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ABSTRACT

New technology development capability plays a key role in making small- and medium-sized enterprises (SMEs) increase their innovation performance, such as in product or process innovation. To examine the influencing factors of SMEs’ new technology development capability, this study empirically analyzes the mediating effects of SMEs’ process design capability and product interior design capability on the positive association between their external information network diversity and new technology development capability. This study performs the ordinary least squares regression on a sample of 2,000 South Korean SMEs. Results reveal that SMEs’ process design capability fully mediates, and product interior design capability partially mediates the positive association between the external information network diversity and new technology development capability.

Keywords: Process Design Capability, Product Interior Design Capability, External Information Network Diversity, New Technology Development Capability, SMEs

I. Introduction

The importance of the new technology development can not be emphasized enough because it enables firms to make product or process innovation (Schilling, 2013; Trott, 2012), which can generate the economic profits that they aim at (Jolly, 1997). But nowadays, in spite of the great importance of the new technology development, it is not very easy for the organizations in the market to effectively and efficiently make a success in new technology development (Jolly, 1997; Schilling, 2013), and this
is the more common case in the context of small and medium-sized enterprises (SMEs) (Hau, 2015a; Hau, 2015b; Hau, 2016). Therefore, it is necessary to empirically analyze the effects of various factors to SMEs' new technology development capability in order to develop the knowledge about the significantly influential factors to the new technology development capability. From this point of view, this research has made an attempt to empirically check the mediating impacts of SMEs' process design and product interior design capabilities on the association between their external information network diversity and new technology development capability.

Firms can imbibe the external innovation-conducive idea, information or knowledge, which they need for their successful technological innovation but do not possess, from their external information network and they can make their new technology development successful by applying the innovation-conducive idea, information or knowledge from the external network to their new technology development (Chesbrough, 2003; Chesbrough, 2006; Hau, 2016; Huston and Sakkab, 2006). This way of using the external information network for successful new technology development is effective in increasing SMEs’ new technology development capability (Chesbrough, 2006; Hau, 2016). In other words, SMEs have a higher tendency of possessing insufficient resources and capabilities for new technology development at the insides of themselves than large enterprises (Hau, 2015a; Hau, 2016; Kim and Park, 2010) but the idea, information or knowledge transfused from their external information network can grow their new technology development capability (Chesbrough, 2006; Hau, 2016). Therefore, recent studies such as Hau (2015a), Hau (2015b), and Hau (2016) have put the stress on the important role of the external information network for SMEs' new technology development. However, they appear to be limited in the aspect that they have paid little attention to such potential mediators as SMEs' process design capability and product interior design capability in the relationship between their external information network diversity and new technology development capability. In other words, they have a tendency of focusing only on the direct impact of the external information network on their new technology development. Accordingly, the objective of this research is to illuminate the mediating roles of SMEs’ process design capability and product interior design capability in the relationship between their external information network diversity and new technology development capability. In line with the objective of this research, this research attempts to empirically answer the two research questions as follows;

(i) What effect does SMEs’ process design capability have on the relationship between their external information network diversity and new technology development capability?
(ii) What effect does SMEs’ product interior design capability have on the relationship between their external information network diversity and new technology development capability?

This article is organized into six sections including this one. The next section presents the two hypotheses related to the two research questions and explains theoretical background on which the hypotheses are based. The third section deals with the research methodology used to perform the empirical analysis for this study. The fourth section reports the results from testing the research model of this study. The fifth section draws the conclusion from the results, followed by the last section making suggestions for better future studies.
II. Research Model and Theoretical Background

This study develops the research model composed of the two hypotheses as illustrated in <Figure 1>. The hypothesis 1 in the mediating model I deals with the mediating effect of SMEs’ process design capability on the relationship between their external information network diversity and new technology development capability and the hypothesis 2 in the mediating model II covers the mediating role of SMEs’ product interior design capability between the relationship.

2.1. The Mediating Model I

New technology development is a knowledge-intensive task which requires a variety of idea, information or knowledge (Trott, 2012). Various idea, information and knowledge are required to successfully develop the new technology to satisfy the customers’ needs in the rapidly changing market (Akhilesh, 2014; Schilling, 2013; Trott, 2012). The internal research and development functions of firms play an important role in carrying out the knowledge-intensive task necessary for the new technology development (Afuah, 2003; Akhilesh, 2014) but it is not very easy for large firms and SMEs to possess every necessary knowledge for successful new technology development (Chesbrough, 2006; Hau, 2015a; Hau, 2015b; Huston and Sakkab, 2006). Viewed in this light, it is effective for such companies as SMEs with meager internal knowledge to get a transfusion of knowledge from a variety of external information sources and use it for technology development in making their new technology development more successful (Chesbrough, 2003; Chesbrough, 2006; Hau, 2015a; Hau, 2015b; Hau, 2016; Kim and Park, 2010; Wynarczyk et al., 2013). In accordance with this, Hau (2016)’s empirical finding has confirmed that SMEs’ new technology development capability is positively influenced by their external information network diversity.

Process innovation enables companies to more efficiently operate their systems by using new methodologies or materials (Afuah, 2003; Schilling, 2013; Trott, 2012). In order for a firm to develop more efficient process technology, it needs a good capability
of designing its process well (Krajewski et al., 2013; Stevenson and Chuong, 2014). And various external innovation-conducive idea, information or knowledge in terms of both technology and customers' needs from firms' external information network can provide the knowledge basis which is useful to growing their process design capability (Chesbrough, 2006; Schilling, 2013; Trott, 2012). Therefore, SMEs' external information network diversity can have a positive impact on their process design capability.

Good process design capability can provide the effective and efficient basis on which firms' process becomes better (Krajewski et al., 2013; Stevenson and Chuong, 2014), which can be beneficial to increasing their new technology development capability. In this sense, SMEs' process design capability can positively influence their new technology development capability. Therefore, considering the positive impact of SMEs' external information network diversity on their process design capability which can have a positive effect on the new technology development capability, this study develops the hypothesis 1.

H1: SMEs' process design capability mediates the positive effect of the external information network diversity on their new technology development capability.

2.2. The Mediating Model II

Companies are required to have a deep understanding of what kinds of new functions of technologies can satisfy customers' needs well and how they can be made possible technically in order to make good product interior design (Hau, 2015c; Stevenson and Chuong, 2014; Trott, 2012). It is an effective way of deepening firms' understanding of their customers and technologies to get a transfuse of the external innovation-conducive idea, information or knowledge from more various sources at the outside of the firms including customers, suppliers, and research institutes (Akhilesh, 2014; Bingham and Spradlin, 2011; Chesbrough, 2003; Chesbrough, 2006; Schilling, 2013; Trott, 2012; Wynarczyk et al., 2013), which suggests the positive influence of the external information network diversity on SMEs' product interior design capability.

Design is one of the essential factors to making innovative products which can loved by customers, and become popular in the market (Trott, 2014; Verganti, 2009). Firms' good product interior design capability can effectively arrange the components of a product (Stevenson and Chuong, 2014; Trott, 2012; Wynarczyk et al., 2013), and can provide an adequate basis in which new technology can be embodied (Betz, 2011; Trott, 2012), which suggests the positive impact of SMEs' product interior design capability on their new technology development capability. Consequently, considering the positive effect of the external information network diversity on their new technology development capability through the product interior design capability, this study generates the following hypothesis 2.

H2: SMEs' product interior design capability mediates the positive effect of the external information network diversity on their new technology development capability.

III. Research Methodology

This research has run the ordinary least squares regression with the IBM SPSS version 23 so as to empirically analyze the mediating roles of the process design capability and product interior design capa-
This study used the 2013 SMEs’ Technology Statistics (2013 SMETS). The Korea Federation of Small and Medium Business (KBIZ) and the Small & Medium Business Administration performed a national survey in 2013 in order to collect the data related to the technology development in South Korean SMEs, which has resulted in the 2013 SMETS. This study has analyzed the 2,000 samples of South Korean SMEs in the 2013 SMETS by running the ordinary least squares regression to test the two hypotheses in the research model. SMEs’ information network diversity was measured by adapting Watson (2007)’s measurement for the context of this research. Based on the adapted Watson (2007)’s measurement for this study, this research examined the number of the eight different types of the external information sources for technology development used by each SME: (1) public research institutes (2) rivals in the same business area (3) seminars, expositions, and conferences, (4) customers (5) consulting firms or private research institutes (6) universities (7) suppliers (8) journals in their area of expertise or books relevant to it. For instance, if a SME used idea or information from the three different types in the eight different types of the external information sources such as customers, suppliers, and universities for technology development from 2011 to 2012, then, its value of the external information diversity was evaluated to be three. The level of SMEs’ process design capability, product interior design capability, and new technology development capability were evaluated by using a 100 % point scale as of the end of June in 2013. If a SME’s process design capability was evaluated to be the best in the world, it took the value of 100%. If a SMEs’ product interior design capability and new technology development capability were evaluated to be 30% and 70%, respectively, they mean that there were respective differences of 70% and 30% between themselves and the world best level in terms of the product interior design capability and new technology development capability.

The <Table 1> provides the range, means and standard deviation of the 2,000 sample for this study in terms of the firm size, research and development cost, and the variables in the research model. The firms size in regard to the number of employees as of the end of June in 2013 ranges from 5 to 299. The research and development cost in 2012 ranges from 0 KRW1) to 35,000,000,000 KRW. The means of the external information network diversity, process design capability, product interior design capability, and new technology development capability are 2.046, 73.241, 71.356, and 72.175, respectively.

1) South Korean Won
IV. Research Model Testing Results

This research carried out the research model testing in three steps. The first step is to test the mediating effect of SMEs’ process design capability in the mediating model I and the second step is to test the mediating impact of SMEs’ product interior design capability in the model II. And the third step is to test the joint mediating effect of SMEs’ process design capability and product interior design capability. This study applied Baron and Kenny (1986)’s mediating impact testing method to the three steps. According to Baron and Kenny (1986), four conditions must be met in order for a potential mediator to prove to be a significant mediator; (I) the independent variable has a significant influence on the dependent variable, (II) the independent variable has a significant impact on the potential mediator, (III) The potential mediator has a significant effect on the dependent variable when the effect of the independent variable has been reflected, (IV) the potential mediator proves to be a significant full mediator if the significant effect of the independent variable in the condition (I) has grown insignificant in the condition (III) but the potential mediator turns out to be a significant partial mediator if the effect of the independent variable in the condition (I) has become smaller than the effect of the independent variable in the condition (III). This study checked whether the four conditions were met in the three steps to test the mediating effects of the SMEs’ process design capability and product interior design capability in the research model in the following sections.

4.1. The Mediating Model I Testing Results

As seen in <Figure 2>, SMEs’ process design capability has turned out to fully mediate the positive effect of the external information network diversity on the new technology development capability, providing support for the hypothesis 1 in the mediating model I. According to the Baron and Kenny (1986)’s four conditions for the significant mediating effect, in order for SME’s process design capability to be a significant and full mediator, SMEs’ external information network diversity must significantly influence their new technology development capability (the condition I), SME’s external information network diversity must have a significant effect on their process design capability (the condition II), the process
design capability must significantly influence the new technology development capability when the influence of the external information network diversity is reflected (the condition III), and the significant effect of the external information network diversity on the new technology development capability in the condition I must grow insignificant after the effect of the process design capability has been considered (the condition IV).

The mediating model I testing results have indicated that SMEs' external information network diversity has a positive and significant impact on their new technology development capability (regression coefficient = 0.918, t-value = 2.895) at the significant level of 0.1, satisfying the condition I. And they have indicated that the external information network diversity significantly and positively influences the process design capability (regression coefficient = 1.198, t-value = 3.992), meeting the condition II. According to the mediating model I testing results, the process design capability has a positive and significant effect on the new technology development capability (regression coefficient = 0.411, t-value = 18.862) when the impact of the external information network diversity is reflected, satisfying the condition III. The mediating model I testing results have revealed that the significant and positive impact of the external information network diversity on the new technology development capability (regression coefficient = 0.918, t-value = 2.895) has been changed into the insignificant effect (regression coefficient = 0.426, t-value = 1.452) when the positive effect of the process design capability is reflected, satisfying the condition IV.

4.2. The Mediating Model II Testing Results

As <Figure 3> shows, the mediating model II testing results have proved that SMEs' product interior design capability partially mediates the positive impact of the external information network diversity on the new technology development capability. According to the Baron and Kenny (1986)'s four conditions for the significant mediating effect, in order for SMEs' product interior design capability to be a significant and partial mediator, SMEs' external information network diversity must significantly influence the new technology development capability (the condition I), the external information network diversity must have a significant impact on
the product interior design capability (the condition II), the product interior design capability must have a significant influence on the new technology development capability when the effect of the external information network diversity is considered (the condition III), the effect size of SMEs' product interior design capability on the new technology development capability in the condition I must decrease when the effect of the product interior design capability is considered in the condition III (the condition IV).

According to the mediating model II testing results, the external information network diversity significantly and positively influences the new technology development capability (regression coefficient = 0.918, t-value = 2.895), which meets the condition I. The external information network diversity significantly and positively impacts the product interior design capability (regression coefficient = 0.623, t-value = 1.724), which satisfies the condition II. The mediating model II testing results has indicated that the product interior design capability has a significant and positive impact on the new technology development capability (regression coefficient = 0.488, t-value = 29.942) when the effect of the external information network diversity is reflected (regression coefficient = 0.614, t-value = 2.328), meeting the condition III. The significant and positive impact of the external information network diversity on the new technology development capability is 0.918 in the condition I but it has decreased to 0.614 in the condition III, satisfying the condition IV.

4.3. The Joint Mediating Model Testing Results

In addition to testing the mediating model I and II, this study has examined the joint mediating effect of the SMEs process design and product interior design capabilities by extending the core logic of the Baron and Kenny (1986)'s mediating impact testing method to this research. Baron and Kenny (1986) points out that a potential mediator can prove to
be a significant full mediator on the case that the significant and direct impact of the independent variable has been changed into the insignificant impact after the impact of the potential mediator has been considered. The joint mediating effect testing results has revealed that the significant and direct effect of the external information network diversity on the new technology development capability (regression coefficient = 0.918, t-value = 2.895) has become insignificant (p-value = 0.101) when the process design and product interior design capabilities jointly mediate the significant and direct effect of the external information network diversity as illustrated in <Figure 4>, which has confirmed that the joint mediating effect of the process design capability and the product interior design capabilities is significant and full.

5.2. Academic and Practical Implications

The three points which this study has revealed can provide meaningful academic and practical implications. In terms of academic implications, this study widens Hau (2016)'s finding about the relationship between SMEs’ external information network diversity and their new technology development capability. Hau (2016) has empirically proved that SMEs’ external information network diversity positively and significantly impacts their new technology development capability but has not considered any mediator on this positive effect of SMEs’ external information network diversity. In other words, Hau (2016) appears to be limited in that any mediator has not been considered in its empirical research model. This study is expected to overcome the limitation of the Hau (2016), providing a fresh academic implication by empirically proving that SMEs’ process design capability and product interior design capability are significant mediators in the relationship between SMEs’ external information network diversity and new technology development technology capability. Furthermore, this study is expected to provide another academic implication that SMEs’ process design capability is a full mediator and product interior design capability is a partial mediator in the relationship between SMEs’ external information network diversity and new technology development technology capability.

In terms of the practical implications based on the three points which this study has revealed, this study suggests that SMEs should pay special attention to the full mediating effect of the process design capability on the association between SMEs’ external technology information network diversity and their new technology development capability. This study has empirically confirmed that SMEs’ process design

capability is a significant and full mediator in the association, meaning that the positive effect of the external information network diversity is linked to the new technology development capability through the process design capability. Moreover, this study provides another practical implication that it is necessary for SMEs to pay special attention to the point that SMEs’ process design capability and product interior design capability fully and jointly mediates the association between SMEs’ external information network diversity and new technology development capability. This means that the positive effect of the external information network diversity is connected to the process design capability and product interior design capability, and then, these two capabilities jointly and fully link the positive effect the external information network diversity to the new technology development capability.

VI. Suggestions for Better Future Studies

Despite the three points which this study has revealed, this study has several limitations which need to be overcome in better future studies. First, there can be more potential mediators in the association between SMEs’ external information network diversity and new technology development capability. Therefore, it will be more effective in making more meaningful implications for future studies to consider more potential mediators in the association between SMEs’ external information network diversity and new technology development capability in their research model. Second, the significant mediating effects of the process design capability and product interior design capability revealed by this study can be meaningful only to Korean SMEs because this study analyzed the data collected from South Korean SMEs. Therefore, it will be better for future studies to check the mediating effects of them based on the data collected from various foreign SMEs. Third, the cross-sectional research was made to test the research model in this study. But, it will be make more interesting research outputs for future studies to examine how the hypothetical relationships in this study will change by using times series research or simulation method. Fourth, this study did not consider the different mediating effects of the process design capability and product interior design capability depending on the various types of SMEs in its research model. Therefore, it will be better for future studies to consider them in their research model.

<References>


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