

An empirical analysis of the influence of external knowledge network on SMEs' new technology development and technology commercialization capabilities in the perspective of open innovation

Yong Sauk Hau

School of Business, Yeungnam University

개방형 혁신의 관점에서 외부 지식네트워크가 중소기업의 신기술 개발 역량 및 기술 사업화 역량에 미치는 영향에 대한 실증분석

허용석

영남대학교 경영학과

Abstract In today's rapidly-changing business context with technology convergence among various fields, new technology development and technology commercialization capabilities are very important to the survival and growth of small and medium-sized enterprises (SMEs). This study develops the research model based on the open innovation perspective and empirically tests it by using 2,000 data from SMEs in South Korea. The empirical analysis result reveals that SMEs' external technology collaboration network and external information network diversities have positive effects on their technology commercialization capability, and these effects are fully mediated by their new technology development capability. Based on these results, the study provides meaningful implications especially in terms of SMEs' managers who pursue entrepreneurship.

Key Words : Technology Convergence, SME, External Knowledge Network, New Technology Development Capability, Technology Commercialization Capability, Entrepreneurship

요 약 다양한 분야 간 기술 융복합화와 함께 빠르게 변화하고 있는 오늘날의 사업 환경에서, 신기술 개발 및 기술 사업화 역량은 중소기업의 생존과 성장에 매우 중요하다. 본 연구는 한국의 중소기업으로부터 수집된 2,000개의 데이터를 사용하여 개방형 혁신의 관점을 기반으로 개발된 연구 모형을 실증적으로 검증한다. 본 연구의 실증 분석 결과는 중소기업의 외부 기술협력 네트워크와 외부 정보 네트워크의 다양성이 중소기업의 기술 사업화 역량에 정(+)의 영향을 미치며, 이러한 정(+)의 영향은 중소기업의 신기술 개발 역량에 의하여 완전 매개 된다는 것을 보여준다. 이러한 실증 분석 결과를 바탕으로, 본 연구는 특히 기업가정신을 추구하는 중소기업의 경영자들의 관점에서 의미 있는 시사점을 제공한다.

주제어 : 기술 융복합, 중소기업, 외부 지식네트워크, 신기술 개발 역량, 기술 사업화 역량, 기업가정신

This work was supported by the Business for University Entrepreneurship Center, funded by the Korea Small and Medium Business Administration in 2015.

Received 29 February 2016, Revised 5 April 2016

Accepted 20 May 2016, Published 28 May 2016

Corresponding Author: Yong Sauk Hau
(School of Business, Yeungnam University)

Email: augustine@yu.ac.kr

ISSN: 1738-1916

© The Society of Digital Policy & Management. All rights reserved. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

1. Introduction

New technology development and successful technology commercialization play very critical roles in making, keeping, and growing the competitive advantages of firms [1, 2, 8, 12]. But, in today's rapidly-changing business context with technology convergence among various fields, firms are facing a big difficulty in developing new technology and successfully commercializing it in their market [2]. Especially, small and medium-sized enterprises (SMEs) are confronted with a bigger difficulty in making technology innovation by lack of their inner capabilities and resources essential for technology development [3].

SMEs' roles in the economic growth in nations are so crucial [4] that there is much demand for more empirical studies about major antecedents to SMEs' new technology development and technology commercialization capabilities for their successful technology innovation. Therefore, this study aims at empirically examining the influence of such an important antecedent as SMEs' external knowledge network on their new technology development and technology commercialization capabilities. Especially, this study divides SMEs' external knowledge network into external technology collaboration network and external information network, and compares the size of their effects on the technology commercialization capability in order to provide fresh strategic implications in term of SMEs' managers pursuing entrepreneurship.

This research attempts to empirically answer the following three research questions about the effect of SMEs' external knowledge network on their new technology development and technology commercialization capabilities:

- (i) What effect does SMEs' external technology collaboration network have on their new technology development and technology commercialization

capabilities?

- (ii) What effect does SMEs' external information network have on their new technology development and technology commercialization capabilities?
- (iii) Which SMEs' external knowledge network, external technology collaboration network or external information network, has more effect on their new technology development and technology commercialization capabilities?

This research builds the research model based on the open innovation perspective [5, 6] and uses such a large sample size as 2,000 data from the SMEs in South Korea in order to provide more reliable empirical analysis results.

2. Theoretical Background and Research Model

In accordance with the three research questions, this study constructs the following three research models in the perspective of open innovation.

2.1 The Mediating Model I

The open innovation perspective emphasizes the importance of firms' external knowledge network to their successful technology innovation [5, 6]. It points out that firms which strategically use not only internal knowledge network but also external knowledge network can be more fruitful in their technology innovation [5, 6, 7]. Through open innovation, firms without sufficient internal capabilities and resources like SMEs can obtain external knowledge and experience essential for their technology innovation by collaborating with various external technology cooperation partners [5, 6, 7]. Technology commercialization capability indicates a firm's ability to imbibe a new technology, make it readapted to the firm's production and marketing activities, and win competitive advantages

over rivals through cost or quality leadership and the imbibition of new technologies [8, 9]. The more diverse external technology cooperation partners a firm collaborates with, the more useful knowledge for technology innovation the firm can get [5, 6, 7]. And Firms' external technology collaboration network diversity has a positive effect on their innovation performance such as more novel product innovation [10]. Therefore, this study hypothesizes the following hypothesis 1.

H1: SMEs' external technology collaboration network diversity has a positive influence on their technology commercialization capability.

According to the open innovation perspective [5, 6, 7], for more successful technology innovation, it is effective for SMEs without adequate internal capabilities and resources to collaborate with various external technology cooperation partners, which can suggest the positive impact of the external technology collaboration network diversity on SMEs' new technology development capability. Furthermore, SMEs' R&D capability has a positive effect on their technology commercialization capability [11]. Therefore, this research proposes the mediating effect of the new technology development capability in the following hypothesis 2.

H2: SMEs' new technology development capability mediates the positive influence of the external technology collaboration network diversity on the technology commercialization capability.

2.2 The Mediating Model II

Technology commercialization capability enables a firm to efficiently and effectively use its technological knowledge such as patents and know-how, and quickly launch many new promising products into the market [8, 13]. The open innovation perspective puts an

emphasis on firms' strategic use of various external information sources for successful product innovation [5, 6, 7]. Therefore, this study hypothesizes the positive impact of SMEs' external information network diversity on their technology commercialization capability in the following hypothesis 3.

H3: SMEs' external information network diversity has a positive influence on their technology commercialization capability.

The open innovation perspective places an emphasis on that a firm using more various external information sources can make more successful technology development [5, 6, 7]. Moreover, SMEs' technology commercialization capability is positively and significantly influenced by their R&D capability [11]. Accordingly, this research proposes the mediating impact of SMEs' new technology development capability in the following hypothesis 4.

H4: SMEs' new technology development capability mediates the positive influence of the external information network diversity on the technology commercialization capability.

2.3 The Effect Size Comparing Model

External technology collaboration network makes its participating firms share not only various information but also complementary resources useful to their technology innovation [2]. The collaborative efforts in the external technology collaboration network enables its participating firms to accomplish much more than their individual effort can accomplish [2], which can make SMEs' external technology collaboration network diversity has a more positive influence on SMEs' technology commercialization capability than their external information network diversity. This generates the hypothesis 5 as follows.

H5: SMEs' technology collaboration network diversity has a more positive influence on the technology commercialization capability than their external information network diversity.

3. Research Methodology

3.1 Data and Measurement

This research analyzed the 2,000 data in the 2013 SMEs' Technology Statistics (2013 SMETS) to empirically test the mediating model I and II including the effect size comparing model. The 2013 SMETS is a national statistical survey jointly performed in 2013 by the Korea Federation of Small and Medium Business (KBIZ) and the Small & Medium Business Administration.

SMEs' technology collaboration network diversity was measured by extending and adapting Tsai (2009)[14]'s collaborative network measurement to the research context of this research. A SME may make the technology collaboration with diverse external partners such as (1) universities, (2) public or national research institutes, (3) private research institutes, (4) large firms, (5) other SMEs, (6) foreign firms and organizations. If a SME made the technology collaboration with all of these six types of partners from 2011 to 2012, then, its external technology collaboration network diversity took the value of six. But, it was zero if a SME did not make the technology collaboration with any of them.

This study used the measurement adapted and extended from Watson (2007)[15] to measure SMEs' external information network diversity. The types of the external information sources of SMEs' technology development may be (1) customers (2) suppliers (3) universities (4) public research institutes (5) consulting companies or private research institutes (6) rivals in the same field (7) global or domestic books or journals in their area of specialization (8) global or domestic

conferences, seminars, and expositions. In the similar way to the measurement of SMEs' external technology collaboration network diversity, the types of the external information sources from which a SME got the technology development-related information or idea were gauged. For example, if a SME got the information or idea from only one of the eight types of the external information sources from 2011 to 2012, its external information network diversity took the value of one.

SMEs' new technology development and technology commercialization capabilities were measured by comparing them to the world-best levels whose values were 100% as of the June in 2013.

The <Table 1> sums up the features of the analyzed data related to the variables in the research model in terms of their average, standard deviation, maximum and minimum values.

<Table 1> The profile of the analyzed data

Variable	Max	Min	Average	Standard Deviation
External Technology Collaboration Network Diversity	6	0	0.520	0.880
External Information Network Diversity	8	0	2.050	1.509
New Technology Development Capability	100	0	72.180	21.439
Technology Commercialization Capability	100	0	71.020	23.764

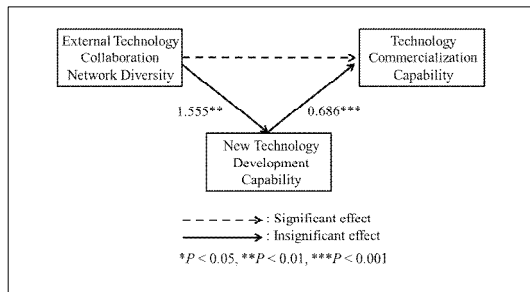
3.2 Empirical Analysis Method

This research tested the mediating model I and II with the ordinary least squares regression analysis by using IBM SPSS version 22 and the effect size comparing model with the path analysis by using partial least squares (PLS) graph version 3.

4. Empirical Analysis Results

4.1 The Mediating Model I Test Results

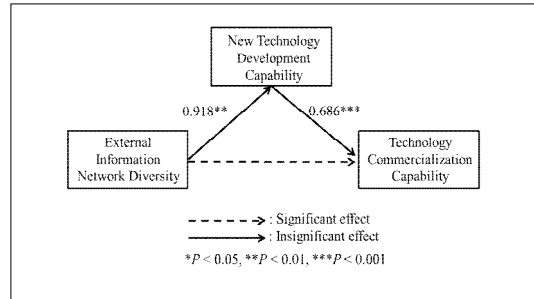
The ordinary least squares regression analysis results by using IBM SPSS version 22 show that SMEs' external technology collaboration network diversity has a positive influence on their technology commercialization capability ($\beta = 1.762$, t -value = 2.923) at the significant level of 0.05. But, this positive and significant influence has become insignificant ($\beta = 0.695$, t -value = 1.465) when SMEs' new technology development capability mediates it as seen in the [Fig. 1], confirming the full mediating effect of the new technology development capability [16]. The z -value resulting from the Sobel test [17] is 2.849, confirming the significant mediating effect of the new technology development capability in the mediating model I.



[Fig. 1] The mediating model I test results

4.2 The Mediating Model II Test Results

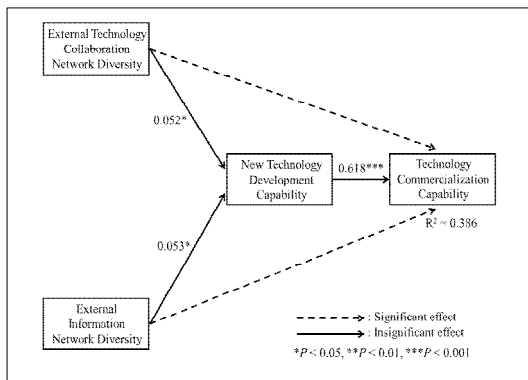
SMEs' external information network diversity has a positive effect on their technology commercialization capability ($\beta = 1.040$, t -value = 2.959). This significant and positive effect has become insignificant ($\beta = 0.410$, t -value = 1.482) when mediated by the new technology development capability, showing the full mediating effect of the new technology development capability [16]. The z -value calculated by the Sobel test [17] is 2.886, and confirms the significant mediating role of the new technology development capability in the mediating model II as seen in the [Fig. 2]



[Fig. 2] The mediating model II test results

4.3 The Effect Size Comparing Model Test Results

The path analysis results by using PLS graph version 3 show that the influence of SMEs' external information network diversity on their new technology development capability is more than the influence of SMEs' external technology collaboration network diversity but the difference in the effect size is minimal (the difference = 0.001). SMEs' external technology collaboration network diversity has a positive influence on their new technology development capability (path coefficient = 0.052, t -value = 2.499) and the external information network diversity has a positive impact on it (path coefficient = 0.053, t -value = 2.380). The results empirically confirm that the new technology development capability have a positive effect on SMEs' technology commercialization capability (path coefficient = 0.618, t -value = 23.809) and the 38.6% of the total variance of it is explained by this effect size comparing model ($R^2 = 0.386$). The total effects of the SMEs' external technology collaboration network diversity and external information network diversity on their technology commercialization capability are 0.0321 and 0.0327, respectively. Therefore, the effect of the external information network diversity is more than the effect of the external technology collaboration network diversity but the difference in the effect size is minimal (the difference = 0.0006).



[Fig. 3] The effect size comparing model test results

5. Implications and Limitations

5.1 Implications

Recently various studies have paid special attention to SMEs' technology commercialization [19, 20, 24], external information network [21], technology development [22, 25], and technology innovation [23] but they can provide few implications about the effects of SMEs' external technology collaboration network and external information network on their new technology development and technology commercialization capabilities.

By analyzing the 2,000 data of SMEs in South Korea, this study provides the three meaningful analysis results which can deepen the understanding about the effect of SMEs' external knowledge network such as external technology collaboration network and external information network on their new technology development and technology commercialization capabilities as follows: (i) SMEs' external technology collaboration network diversity has a positive influence on their technology commercialization capability and this influence is fully mediated by their new technology development capability (ii) SMEs' external information network diversity has a positive impact on their technology commercialization capability and this impact is perfectly mediated by their new technology

development capability (iii) SMEs' external information network diversity has a more positive effect on both new technology development and technology commercialization capabilities than their external technology collaboration network diversity but the differences in the effect sizes of these two external network diversities on the new technology development and technology commercialization capabilities are minimal.

The open innovation perspective is highly associated with entrepreneurship because one of the theoretical pillars of open innovation depends on entrepreneurship theories [18]. Therefore, the analysis results from this study can be translated into two meaningful implications in terms of SMEs' managers who pursue entrepreneurship as follows. First, with regard to effectively reinforcing SMEs' new technology development and technology commercialization capabilities through the entrepreneurship in SMEs, this study provides the meaningful implication that SMEs' managers pursuing entrepreneurship should strategically make more diverse external technology collaborations and use more various external information sources. Second, empirically revealing the minimal differences in the effect sizes of the external technology collaboration network and external information network, this study suggests that SMEs' managers pursuing entrepreneurship should make a strategic use of both external technology collaboration network and external information network to develop their new technology development and technology commercialization capabilities.

5.2 Limitations

This research is limited in the following three ways. First, the large sample size of this research is effective in increasing the generalizability of the empirical analysis results but all of the 2,000 samples were collected only from the SMEs in South Korea. Second, this study focuses on the external technology collaboration network diversity and external information network diversity as the major antecedents to SMEs' new

technology development capability and technology commercialization capability but it will be better for future research to empirically analyze more various antecedents in its research model. Third, this research is a cross-sectional study. Therefore, it can not cover the dynamic influence of SMEs' external knowledge network over time.

ACKNOWLEDGMENTS

This work was supported by the Business for University Entrepreneurship Center, funded by the Korea Small and Medium Business Administration in 2015.

REFERENCES

- [1] S. A. Shane "Technology Strategy for Managers and Entrepreneurs: Pearson", 2014.
- [2] M. A. Schilling "Strategic Management of Technological Innovation: McGraw-Hill", 2013.
- [3] H. Kim and Y. Park, The effects of open innovation activity on performance of SMEs: the case of Korea, *International Journal of Technology Management*, Vol. 52, No. 3/4, pp. 236-256, 2010.
- [4] R. K. Singh, S. K. Garg, and S. G. Deshmukh, Strategy development by SMEs for competitiveness: a review, *Benchmarking: An International Journal*, Vol. 15, No. 5, pp. 525-547, 2008.
- [5] H. W. Chesbrough, The era of open innovation, *MIT Sloan Management Review*, Vol. 44, No. 3, pp. 35-41, 2003.
- [6] H. W. Chesbrough "Open Innovation - The New Imperative for Creating and Profiting from Technology. Boston: Harvard Business School Press", 2006.
- [7] L. Huston and N. Sakkab, Connect and Develop: Inside Procter & Gamble's New Model for Innovation, *Harvard Business Review*, Vol. 84, No. 3, pp. 58-66, 2006.
- [8] V. K. Jolly "Commercializing new technologies: Getting from mind to market. Cambridge: Harvard Business School Press", 1997.
- [9] T. M. Nevens, G. L. Summe, and B. Uttal, Commercializing technology: What the Best Companies Do., *Harvard Business Review*, Vol. 68, No. 3, pp. 154-163, 1990.
- [10] M. J. Nieto, and L. Santamaría, The importance of diverse collaborative networks for the novelty of product innovation, *Technovation*, Vol. 27, No. 6-7, pp. 367-377, 2007.
- [11] T. Park and D. Ryu, Drivers of technology commercialization and performance in SMEs: The moderating effect of environmental dynamism, *Management Decision*, Vol. 53, No. 2, pp. 338-353, 2015.
- [12] P. Trott "Innovation Management and New Product Development: Prentice Hall", 2012.
- [13] T. Park and J. Rhee, Network types and performance in SMEs: the mediating effects of technology commercialization, *Asian Journal of Technology Innovation*, Vol. 21, No. 2, pp. 290-304, 2013.
- [14] K. Tsai, Collaborative networks and product innovation performance: Toward a contingency perspective, *Research Policy*, Vol. 38, No. 5, pp. 765-778, 2009.
- [15] J. Watson, Modeling the relationship between networking and firm performance, *Journal of Business Venturing*, Vol. 22, No. 6, pp. 852-874, 2007.
- [16] R. M. Baron, and D. A. Kenny, The Moderator-Mediator Variable Distinction in Social Psychological Research : Conceptual, Strategic, and Statistical Considerations, *Journal of Personality and Social Psychology*, Vol. 51, No. 6, pp. 1173-1182, 1986.
- [17] M. E. Sobel, Asymptotic confidence intervals for indirect effects in structural equations models, *Sociological methodology*, Vol. 13, pp. 290-312, 1982.
- [18] P. Wynarczyk, P. Piperopoulos and M. McAdam, Open innovation in small and medium-sized enterprises: An overview, *International Small Business Journal*, Vol. 31, No. 3, pp. 240-255, 2013.
- [19] M.-Y. Kang and I.-O. J, Effect of Small and

Medium-sized Enterprises' Technological Competitiveness and Technology Marketing on Commercialization Performance, Journal of Digital Convergence, Vol. 11, No. 12, pp. 213-227, 2013.

- [20] D.-K. Yoon, D.-W. Yang, An empirical study on a cause of the gap between technological success rate and commercialization success rate on the government-funded R&D projects of SMEs, Journal of Digital Convergence, Vol. 11, No. 8, pp. 127-141, 2013.
- [21] Y. S. Hau, External Information Network Diversity and Production Management Capability in IT SMEs in the Age of Digital Convergence : The Mediating Effect of Manufacturing Capability, Journal of Digital Convergence, Vol. 13, No. 9, p. 99-104, 2015.
- [22] S.-W. Choi, J.-T. Jung, and Y.-Y. You, The Effect of Government R&D Subsidies Program Participation Factor for SMEs R&D Performances, Journal of Digital Convergence, Vol. 12, No. 5, pp. 171-180, 2014.
- [23] H.-C. Kim and S.-K. Lee, An Empirical Study on the Critical Success Factor of Technological Innovation of Small-Medium Sized enterprises by growth stages - Focusing on the Case Study, Journal of Digital Convergence, Vol. 12, No. 10, pp. 1-20, 2014.
- [24] Y.-S. Shin and K.-S. Ha, A Study on the Effects of the Technology Management Capability on the Success of Technology Commercialization, Journal of Digital Convergence, Vol. 10, No. 8, pp. 97-110, 2012.
- [25] M.-G. Huh, Characteristics and Technology Development Mode of Local Hidden Champions in Korea : How are they different?, Journal of Digital Convergence, Vol. 13, Issue 8, pp. 221-233, 2015.

허 용 석(Hau, Yong Sauk)



- 1999년 2월 : 성균관대학교 경영학과(경영학사)
- 2001년 8월 : 서울대학교 경영대학(경영학석사)
- 2010년 8월 : KAIST 경영대학(경영공학박사)
- 2013년 3월 ~ 현재 : 영남대학교 경영학과 조교수

- 관심분야 : 기술경영, 지식경영
- E-Mail : augustine@yu.ac.kr