

SMEs' External Technological Information Network Diversity and Sales Growth : The Mediating Impact of the Productivity Improvement and the Moderating Effect of the Technology Development Driven by CEO

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중소기업의 외부 기술 정보 네트워크의 다양성과 매출 성장 : 생산성 향상의 매개 효과와 최고경영자가 주도하는 기술 개발의 조절 효과

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Abstract This research empirically analyzes not only the direct impact of the external technological information network diversity of small and medium-sized enterprises (SMEs) on the sales growth from their technology development but also the mediating impact of their productivity improvement and the moderating effect of the technology development driven by CEO on this direct impact in order to deepen the research stream on SMEs' external technological information network. Based on the ordinary least squares regression by using 2,200 data of South Korean SMEs, this study reveals the three findings. First, SMEs' external technological information network diversity positively influences their sales growth from technology development. Second, SMEs' productivity improvement partially mediates this positive influence of the external technological information network diversity. Third, SMEs' technology development driven by CEO moderates the positive influence.

Key Words : SMEs, External Technological Information Network, Productivity Improvement, Sales Growth, Technology Convergence, Technology Development Driven by CEO

요 약 본 연구는 중소기업의 외부 기술 정보 네트워크에 대한 연구 흐름의 깊이를 더하기 위해 외부 기술 정보네트워크의 다양성이 중소기업의 기술개발로 인한 매출 증대에 미치는 직접적인 영향 뿐만 아니라, 이러한 직접인 영향에 대한 생산성 향상의 매개 효과와 최고 경영자가 주도하는 기술 개발의 조절 효과를 실증적으로 분석한다. 2,200개의 한국 중소기업 데이터를 사용한 최소자승 회귀분석을 바탕으로 다음과 같은 결과를 본 연구는 제공한다. 첫째, 중소기업의 외부 기술 정보 네트워크의 다양성은 기술 개발로 인한 매출 성장에 정(+)의 영향을 미친다. 둘째, 중소기업의 생산성 향상은 외부 기술 정보 네트워크의 다양성이 매출 성장에 미치는 이러한 정(+) 영향을 부분 매개한다. 셋째, 최고경영자가 주도하는 기술개발은 중소기업의 외부 기술 정보 네트워크의 다양성이 매출 성장에 미치는 정(+)의 영향을 조절한다.

주제어 : 중소기업, 외부 기술 정보 네트워크, 생산성 향상, 매출 성장, 기술 융합, 최고경영자 주도 기술개발

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1. Introduction

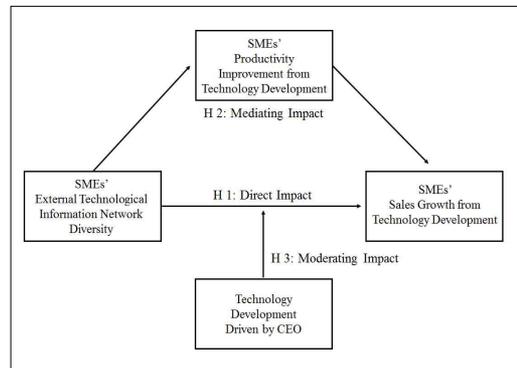
It is very useful firms' making strategic use of their external technological information network to creating and sustaining innovations which can provide competitive advantage for the firms in today's high competition accelerated with the technology convergence in various business domains [1, 2, 3, 4, 5, 6, 7].

The external technological information network is very important to improving the performances from the technology R & D of small and medium-sized enterprises (SMEs) which do not own enough organizational R & D capacities and resources for successful technology development within themselves [1, 2, 3]. Therefore, recent studies seems to have a tendency of paying their special attention to the various roles of SMEs' external technological information network diversity. For example, Hau (2016) [3] reveals that SMEs' external technological information network diversity plays an important role in increasing their new technology development capability and technology commercialization capability. Hau (2015) [4] shows that IT SMEs' external technological information network diversity plays a significant role in increasing their manufacturing capability and production management capability. Hau (2017) [5] empirically proves the significant role of IT SMEs' external technological information network diversity in improving their production process and product quality from technology development. But, these recent studies show the limitation that they can not explain what direct influence SMEs' external technological information network diversity has on such an importance performance as their sales growth from technology development. Moreover, they pay little attention to the mediating impact of SMEs' productivity improvement and the moderating effect of the technology development driven by chief executive officer (CEO) on this direct influence of SMEs' external technological information network diversity. Accordingly, this

research attempts to empirically analyze not only the direct effect of SMEs' external technological information network diversity on their sales growth from technology development but also the mediating impact of their productivity improvement and the moderating effect of the technology development driven by CEO on this direct impact in order to deepen the research stream on SMEs' external technological information network. In line with this, the three research questions are raised in this study as follows;

- (1) What is the influence of SMEs' external technological information network diversity on their sales growth from technology development?
- (2) What is the effect of SMEs' productivity improvement from technology development on the influence?
- (3) What is the effect of SMEs' technology developments driven by CEO on the influence?

2. Theory and Research Model



[Fig. 1] Research Model

As illustrated in the [Fig. 1], this study constructs the research model consisting of the direct impact of SMEs' external technological information network diversity (H1), the mediating effect of their productivity

improvement from technology development (H2), and the moderating influence of SMEs' technology development driven by CEO (H3). And this study uses the number of R & D staffs as a control variable in the research model.

In order for the new technologies developed by firms to be successfully commercialized in the market and generate the economic values, it is necessary for firms to reflect various information and knowledge into their technology development [6, 7, 8]. But, the knowledge in the inside of firms is not unlimited, and they need to receive the external information transfusion from the various external information sources for the success in their technology development and commercialization [1, 2, 3, 6, 8]. Therefore, this research generates the hypothesis 1 related to the positive influence of SMEs' external technological information network diversity as follows;

H1 : SMEs' external technological information network diversity positively influences their sales growth from technology development.

Firms can enhance their productivity through their successful technical developments [6, 7, 10, 11, 12]. SMEs' external technological information network diversity increases their technology development capability [3] and makes their innovations more successful [1, 2, 6, 7]. In line with this, Hau(2017) [9] has empirically proved the significant influence of IT SME ventures' external technological information network diversity on their productivity improvement from technology development. Moreover, other things being equal, firms' productivity improvement enables the firms to produce more outputs without increasing their inputs [9, 10], which can make firms have more cost leadership, and increase their sales [6, 11, 12, 13]. Therefore, this study develops the hypothesis 2 concerning the mediating role of SMEs' productivity improvement as follows;

H2 : The productivity improvement from technology development mediates the positive influence of SMEs' external technological information network diversity on the sales growth from technology development.

There exists the two types of the ways for the technology developments for firms' technology innovations [11, 14]. One is top-down way but the other is bottom-up way [11, 14]. The top-down way is more effective in increasing firms' performances from technology developments through external information sources for innovations [14, 15]. Therefore, this research generates the hypothesis 3 related to the moderating effect of SMEs' technology development driven by CEO.

H3 : SMEs' technology development driven by CEO moderates the positive impact of their external technological information network diversity on the sales growth from technology development.

3. Research Methodology

This study examined the significances of the hypothesis 1 through 3 by analyzing the 2,200 data of SMEs in the Republic of Korea from the 2014 SMEs' Technology Statistics (2014 SMETs). The Korea Federation of Small and Medium Business (KBIZ) and the Small & Medium Business Administration ran the survey about SMEs' management of technology R&D and commercialization across the Republic of Korea, resulting in the 2014 SMETs. The <Table 1> reports the descriptive statistics of the 2,200 data analyzed for this study in terms of SMEs' number of employees, total sales, and R & D spending.

This research measured the degree of SMEs' external technological information network diversity by adapting Watson (2007)'s measurement [16] for the

context of South Korean SMEs' management of technology R & D and commercialization. In other words, this study measured the number of the kinds of the external technological information sources which each SME used to make technology development. The kinds of the external information sources were sorted into such eight types as (1) customers (2) international or domestic conferences, seminars, and expos, (3) national or private research organizations, (4) competitors in the same business domain, (5) international or domestic special journals or books (6) suppliers (7) private service organizations such as consulting firms or private research institutes, and (8) universities. The degrees of SMEs' productivity improvement and sales growth from technology development were gauged by using the five point scale that ranged from one (= no or very low degree) from to five (= very high degree). The number of R & D staffs in each SME was measured for the control variable in the research model.

The research carried out the ordinary least squares (OLS) regression analysis, the Sobel test [17], and the Baron and Kenny test [18] by using the IBM SPSS version 23 to test the research model.

<Table 1> Descriptive Statistics of the Data Analyzed for This Study

Variable	Max	Min	Average	Standard Deviation
The Number of Employees	299	5	49.6	58.4
Total Sales (South Korean Million Won)	216,371	0	18,218.6	27,764.9
R & D Spending (South Korean Million Won)	26,817	1	585.5	1,096.2

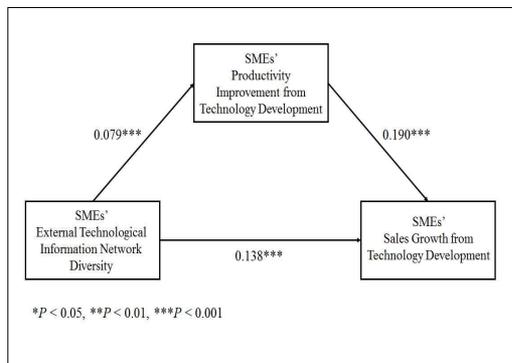
4. Research Model Testing Results

4.1 The Direct Effect of SMEs' External Technological Information Network Diversity

The OLS regression analysis results from this research have provided the empirical evidence supporting the significance of the direct influence of the external technological information network diversity. They have empirically revealed that SMEs' external technological information network diversity positively impacts their sales growth from technology development (regression coefficient = 0.153, t-value = 6.820) at the significant level of 0.05, supporting the hypothesis 1. The number of R & D staffs, which is the control variable, has a positive impact on the sales growth from technology development (regression coefficient = 0.007, t-value = 2.464).

4.2 The Mediating Effect of SMEs' Productivity Improvement from Technology Development

The Sobel test [17] has resulted in the z-value of 3.534, which empirically proves that SMEs' productivity improvement significantly mediates the positive influence of their external technological information network diversity on the sales growth from technology development, supporting the hypothesis 2. According to the results from the Baron and Kenny test [18], the productivity improvement in the research model has turned out to be a partial mediator between the external technological information network diversity and sales growth. In more details, the external technological information network diversity positively impacts the sales growth from technology development (regression coefficient = 0.153, t-value = 6.820) without considering the mediating impact of the productivity improvement. But, this positive effect of the external technological information network diversity has been reduced to 0.138 (t-value = 6.220) after considering the mediating impact of the productivity improvement, which proves that the productivity improvement is the partial mediator in the hypothesis 2 according to the Baron and Kenny [18]. The [Fig. 2] illustrates the mediating effect testing results.



[Fig. 2] The Mediating Effect Testing Results

4.3 The Moderating Effect of SMEs'

Technology Development Driven by CEO

The analysis results in this research have empirically confirmed the significant moderating effect of the technology development driven by CEO, supporting the hypothesis 3. In order to examine the moderating effect, this study has taken two steps. First, this study tested the research model depending on the two groups: One is the group whose technology development is driven by CEO and the other is the group whose technology development is not driven by CEO. Second, this research compared the impacts of the external technological information network diversity on the sales growth from technology development in both groups and investigated whether the difference in the effects between both groups was significant by using the statistical method on the basis of Clogg, Petkova, and Haritou, (1995) [19] and Paternoster, Brame, Mazerolle and Piquero (1998) [20].

The analysis results have indicated that the external technological information network diversity positively impacts their sales growth from technology development (regression coefficient = 0.214, t-value = 6.435) and the mediating impact of the productivity improvement from technology development is significant (the z-value from the Sobel test [17] = 2.347) in the group whose technology development is driven by CEO (n = 1,125). The analysis results have

shown that the external technological information network diversity positively influences the sales growth from technology development (regression coefficient = 0.079, t-value = 2.628) and the mediating impact of the productivity improvement from technology development is significant (the z-value from the Sobel test [17] = 2.517) in the group whose technology development is not driven by CEO (n = 1,075).

This study has calculated the z-value to examine the significance of the difference (0.214-0.079 = 0.135) in the effects of SMEs' external technological information network diversity on the sales growth in both groups by using the statistical method on the basis of Clogg, Petkova, and Haritou, (1995) [19] and Paternoster, Brame, Mazerolle and Piquero (1998) [20], which indicates that the z-value is 3.027, and supports the hypothesis 3. The <Table 2> summarizes the empirical analysis results according to the groups.

<Table 2> Empirical Analysis Results According to the Groups

Group	Group I (n = 1,125)	Group II (n = 1,075)
The regression coefficient of the external technological information network diversity on the sales growth	0.214***	0.079**
The z-value from the Sobel test [17]	2.347	2.517
The z-value from the test on the basis of Clogg, Petkova, and Haritou, (1995) [19] and Paternoster, Brame, Mazerolle and Piquero (1998) [20]	3.027	

Note: *P < 0.05 ; **P < 0.01; *** P < 0.001; Group I stands for the group whose technology development is driven by CEO and Group II stands for the group whose technology development is not driven by CEO.

5. Conclusion

5.1 Implication

Based on the empirical analyses by using 2,200 data of South Korean SMEs, this study is expected to deepen the recent research on SMEs' management of technology management including Kim and Hwang (2016) [21], Sohn, Lee, and Kim (2017) [22], Lee and Kim (2016) [23], and Hau (2015) [24] by revealing the three points and implications from them as follows. First, SMEs' external technological information network diversity positively and directly influences the sales growth from technology development. This implies that SMEs should try to make their external technological information network more diverse in order to increase their sales growth from technology development. Second, SMEs' productivity improvement partially mediates this direct influence of their external technological information network diversity on their sales growth from technology development. This means that SMEs' external technological information network diversity positively influences not only the sales growth but also productivity improvement from technology development and that the productivity improvement positively influences the sales growth from technology development. Third, SMEs' technology development driven by CEO moderates the direct effect of their external technological information network diversity on the sales growth from technology development. This suggests that the impact of SMEs' external technological information network diversity on their sales growth from technology development is higher when their CEOs drive their technology development.

5.2 Limitation

The findings from this study are limited in several points. First, this study controlled the effect of SMEs' R & D staffs on the dependent variable but it will be better to use more various control variables in future research. Second, the analysis results in this study were made by using the cross sectional data. So, they can not show how the findings from this study can

change as time flows. Third, the findings from this study can be applied to only SMEs. Therefore, it is desirable for future studies to reflect the data from both large enterprises and SMEs into their analyses, which can provide useful findings applicable to both large enterprises and SMEs.

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