The Effect of the Exterior R&D Network on the Import Substitution of Small and Medium Venture Firms: The Moderating Impact of Corporate R&D Center

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외부 연구개발 네트워크가 중소 벤처기업의 수입 대체에 미치는 영향: 기업부설 연구소의 조절 효과

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Abstract   The business environment changing very fast with technology advance and convergence makes the role of R&D become more and more important to firms' success. By analyzing the 683 firm-level data of small and medium venture firms with the ordinary least squares regression, this study sheds new light on the following four points. First, small and medium venture firms' exterior R&D collaboration network heterogeneity positively impacts their import substitution from technology development. Second, the existence of the corporate R&D center moderates the positive impact of small and venture firms' exterior R&D collaboration network heterogeneity on their import substitution from technology development. Third, small and venture firms' exterior R&D information network heterogeneity positively impacts their import substitution from technology development. Fourth, The existence of the corporate R&D center moderates the positive influence of small and venture firms' exterior R&D information network heterogeneity on their import substitution from technology development.

Key Words : Small and Medium Venture Firm, Exterior R&D, Collaboration Network, Information Network, Import Substitution, Corporate R&D Center, Technology Convergence

요 약 기술 진보 및 융합과 함께 매우 빠르게 변화하는 사업 환경은 기업의 성공에 있어서 연구개발(R&D)의 역할을 더욱 더 중요하게 하고 만들고 있다. 본 연구는 기업 수준의 683개 중소 벤처기업 데이터를 대상으로 최소 자승 회귀분석을 실시하여 다음과 같은 4가지 주요 사항을 새롭게 조명한다. 첫째, 중소 벤처기업의 외부 R&D 협력 네트워크의 다양성은 기술 개발로 인한 수입 대체에 정(+)의 영향을 준다. 둘째, 기업 부설 연구소의 존재는 중소 벤처기업의 외부 R&D 협력 네트워크의 다양성이 기술 개발로 인한 수입 대체에 주는 양(+)의 영향을 조절한다. 셋째, 중소 벤처기업의 외부 R&D 정보 네트워크의 다양성은 기술 개발로 인한 수입 대체에 정(+)의 영향을 미친다. 넷째, 기업 부설 연구소의 존재는 중소 벤처기업의 외부 R&D 정보 네트워크의 다양성이 기술 개발로 인한 수입 대체에 주는 양(+)의 영향을 조절한다.

주제어 : 중소 벤처기업, 외부연구개발, 협력네트워크, 정보네트워크, 수입 대체, 기업부설 연구소, 기술 융합

1. Introduction

The research and development (R&D) is very critical to creating and sustaining product innovation which can provide successful differentiation or cost leadership for enterprises [1, 2]. Enterprises' R&D are based on either closed innovation or open innovation [3, 4, 5]. In the closed innovation, enterprises' R&D is implemented within their interior knowledge network, and their product innovation was limited to the interior knowledge network [3, 4, 5]. On contrary to this, in the open innovation, enterprises can increase their success in R&D by strategically using their exterior knowledge network as well as interior knowledge network [3, 4, 5].

The R&D based on the open innovation can significantly contribute to increasing the product innovation of not only large enterprises [3, 4, 5] but also small and medium-sized enterprises (SMEs) [6, 7]. Therefore, special attention has been given to the important role of the exterior knowledge network in generating various performances from SMEs' technology R&D and developing their diverse capabilities in recent studies such as [7, 8, 9, 10, 11, 12, 13]. But, these recent studies seem to be limited in that they have not empirically and sufficiently explained the main effect of the exterior R&D network on the import substitution especially in the context of small and medium venture firms and the moderating impact of their corporate R&D center on the main effect. Moreover, enterprises' exterior R&D network consists of the exterior R&D collaboration network and the exterior R&D information network [3, 4, 8, 15, 16] but the recent studies scarcely appear to consider the effects of the exterior R&D collaboration network and the exterior R&D information network on the import substitution of small and medium venture firms in their research model at the same time. These limitations in the recent studies have motivated this research to attempt to construct a research model about the effects of the exterior R&D collaboration network and the exterior R&D information network on the import substitution of small and medium venture firms and empirically examine the research model. Futhermore, the economy of the South Korea heavily depends on the import [17, 18, 19] and SMEs compose the majority of the total numbers of enterprises in the South Korea [19]. Therefore, there is much demand for the studies empirically looking into the influential factors to the import substitution of small and medium venture firms, which make this study address the following research questions;

(i) What is the effect of small and medium venture firms' exterior R&D collaboration network heterogeneity on their import substitution from technology development?

(ii) What is the impact of small and medium venture firms' exterior R&D information network heterogeneity on their import substitution from technology development?

(iii) What is the influence of small and medium venture firms' corporate R&D center on the effects of the exterior R&D collaboration network heterogeneity and the exterior R&D information network heterogeneity on their import substitution from technology development?

2. Theory and Research Model

The hypothesis 1 treats the main effect of the exterior R&D collaboration network heterogeneity on small and medium venture firms' import substitution from technology development. Technical knowledge is one of the important sources to producing new or improved products or decreasing the cost of products [1, 2, 40, 41, 42, 43, 44, 45], which contributes to SMEs' successful import substitution [28]. Various exterior R&D collaboration enables firms to learn and digest

technical knowledge which does not exist within their interior knowledge network [2, 3, 4, 5, 6, 7, 31, 33]. In this sense, Hau(2016) [8] has empirically revealed that SMEs' exterior R&D collaboration network heterogeneity positively influences their new technology development capability. Therefore, the exterior R&D collaboration network diversity is hypothesized to positively influence the import substitution from technology development in the hypothesis 1 as follows;

H1 : Small and medium venture firms' external R&D collaboration network heterogeneity positively influences their import substitution from technology development.

It is necessary for firms to develop their absorptive capacity so as to effectively recognize useful external knowledge, imbibe this knowledge, and apply it to their successful product R&D [20, 32]. However valuable the external knowledge from the R&D collaboration may be, the firms without the absorptive capacity can not benefit from it [20, 21, 34, 35, 36, 37, 38]. Absorptive capacity can be captured by the existence of enterprises' formal and permanent organization for R&D such as the R&D department [23, 24]. Veugelers (1997) [23] indicates that R&D cooperation positively influences their internal R&D capabilities only if they have their own absorptive capacity represented by their permanent R&D department. Therefore, this study builds the hypothesis 2 about the moderating role of small and medium venture firms' corporate R&D center as follows;

H2 : Small and medium venture firms' corporate R&D center moderates the positive influence of the exterior R&D collaboration network heterogeneity on their import substitution from technology development.

Enterprises' successful R&D requires various information and diverse external information sources such as customers, suppliers, university, etc, which is very helpful to increasing SMEs' performances from R&D [1, 2, 3, 4, 6, 7, 39]. Enterprises using diverse external information network can overcome the limitation in their internal knowledge network, and increase their performances from R&D [1, 2, 3, 4, 7, 15, 16, 39]. In line with this, Hau (2017) [25] empirically shows that the exterior R&D information from SMEs' customers and suppliers positively influences their product quality improvement and cost reduction from technology development. Accordingly, this study builds the hypothesis 3 about the main effect of the exterior R&D information heterogeneity as follows;

H3 : Small and medium venture firms' external R&D information network heterogeneity positively influences their import substitution from technology development.

Enterprises' absorptive capacity is a very important capability to their innovation performances, playing an important role in recognizing the worth of exterior information [12, 20, 39]. Poor absorptive capacity can prevent firms from accurately evaluating the valuable external information for product innovation [20, 21, 39]. Absorptive capacity can be embedded in permanent and official R&D organization within firms [23, 24] and Escribano, Fosfuri, and Tribó (2009) [22] empirically shows the significant moderating role of firms' absorptive capacity in the relation between their innovation performance and external knowledge flows. Therefore, this research constructs the hypothesis 4 as follows;

H4 : Small and medium venture firms' corporate R&D center moderates the positive influence of the exterior R&D information network heterogeneity on their import substitution from technology development.

In addition, this study uses the size of employees, the size of R&D workers, and the technology sector as the control variables in the research model. This study constructs a research model made up of four hypotheses as seen in the [Fig. 1].
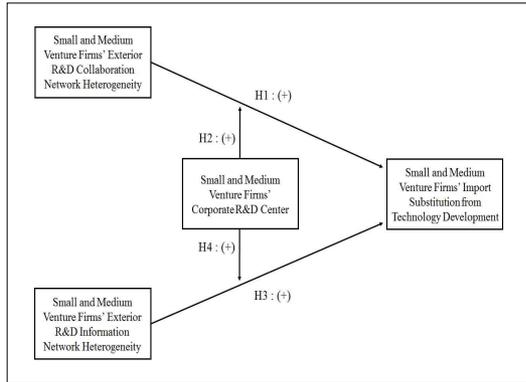
[Fig. 1] Research Model

3. Research Methodology

3.1 Data

This study used a kind of the South Korea Government-authorized survey data named 2014 SMEs' Technology Statistics (2014 SMETS) to empirically test the four hypotheses. The 2014 SMETS is a firm-level survey data of SMEs' R&D management in 2013 and it was performed by the Korea Federation of Small and Medium Business (KBIZ) and the Small & Medium Business Administration in 2014. This research used the 683 data of SMEs belonging to venture firms in the 2,200 data in the 2014 SMETS. The 154 data belonged to the information technology(IT) sector(22.5%) and the other 529 data belonged to the non-IT sector(77.5%) in the 683 data analyzed for this study. The <Table 1> reports the outline of the 683 data with regard to the total sales, the number of employees, and the number of R&D workers.

<Table 1> The outline of the data

Item	Max	Min	Mean	Standard Deviation
Total Sales (South Korean Million Won)	168,006	0	12,257	20,036
The Number of Employees	299	5	40.26	50.01
The Number of R&D Workers	197	1	8.10	13.88

3.2 Measurement

Small and medium venture firms' external R&D collaboration network heterogeneity indicates the number of the different types of the external R&D partners that small and medium venture firm cooperates with [8, 26]. This study measured the degrees of the exterior R&D collaboration network heterogeneity by using the adapted measurement from Tsai(2009)[26]. In this measurement for the degrees of the exterior R&D collaboration network heterogeneity, the types of the external R&D partners were categorized into six types such as (1) national research institutes, (2) private research institutes, (3) foreign enterprises and organizations, (4) universities, (5) large enterprises, and (6) other SMEs.

Small and medium venture firms' external R&D information network heterogeneity is referred to as the number of the different types of the external R&D information sources that small and medium venture firm used for their R&D [8, 9, 10, 27]. This study measured the degrees of the exterior R&D information network heterogeneity through the adapted measurement from Watson(2009)[27]. In this measurement for the degrees of the exterior R&D information network heterogeneity, the types of the external R&D information sources were classified into eight types such as (1) private or national research organizations, (2) global or domestic expos, conferences, and seminars, (3) universities, (4) global or domestic special books or journals, (5) competitors in the same business domain, (6) private service

organizations such as private research institutes or consulting firms, (7) suppliers, and (8) buyers.

Corporate R&D centers indicate annex research institutes for enterprises' R&D activities [46]. This study examined whether each small and medium venture firm had its corporate R&D center or not in order to measure the existence of the corporate R&D center by using the extended measurement Veugelers(1997)[23] and Cassiman and Veugelers(2002)[24] through a dummy variable with the value of either one (= existence) or zero (= non-existence).

Small and medium venture firms' import substitution indicates converting the products depending on the imports from foreign nations into the product produced by themselves [47]. In measuring the degree of small and medium venture firms' import substitution from technology development, this research used the five point scale from the value of one (= no or very low degree) and to the value of five (= high degree).

3.3 Analysis Method and Model

This study used the ordinary least squares (OLS) regression with the IBM SPSS version 23 to test the four hypotheses. The hypothesis testing was performed in two steps. This study tested the direct effects in the hypothesis 1 and 3 by using the 683 data in the first step and the moderating effects in the hypothesis 2 and 4 by using the data depending on the two groups in the second step : the group with the corporate R&D center (n = 415) and the group without the corporate R&D center (n = 268). The OLS regression model was used as the analysis model to test the hypothesis 1 through 4 as follows;

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$$

In this OLS regression model, Y stands for the import substitution from technology development, X_1 for the exterior R&D collaboration network

heterogeneity, X_2 for the exterior R&D information network heterogeneity, X_3 for the number of employees, X_4 for the number of R&D workers, X_5 for the technology sector, β_0 for the constant term, β_1 through β_5 for the regression coefficients for X_1 through X_5, respectively, and ε for the error term.

4. Analysis Results

The analysis results based on the total group (n = 683) have shown that small and medium venture firms' exterior R&D collaboration network heterogeneity positively influences their import substitution from technology development at the significant level of 0.05 (β_1 = 0.116, t-value = 3.590), supporting the hypothesis 1. The results have revealed that the exterior R&D information network heterogeneity positively influences the import substitution (β_2 = 0.075, t-value = 3.394), supporting the hypothesis 3. The effect of the exterior R&D collaboration network heterogeneity is positive and significant (β_1 = 0.143, t-value = 3.565) in the group with the corporate R&D center (n = 415) but it is not significant (β_1 = −0.034, t-value = −0.562) in the group without the corporate R&D center (n = 268), supporting the hypothesis 2. In the group with the corporate R&D center (n = 415), the impact of the exterior R&D information network heterogeneity is positive and significant (β_2 = 0.086, t-value = 2.946) but in the group without the corporate R&D center (n = 268), it is not significant (β_2 = 0.056, t-value = 1.744), supporting the hypothesis 4.

As an additional analysis, this study compared the effect sizes of the exterior R&D collaboration network heterogeneity and the exterior R&D information network heterogeneity on small and medium venture firms' import substitution from technology development by using the standardized regression coefficients of them. In the total group (n = 683), the standardized regression coefficients of the exterior R&D

collaboration network heterogeneity and the exterior R&D information network heterogeneity are 0.142 and 0.133, respectively, indicating that the positive effect of the exterior R&D collaboration network heterogeneity on the import substitution from technology development is larger than the positive impact of the exterior R&D information network heterogeneity. The <Table 2> reports the analysis result and the <Table 3> summarizes the results from hypothesis testing.

<Table 2> The analysis results

	Total Group (n = 683)		The Group with the Corporate R&D Center (n = 415)		The Group without the Corporate R&D Center (n = 268)	
	URC	VIF	URC	VIF	URC	VIF
β_1	0.116***	1.117	0.143***	1.116	−0.034	1.104
β_2	0.075***	1.090	0.086**	1.094	0.056	1.077
β_3	0.000	1.381	0.000	1.408	−0.001	1.154
β_4	0.001	1.417	0.001	1.394	−0.002	1.285
β_5	0.053	1.085	0.055	1.065	0.002	1.173

Note: $*P < 0.05$, $**P < 0.01$, $***P < 0.001$; URC stands for unstandardized regression coefficient; VIF stands for variance inflation factor.

<Table 3> The hypothesis testing results

Hypothesis	Result	Type of Effect
H1	Supported	Direct
H2	Supported	Moderating
H3	Supported	Direct
H4	Supported	Moderating

5. Conclusion

The business environment changing very fast with technology advance and convergence makes the role of R&D become more and more important to firms' success [1, 2, 8, 16]. Related to the R&D in small and medium venture firms, the findings from this study sheds new light on the four points and provide useful implications based on them, which can deepen the research stream on management of technology in firms

in recent studies such as [6, 8, 9, 10, 13, 14, 29, 30].

First, small and medium venture firms' exterior R&D collaboration network heterogeneity positively impacts their import substitution from technology development. This implies that it is effective for small and medium venture firms to make R&D collaboration with diverse partners in increasing their import substitution from technology development. Second, the existence of the corporate R&D center moderates the positive impact of the exterior R&D collaboration network heterogeneity on the import substitution. This suggests that it is necessary for small and medium venture firms to establish and operate the corporate R&D center so as to effectively absorb and apply the exterior useful knowledge from their exterior R&D collaborations. Third, small and venture firms' exterior R&D information network heterogeneity positively impacts their import substitution. This points out that small and medium venture firms' strategic efforts to get external R&D information from various sources play an effective role in increasing the import substitution. Fourth, The existence of the corporate R&D center moderates the positive influence of the exterior R&D information network heterogeneity on the import substitution, This indicates the critical role of the corporate R&D center in increasing small and medium venture firms' import substitution, emphasizing the importance of the absorptive capacity to obtaining and digesting the exterior R&D information.

6. Limitation

The following limitations of this study require the cautious interpretation of the findings from this research. First, the research subject for this study is limited to only small and medium venture firms. Second, the data for this study was not collected from small and medium ventures form various nations.

Third, the research model in this study did not consider potential mediators.

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