

The Impact of Outer R&D Knowledge Network on SMEs' Sales Growth: The Mediating Effect of Diversification into New Business Field

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ABSTRACT

The goal of this study is to empirically look into what effect the outer research and development (R&D) knowledge network of small and medium-sized enterprises (SMEs) has on their sales growth and diversification into new business field. Outer R&D knowledge network is of importance to increasing the competitiveness of SMEs through technological innovation. But, relevant prior studies show the limitations that they hardly explored the mediating effect of SMEs diversification into new business field in the relationship between their outer R&D knowledge network and sales growth and they have scarcely answered which outer R&D knowledge network, outer R&D collaboration network or R&D information network, has a more positive impact on their sales growth. Therefore, this study reveals the following four points by analyzing the 2,200 data of South Korea SMEs. First, SMEs' diversification into new business field partially mediates the positive impact of their outer R&D collaboration network diversity on their sales growth. Second, SMEs' diversification into new business field partially mediates the positive impact of their outer R&D information network diversity on their sales growth. Third, SMEs' outer R&D information network diversity has a more positive effect on their sales growth than their R&D collaboration network diversity has. Fourth, SMEs' outer R&D collaboration network diversity has a more positive effect on their diversification into new business field than their outer R&D information network diversity has.

Key Words : SMEs, Outer R&D Knowledge Network, Sales Growth, Diversification

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I. Introduction

The goal of this study is to empirically look into what effect the outer research and development (R&D) knowledge network of small and medium-sized enterprises (SMEs) has on their sales growth and diversification into new business field.

Enterprises' outer R&D knowledge network is of importance to increasing the competitiveness of SMEs through technological innovation (Hau, 2016). Firms' successful technological innovation depends on their R&D knowledge network (Afuah, 2003; Betz, 1993; Trott, 2012). Their R&D knowledge network can be divided into inner R&D knowledge network and outer R&D knowledge network in terms of their organizational boundary (Chesbrough, 2006a; Chesbrough, 2006b). The outer R&D knowledge network can be classified into outer R&D collaboration network and outer R&D information network (Hau, 2016). SMEs' inner knowledge network is relatively smaller than large enterprises' inner knowledge network in terms of firms' knowledge network (Kim & Park, 2010). Therefore, it is strategically important for SMEs to strategically use their outer knowledge network in order to increase successful technological innovations (Chesbrough, 2003; Chesbrough, 2006a). In accordance with this, prior studies point out the significant role of SMEs' outer R&D knowledge network in their capacities and technological innovation performances. For example, outer R&D collaboration with diverse partners positively influences not only SMEs' new technology development capacity but also technology commercialization capacity (Hau, 2016). Venture SMEs' diverse outer R&D information network positively impacts their product planning capacity, which positively influences their new technology development capacity (Hau, 2018c). SMEs' outer R&D collaboration network positively impacts not only their export growth but also employment increase (Hau, 2018a). SMEs' outer R&D collaboration network diversity positively impacts their diversification into new business field (Hau, 2017c).

The prior studies appear to contain the limitations that they hardly explored the mediating effect of SMEs diversification into new business field in the relationship between their outer R&D knowledge network and sales growth and they have scarcely answered which outer R&D knowledge network, outer R&D collaboration

network or outer R&D information network, has a more impact on their sales growth. Therefore, this research attempts to answer the following three questions:

- (1) What is the role of SMEs' diversification into new business field between their outer R&D collaboration network and sales growth?
- (2) What is the role of SMEs' diversification into new business field between their outer R&D information network and sales growth?
- (3) Which outer R&D knowledge network, outer R&D collaboration network or outer R&D information network, has a more impact on their sales growth?

II. Literature Review

According to the open innovation (Chesbrough, 2003; Chesbrough, 2006a; Chesbrough, 2006b), it is crucial for SMEs to use their outer R&D collaboration network and outer R&D information network in order to overcome their limitation in the depth and width of inner R&D knowledge network. SMEs' outer R&D collaboration network and outer R&D information network play a significant role in generating their technological innovations (Hau, 2017a; Lin & Lin, 2016; Paramonova & Thollander, 2016). Therefore, various prior studies have paid their special attention to the influence of SMEs' outer R&D collaboration network or outer R&D information network on their various technological innovation performances under the open innovation.

One research stream in them concentrates on the positive impact of the outer R&D collaboration network on SMEs' various technological performances and capacities. In more details, Hau (2018a) empirically found out that SMEs' outer R&D collaboration network diversity directly influenced their employment increase and this direct influence was partially mediated by their export growth. Hau (2018b) empirically showed that SMEs' outer R&D collaboration network diversity directly impacted their cost reduction and this direct impact was not only partially

influenced by their productivity improvement but also moderated by their chief executive officer-driven technology development. Hau (2017b) empirically indicated that venture SME's outer R&D collaboration network diversity and outer R&D information network diversity had positive effects on their import substitution and these positive effects were moderated by their corporate R&D center. Hau (2017c) pointed out that SME's outer R&D collaboration network diversity positively influenced their diversification into new business field and this direct influence was moderated by their technology development by chief technology officer.

The other research stream focuses on the positive effect of the outer R&D information network on SMEs' various technological performances and capacities. For example, Hau (2018c) empirically revealed the point that SMEs' outer R&D information network diversity directly influenced their new technology development capacity and their product planning capacity partially mediated this direct influence. Hau (2017e)'s empirical analysis results indicated that SMEs' outer R&D information network diversity directly influenced their green management performance and their production process improvement partially mediated this direct influence. Hau (2017d) empirically showed that the positive influence of venture SMEs' outer R&D information network diversity on their technology commercialization capacity is jointly and partially mediated by their manufacturing capacity and testing and inspection capacity. Hau (Hau, 2017f) revealed that SMEs' productivity improvement partially mediated the positive influence of their outer R&D information network diversity on sales growth and this positive influence is moderated by technology development by chief executive officer.

The two research streams in SMEs' outer R&D knowledge network seem to show have two limitations as follows. One limitation is that little light has been paid to the mediating effect of SMEs' diversification into new business between their outer R&D knowledge network and sales growth. In other words, the prior studies has barely explored the mediating role of SMEs' diversification into new business in the association between their outer R&D collaboration network diversity and sales growth as well as the association between their outer R&D information network diversity and sales growth. Therefore, this study attempts to illuminate the mediating roles of SMEs' diversification into new business field not only in the

association between their outer R&D information network diversity and sales growth but also in the association between their outer R&D collaboration network diversity and sales growth in order to overcome the limitations of the prior studies.

III. Theoretical Background and Hypothesis Development

This research develops three hypotheses under the theoretical background open innovation (Chesbrough, 2003; Chesbrough, 2006a; Chesbrough, 2006b). According to the three research questions for this research, hypothesis 1 is constructed for the mediating impact of SMEs' diversification into new business field in the association between their outer R&D collaboration network diversity and sales growth and hypothesis 2 treats the mediating impact of SMEs' diversification into new business field in the association between their outer R&D information network diversity and sales growth. Hypothesis 3 is constructed to compare the effect sizes of SMEs' outer R&D collaboration network diversity and outer R&D information network diversity on their sales growth.

Enterprises' successful R&D plays an essential role in creating and developing useful knowledge necessary for sales increase (Afuah, 2003; Trott, 2012). The open innovation suggests that SMEs can widen or deepen their knowledge by using their outer R&D knowledge network (Chesbrough, 2007; Enkel, Gassmann, & Chesbrough, 2009), and it is made up of outer R&D collaboration network and R&D information network (Hau, 2016). Therefore, SMEs' outer R&D collaboration network diversity can positively their sales growth. In line with this, SMEs' R&D information network diversity has been revealed to positively influence their sales growth by Hau (2017f)

Enterprises' successful diversification into new business field requires various knowledge and information (Kim & Mauborgne, 2015; Siegemund, 2008; Tidd & Bessant, 2014; Trott, 2012). Enterprises' outer R&D collaboration network and outer R&D information network are effective knowledge and information sources (Chesbrough, 2003; Chesbrough, 2006; Enkel et al., 2009; Hau, 2016). Therefore, SMEs' outer R&D information network diversity can positively influence their

diversification into new business field. In this sense, Hau (2017c) empirically showed that SMEs' outer R&D collaboration network diversity positively impacted their diversification into new business field. Furthermore, diversification into new business field can provide more fertile soils for SMEs' revenues increase (Kim & Mauborgne, 2015; Siegemund, 2008). This can make SMEs' diversification into new business field positively influence their sales growth. Therefore, considering the positive impact of SMEs' outer R&D collaboration network on their diversification into it, the positive effect of diversification into new business field on their sales growth, and the positive impact of the outer R&D collaboration network on SMEs' sales growth, this study generates the hypothesis 1 as follows:

Hypothesis 1 : SMEs' diversification into new business field mediates the positive impact of their outer R&D collaboration network diversity on sales growth.

This research makes the following hypothesis 2 (H2), taking the positive influence of SMEs' outer R&D information network on their diversification into it, the positive impact of diversification into new business field on their sales growth, and the positive impact of the outer R&D information network on the sales growth into consideration:

Hypothesis 2 : SMEs' diversification into new business field mediates the positive impact of the outer R&D information network diversity on sales growth.

Outer R&D collaboration can provide not only useful knowledge but also learning for enterprises (Hau, 2016; Schilling, 2017). The cooperative learning in outer R&D collaboration network makes it possible for an individual enterprise within the network to fulfill more performances than it can make alone (Hau, 2016; Schilling, 2017). Therefore, this research generates hypothesis 3 as follows:

Hypothesis 3 : SMEs' outer R&D collaboration network diversity influences exerts a more positive impact on their sales growth than their outer R&D information network diversity exerts.

IV. Research Methodology

1. Data and Measurement

This research statistically analyzed the 2,200 data from the 2014 SMEs' Technology Statistics (2014 SMETS) for testing the three hypotheses. The 2014 SMETS is a survey in the organization-level about South Korean SMEs' technology R&D in 2013 and it was carried out in 2014 by the Korea Federation of Small and Medium Business (KBIZ) and the Small & Medium Business Administration. Table 1 presents the profile of data analyzed for this study in terms of the number of employees, the number of R&D workers, the amount of R&D investment, and type of enterprise with technology sector.

〈Table 1〉 Profile of data analyzed

Item	Min	Max	Mean	Standard Deviation
The number of employees	5	299	49.61	58.46
The number of R&D workers	1	197	6.61	10.525
The amount of R&D investment (South Korean Million Won)	1	268,17	585.59	1,096.21
Type of enterprise	Venture		Non-Venture	
	683		1,517	
Technology sector	IT		Non-IT	
	312		1,888	

2. Measurement

To measure the independent variables, this study measured the degrees of SMEs' outer R&D collaboration network diversity and their outer R&D collaboration information diversity by adapting Tsai (2009) and Watson (2007), respectively, for the contexts for SMEs' technology R&D in South Korea. In more details, this research measured the number of different types of outer R&D collaboration

partners with which an SME made cooperation. The different types of the outer R&D collaboration partners were sorted into six kinds: (1) other SME, (2) large companies, (3) private research institutes, (4) foreign companies and organizations, (5) national research institutes, and (6) universities. This research checked the number of different types of outer R&D information sources which an SME used for their technology R&D. The different types of the outer R&D information were divided into eight kinds: (1) buyers (2) suppliers (3) public research institutes (4) universities (5) private research institute or consulting companies (6) competitors in the same domain (7) domestic or global journals or books in the area of specialization, and (8) domestic or global seminars, conferences, and expositions.

This research measured the mediating variable and the dependent variable, SMEs' diversification into new business field and their sales growth based on Hau (2017c) and Hau (2017f). In more details, this study measured the degree of SMEs' diversification into new business field from technology R&D with 5 point scale ranging from the value of one (little degree including no degree) to the value of five (very high degree). This research gauged the degree of sales growth from technology R&D with 5 point scale ranging from the value of one (little degree including no degree) to the value of five (very high degree).

3. Analysis Method

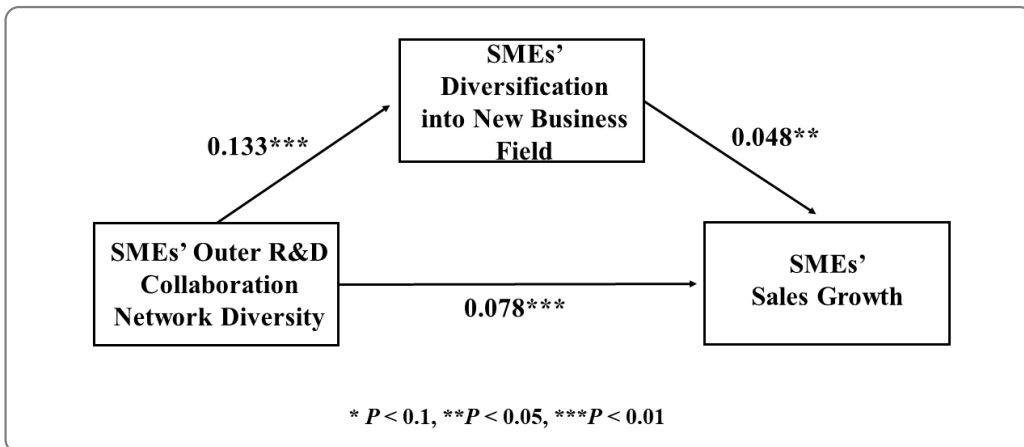
This research tested the three hypotheses through the ordinary least squares (OLS) regression by using IBM SPSS version 23. This study used the Baron and Kenny test (1986) to test the mediating impacts in the hypotheses. According the Baron and Kenny test (1986), the following four conditions must be satisfied: (1) the direct impact of the causal variable on the resultant variable without considering the impact of the mediator must be significant (mediating impact condition I), (2) the direct impact of the mediating variable, with considering the impact of the causal variable, must be significant on the resultant variable (mediating impact condition II), (3) the direct influence of the causal variable on the mediator must be significant, (mediating impact condition III) and (4) the direct effect of the causal variable in the mediating impact condition II must be

smaller than the direct effect of the independent variable in the mediating impact condition I, which proves to be a partial mediating effect or it must be insignificant, which proves to be a full mediating effect (mediating impact condition IV). These four mediating impact conditions were applied to testing the mediating effects in the hypotheses.

V. Hypothesis Testing Results

1. Hypothesis 1 Testing Results

[Figure 1] Hypothesis 1 Testing Result

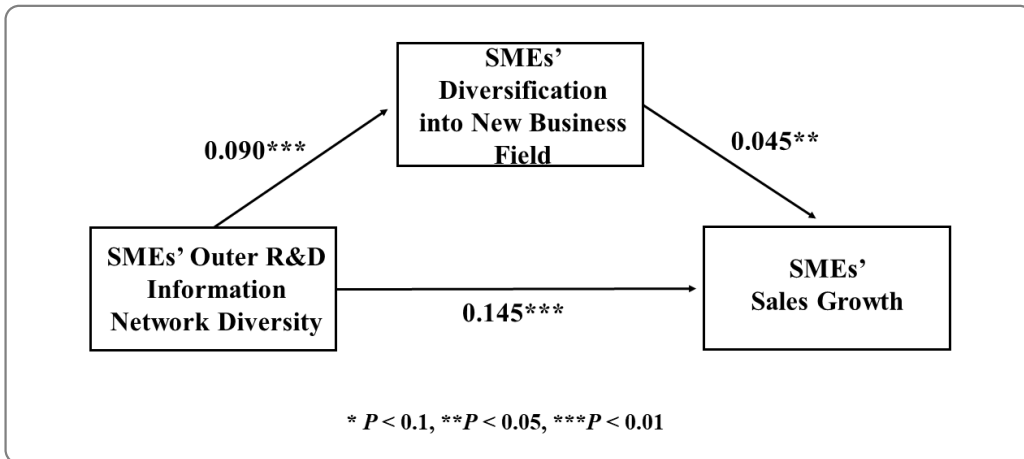


The analysis results in this study shows that the hypothesis 1 has been supported. The hypothesis 1 targets at the mediating role of SMEs' diversification into new business field in the relation between their outer R&D collaboration network diversity and sales growth. In the Baron and Kenny test (1986), the direct effect of SMEs' outer R&D collaboration network diversity on their sales growth was significant and positive in the mediating impact condition I (standardized regression coefficient = 0.084, t-value = 3.960) at the significant level of 0.1. In the mediating impact condition II, the direct effect of SMEs' outer R&D collaboration network diversity on their sales growth was significant and positive

(standardized regression coefficient = 0.078, t-value = 3.630) and the direct effect of SMEs' diversification into new business field on their sales growth was also significant and positive (standardized regression coefficient = 0.048, t-value = 2.245). In the mediating impact condition III, the direct effect of SMEs' outer R&D collaboration network diversity on their diversification into new business field was positive and significant (standardized regression coefficient = 0.133, t-value = 6.286). The significant direct effect of SMEs' outer R&D collaboration network diversity on their sales growth in the mediating impact condition I (standardized regression coefficient = 0.084, t-value = 3.960) was reduced to 0.078 (t-value = 3.630) in the mediating impact condition II. These analysis results have confirmed the significant mediating impact in the hypothesis 1. Figure 1 represents the hypothesis 1 testing results.

2. Hypothesis 2 Testing Results

[Figure 2] Hypothesis 2 Testing Result

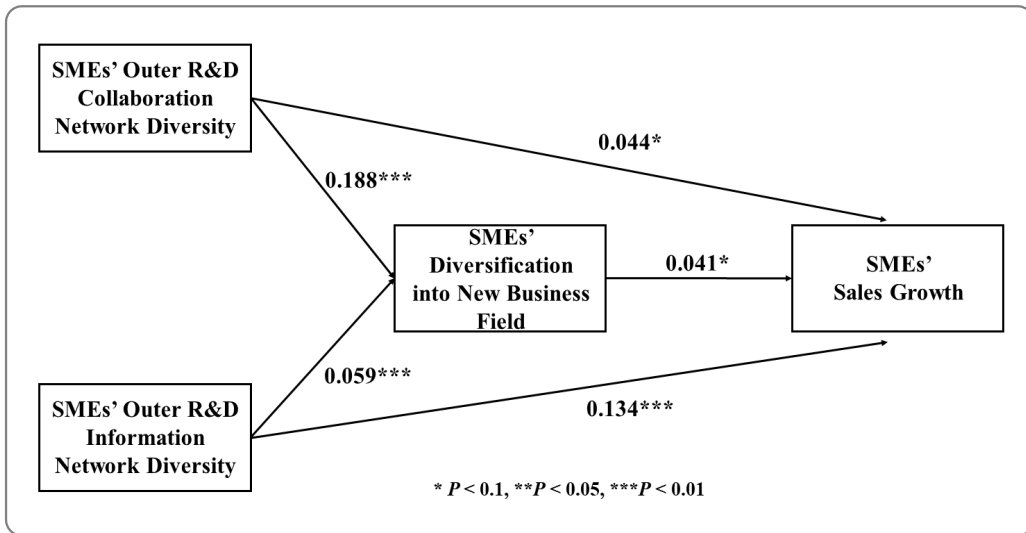


The analysis results for this research reveals that the hypothesis 2 has been supported. The hypothesis 2 deals with the mediating role of SMEs' diversification into new business field in the relation between their outer R&D information network diversity and sales growth. In the Baron and Kenny test (1986), the direct effect of SMEs' outer R&D information network diversity on their sales growth was

significant and positive in the mediating impact condition I (standardized regression coefficient = 0.149, t-value = 7.084) at the significant level of 0.1. In the mediating impact condition II, the direct effect of SMEs' outer R&D information network diversity on their sales growth was significant and positive (standardized regression coefficient = 0.145, t-value = 6.869) and the direct effect of SMEs' diversification into new business field on their sales growth was also significant and positive (standardized regression coefficient = 0.045, t-value = 2.147). In the mediating impact condition III, the direct effect of outer R&D information network diversity on their diversification into new business field was positive and significant (standardized regression coefficient = 0.090, t-value = 4.216). The significant direct effect of SMEs' outer information network diversity on their sales growth in the mediating impact condition I (standardized regression coefficient = 0.149, t-value = 7.084) was reduced to 0.145 (t-value = 6.860) in the mediating impact condition II. These analysis results have proved the significant mediating impact in the hypothesis 2. Figure 2 reports the hypothesis 2 testing results.

3. Hypothesis 3 Testing Results

[Figure 3] Hypothesis 3 Testing Result



The analysis results for this research indicates that the hypothesis 3 has not been supported. The hypothesis 3 aims at comparing the effect sizes of SMEs' outer R&D collaboration network and outer R&D information network on their sales growth, considering the mediating effect of their diversification into new business field. When considering the mediating impact of SMEs' diversification into it, the total effect (direct effect + indirect effect) of the outer R&D collaboration network diversity on the sales growth was 0.051 but the total effect (direct effect + indirect effect) of the outer R&D information network diversity on the sales was 0.142, confirming that the total effect of the outer R&D collaboration network diversity on the sales was smaller than the total effect of the outer R&D information network diversity on it. In addition, however, the impact of SMEs' outer R&D collaboration network diversity on their diversification into new business field (standardized regression coefficient = 0.118, t-value = 5.375) was larger than the effect of SMEs' outer R&D information network diversity on it (standardized regression coefficient = 0.059, t-value = 2.696). Figure 3 summarizes the hypothesis 3 testing result.

VI. Implication and Limitation

1. Summary of Major Findings

The analysis results shed a new light on the four points as follows. First, SMEs' diversification into new business field partially mediates the positive impact of their outer R&D collaboration network diversity on their sales growth (hypothesis 1 supported). Second, SMEs' diversification into new business field partially mediates the positive impact of their outer R&D information network diversity on their sales growth (hypothesis 2 supported). Third, SMEs' outer R&D information network diversity has a more positive effect on their sales growth than their R&D collaboration network diversity has. Fourth, SMEs' outer R&D collaboration network diversity has a more positive effect on their diversification into new business field than their outer R&D information network diversity has.

2. Implication

This research provides implications useful for SMEs' technology R&D management. First, SMEs' outer R&D collaboration network diversity positively influences on their diversification into new business field and sales growth. Second, SMEs' outer R&D information network diversity exerts a positive influence on their diversification into new business field and sales growth. Third, SMEs' outer R&D collaboration network diversity has a more positive effect on their diversification into new business field than their outer R&D information network diversity has. Fourth, SMEs' outer R&D information network diversity exerts a more positive effect on their sales growth than their R&D collaboration network diversity has.

3. Limitation

This study possess several limitations which needs to be overcome in the future research. First, the analysis results are based on only South Korean SMEs, which requires careful interpretation when they are applied to foreign SMEs. Second, it will be better for the future research to compare the effects of large enterprises' R&D collaboration network diversity and the R&D information network diversity with the effects of SMEs' R&D collaboration network diversity and the R&D information network diversity on the sales growth and diversification into new business field. Third, this research used a cross-sectional data but time series data can result in more insightful implications in the future research.

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외부 R&D 지식네트워크가 중소기업의 매출 증대에 미치는 효과: 새로운 사업 분야로의 다각화의 매개효과

허용석*

■ 요약

본 연구의 목적은 중소기업의 외부 R&D 지식 네트워크가 중소기업의 매출 증대 및 새로운 사업 분야로의 다각화에 미치는 효과를 실증적으로 분석하는 것이다. 외부 R&D 지식 네트워크는 기술 혁신을 통한 중소기업의 경쟁력을 증진 시키는 데에 매우 중요하다. 그러나, 유관 선행 연구들은 중소기업의 외부 R&D 지식네트워크와 매출 증대간의 관계에 미치는 새로운 분야로의 다각화의 매개효과에 대한 분석이 부족하다는 점과 외부 R&D 지식 네트워크를 구성하는 외부 R&D 협력 네트워크와 외부 R&D 정보 네트워크 중 어떤 것이 매출 증대에 더 많은 정(+)의 영향을 미치는지를 조명하지 못하고 있다는 면에서 한계점을 보여주고 있다. 따라서, 본 연구는 2,200개 한국 중소기업들에 대한 데이터를 분석하여 다음과 같은 주요 결과들을 제공한다. 첫째, 중소기업의 새로운 사업 분야로의 다각화는 중소기업의 외부 R&D 협력네트워크 다양성과 매출 증대간의 관계에서 부분 매개 역할을 한다. 둘째, 중소기업의 새로운 사업 분야로의 다각화는 중소기업의 외부 R&D 정보 네트워크의 다양성과 매출 증대간의 관계에서 부분 매개 역할을 한다. 셋째, 중소기업의 외부 R&D 정보 네트워크의 다양성은 중소기업의 매출 증대에 외부 R&D 협력 네트워크 다양성 보다 더 큰 정(+)의 영향을 미친다. 넷째, 중소기업의 외부 R&D 협력 네트워크의 다양성은 중소기업의 새로운 사업 분야로의 다각화에 외부 R&D 정보 네트워크의 다양성 보다 더 큰 정(+)의 영향을 미친다.

핵심 주제어 : 중소기업, 외부 R&D 지식 네트워크, 매출 증대, 다각화

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