & Jaffe, A. B. (1996). Bounding the effects of R&D: An investigation using matched establishment-firm data. *NBER Working Paper No. 5544*, 1-40.

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: a longitudinal study. *Administrative Science Quarterly, 45*(3), 425-55.

Asheim, B. T. & Coenen, L. (2005). Knowledge bases and regional innovation systems: comparing nordic clusters. *Research Policy, 34*(8), 1173-90.

Atuahene-Gima, K. (2005). Resolving the capability: Rigidity paradox in new product innovation. *Journal of Marketing, 69*(4), 61-83.

Autio, E., Sapienza, H. J. & Almeida, J. G. (2000). Effects of age at entry, knowledge intensity, and imitability on international growth. *Academy of Management Journal, 43*(5), 909-24.

Bea , J. C. & Lee, S. Y. (2013). The effect of firm's absorptive capacity and IT utilization to innovation. *Journal of Information Technology Applications & Management, 20*(3), 173-95.

Becheikh, N., Landry, R. & Amara, N. (2006). Lessons from innovation empirical studies in the manufacturing sector: a systematic review of the literature from 1993–2003. *Technovation, 26*(5), 644-64.

Bell, J. (1995). The internationalization of small computer software firms: a further challenge to "stage theories. *European Journal of Marketing, 29*(8), 60-75.

Bell, J., Crick, D. & Young, S. (2004). Small firm internationalization and business strategy an exploratory study of knowledge-intensiveand traditionalmanufacturing firms in the UK. *International Small Business Journal, 22*(1), 23-56.

Bianchi, M., Campodallorto, S., Frattini, F. & Vercesi, P. (2010). Enabling open innovation in small-and medium-sized enterprises: how to find alternative applications for your technologies. *R&D Management, 40*(4), 414-31.

Brown, L. S. & Eisenhardt, M. K. (1995). Product development: past research, present findings, and future directions. *The Academy of Management Review, 20*(2), 343-378.

Bstieler, L. & Hemmert, M. (2010) Trust formation in Korean new product alliances: how important are pre-existing social ties?. *Asia Pacific Journal of Management, 27*(2), 299-319.

Calantone, R. J., Cavusgil, S. T. & Zhao, Y. (2002). Learning orientation, firm innovation capability, and firm performance. *Industrial Marketing Management, 31*(2), 515-24.

Carayannis, E. G., Rogers, E. M., Kurihara, K. & Allbritton, M. M. (1998). High-technology spin-offs from government R&D laboratories and research universities. *Technovation*, 18(3), 1-11.

Cassiman, B. & Golovko, E. (2011) Innovation and internationalization through exports. *Journal of International Business Studies, 42*(2), 56-75.

Chesbrough, H. (2006). *Open business models*. Harvard Business Press.

Chesbrough, H. & Crowther, A. K. (2006). Beyond high tech: early adopters of open innovation in other industries. *R&D Management, 36*(2), 229-36.

Chesbrough, H. W. (2003). *Open innovation: the new imperative for creating and profiting from technology*. BA, USA: Harvard Business Review Press.

Choi, J. I. (2010). *The impact of openness on innovation efficiency*. Seoul, Korea: Sungkyunkwan University Press.

Dewar, R. D. & Dutton, J. E. (1986). The adoption of radical and incremental innovations: an empirical analysis. *Management Science, 32*(3), 1422-33.

Enkel, E., Gassmann, O. & Chesbrough, H. (2009) Open R&D and open innovation: exploring the phenomenon. *R&D Management, 39*(2), 311-326.

Ettlie, J. E., Bridges, W. P. & O keefe, R. D. (1984). Organization strategy and structural differences for radical versus incremental innovation. *Management Science, 30*(2), 682-95.

Golovko, E. and Valentini, G. (2011). Exploring the complementarity between innovation and export for SMEs' growth. *Journal of International Business Studies, 42*(3), 362-380.

Ha, T. W., Kang, H. J., Park, K. S. & Kang, W. M. (2010). 2010 Korea technology innovation survey: manufacturing factor. *STEPI*, 2010(1), 1-25.

Hatzichronoglou, T. (1997). Revision of the high-technology sector and product classification. *STI Working Paper*, 59918, 1-25.

Helpman, E., Melitz, M. J. & Yeaple, S. R. (2004). Export versus FDI with heterogeneous firms. *American Economic Review, 94*(1), 300-316.

Hirsch, B. T. & Link, A. N. (1987). Labor union effects on innovative activity. *Journal of Labor Research, 8*(4), 323-32.

Hitt, M. A., Hoskisson, R. E. & Ireland, R. D. (1994). A mid-range theory of the interactive effects of international and product diversification on innovation and performance. *Journal of Management, 20*(2), 297-326.

Hitt, M. A., Hoskisson, R. E. & Kim, H. (1997). International diversification: Effects on innovation and firm performance in product-diversified firms. *Academy of Management Journal, 40*(2), 767-98.

Johanson, J. & Vahlne, J. E. (1977). The internationalization process of the firm: a model of knowledge development and increasing foreign market commitments. *Journal of International Business Studies, 8*(1), 23-32.

Johanson, J. & Vahlne, J. E. (1990). The mechanism of internationalization. *International marketing review, 7*(4), 12-24.

Kafouros, M. I. (2006). The impact of the Internet on R&D efficiency: theory and evidence. *Technovation, 26*(7), 827-835.

Kafouros, M. I., Buckley, P. J., Sharp, J. A. & Wang, C. (2008). The role of internationalization in explaining innovation performance. *Technovation, 28*(1), 63-74.

Katila, R. (2002). New product search over time: past ideas in their prime?. *Academy of Management Journal*, 45(5), 995-1010.

Kim, D. (2010). An empirical study on the partner selection decision-making criteria by open innovation process archetypes. Chengju, Korea: Thesis for Doctrate in ChungBook University.

Kotabe, M., Srinivasan, S. S., & Aulakh, P. S. (2002). Multinationality and firm performance: The moderating role of R&D and marketing capabilities. *Journal of International Business Studies, 33*(1), 79-97.

Kuemmerle, W. (2002). Home base and knowledge management in international ventures. *Journal of Business Venturing, 17*(2), 99-122.

Laursen, K. & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal, 27*(2), 131-150.

Lavie, D. & Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation. *Academy of Management Journal, 49*(4), 797-818.

Lee, J. Y. & Lee, E. S. (2004). International joint venture, IJV, structure of control, JV performance, opportunitism, trust. *International Business Research, 15*(2), 31-59.

Lee, S., Park, G., Yoon, B. & Park, J. (2010). Open innovation in SMEs: an intermediated network model. *Research Policy*, *39*(1), 290-300.

Li, L. & Jifei, W. (2009). The search tactics for external knowledge sources in Chinese manufacturing firms, information management. *Innovation Management and Industrial Engineering, 2*(1), 12-23.

Lichtenthaler, U. (2008). Open innovation in practice: an analysis of strategic approaches to technology transactions. *Engineering Management, 55*(1), 148-157.

Lu, J. W. & Beamish, P. W. (2001). The internationalization and performance of SMEs. *Strategic Management Journal, 22*(2), 565-586.

Lucier, R. A. (2009). *Comparing relationships of employee satisfaction, organizational size, years with firm, and age*. Capella University Press.

Majocchi, A. & Zucchella, A. (2003). Internationalization and performance findings from a set of Italian SMEs. *International Small Business Journal, 21*(2), 249-68.

Martini, A., Aloini, D. & Neirotti, P. (2012). Degree of openness and performance in the search for innovation. *International Journal of Engineering Business Management*, 4(1), 22-34.

Montoya-Weiss, M. M. & Calantone, R. (1994). Determinants of new product performance: a review and meta-analysis. *Journal of product innovation management, 11*(2), 397-417.

Moon, B. J. (2006). Determinants and outcomes of radical product innovation by Korean firms. *Marketing Science Research, 16*(2), 13-36.

Moon, S. (2011) How does openness influence innovation of Korean Manufacturing Firms?. *Journal of Korean Technology Innovation Society, 14*(1), 711-735.

Mowery, D. & Rosenberg, N. (1979). The influence of market demand upon innovation: a critical review of some recent empirical studies. *Research Policy, 8*(2), 102-53.

Noh, J. H. (2010). Analysis on the patterns of technological innovation in Koreas manufacturing sector according to the technology intensity. Pohang Korea: Thesis for Doctorate in Program Pohang University of Science and Technology.

OECD & Development, O. F. E. C. A. (2005). The measurement of scientific and technological activities. *OECD, 3*(1), 1-27.

Onetti, A., Zucchella, A., Jones, M. V. & Mcdougall-Covin, P. P. (2012). Internationalization, innovation and entrepreneurship: business models for new technology-based firms. *Journal of Management & Governance, 16*(3), 337-68.

Pénin, J. (2008). More open than open innovation? rethinking the concept of openness in innovation studies. *Bureau dEconomie Th orique et Appliqu e, 18*(1), 1-20.

Reid, S. D. (1981). The decision-maker and export entry and expansion. *Journal of International Business Studies, 12*(2), 101-12.

Rogers, E. M., Takegami, S. & Yin, J. (2001). Lessons learned about technology transfer. *Technovation, 21*(1), 253-261.

Shin, D. R. (2013). The study of determinants of profitability: focusing on Korea and Japan electronic industry. *Korean and Japan Current Account, 61*(1), 147-69.

Teece, D. (1986). Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy, 15*(6), 285-305.

Van De Vrande, V., De Jong, J. P., Vanhaverbeke, W. & De Rochemont, M. (2009). Open innovation in SMEs: trends, motives and management challenges. *Technovation, 29*(2), 423-437.

West, J. & Gallagher, S. (2006). Challenges of open innovation: the paradox of firm investment in open-source software. *R&D Management*, 36(2), 319-331.

Yang, H. J. (2012). Relationships among international entrepreneurship, core capabilities, and network activities. Kyoungsan, Korea: Thesis for Master in Young Nam University.