

The Mediating Effects of the Manufacturing Capability and the Testing and Inspection Capability on the Relation between Small and Medium Venture Firms' External Information Network Heterogeneity and Technology Commercialization Capability

Yong Sauk Hau

School of Business, Yeungnam University

제조 역량과 시험 및 검사 역량이 중소벤처기업의 외부 정보 네트워크의 다양성과 기술 사업화 역량 사이의 관계에 미치는 매개 효과

허용석

영남대학교 경영대학

Abstract This study has attempted to empirically analyze the mediating effects of small and medium venture firms' manufacturing capability and testing and inspection capability on the relation between their external information network heterogeneity and technology commercialization capability with a view to diversifying the research stream on the influential factors to small and medium firms' technology commercialization capability. By performing the ordinary least squares regression analysis, the Sobel test, and the Baron and Kenny test based on the 683 data of South Korean small and medium venture firms with the IBM SPSS version 23, this study provides the three empirical findings to be useful for future studies on the roles of small and medium venture firms' the manufacturing capability and testing and inspection capability. First, small and medium venture firms' manufacturing capability partially mediates the positive effect of their external information network heterogeneity on their technology commercialization capability. Second, their testing and inspection capability partially mediates this positive effect. Third, their manufacturing capability and testing and inspection capability jointly and partially mediates this positive effect.

Key Words : Small and Medium Venture Firm, External Information Network Heterogeneity, Technology Commercialization Capability, Testing and Inspection Capability, Manufacturing Capability, Technology Convergence

요 약 본 연구는 중소기업의 기술 사업화 역량에 영향을 미치는 요인들에 대한 연구의 흐름을 다양화하기 위해 중소벤처기업의 제조 역량과 시험 및 검사 역량이 외부 정보 네트워크의 다양성과 기술 사업화 역량 사이의 관계에 미치는 매개 효과를 실증 분석하였다. IBM SPSS 23을 사용하여 한국의 683개 중소벤처기업에 대해 실시한 최소자승 회귀분석, Sobel 검정과 Baron 및 Kenny 검정 결과를 통해 본 연구는 중소기업의 제조 역량과 시험 및 검사 역량의 역할에 대한 후속 연구에 유용한 세 가지 실증 분석 결과를 제공한다. 첫째, 중소벤처기업의 제조 역량은 중소벤처기업의 외부 정보 네트워크의 다양성이 기술 사업화 역량에 미치는 양(+)의 효과를 부분 매개하는 것으로 분석되었다. 둘째, 중소벤처기업의 시험 및 검사 역량은 이러한 양(+)의 효과를 부분 매개하는 것으로 밝혀졌다. 셋째, 중소기업의 제조 역량과 시험 및 검사 역량은 이러한 양(+)의 효과를 공동으로 부분 매개하는 것으로 분석되었다.

주제어 : 중소벤처기업, 외부 정보 네트워크의 다양성, 기술 사업화 역량, 시험 및 검사 역량, 제조 역량, 기술 융합

Received 1 September 2017, Revised 29 September 2017
Accepted 20 October 2017, Published 28 October 2017
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

In the era of technology convergence like today, technology commercialization capability is of great importance to firms' growth from technology R&D because, without this capability, they can not link their results from technology R&D to the economic value which they target at [1, 2, 3]. Accordingly, recent studies put the focus on the influential factors to the commercialization capability of small and medium firms. For example, Hau (2016)[3] empirically shows that both external information network heterogeneity and external technology collaboration network heterogeneity positively influence small and medium firms' technology commercialization capability and these positive influences are mediated by their new technology development capability. Hau(2016)[4] reveals that small and medium firms' process design capability positively impacts their technology commercialization capability and this positive impact is moderated by their testing and inspection capability. Futhermore, Hau(2017)[2] indicates that small and medium firms' testing and inspection capability and product interior design capability jointly links the impact of their external technology collaboration network heterogeneity to the technology commercialization capability.

The recent studies illuminate several influential factors to small and medium firms' technology commercialization capability but they appear to have two shortages. One shortage is that they have hardly examined the mediating roles of small and medium venture firms' manufacturing capability and testing and inspection capability between small and medium firms' external information network heterogeneity and their technology commercialization capability. The other shortage is that they can barely provide any useful implications about the influential factors to small and medium venture firms' technology commercialization capability because their empirical analyses were

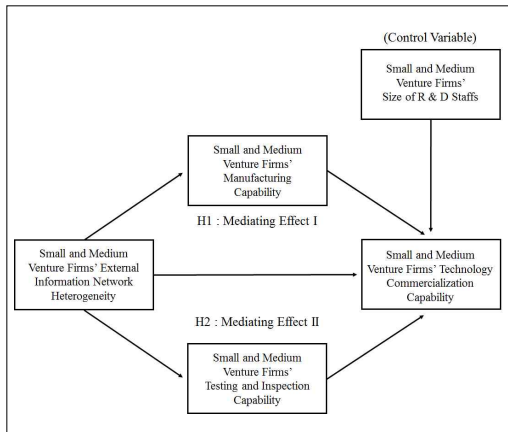
performed based on the data only from small and medium firms. Therefore, so as to overcome the two shortages of the recent studies, this study concentrates especially on the mediating effects of small and medium venture firms' manufacturing capability and testing and inspection capability on the relation between their external information network heterogeneity and technology commercialization capability. And this study empirically tests the mediating effects of them by using the 683 data of the small and medium venture firms in the Republic of Korea with a view to diversifying the research stream on the influential factors to small and medium firms' technology commercialization capability. This study attempt to illuminate the mediating effects of small and medium venture firms' manufacturing capability and testing and inspection capability on the relation between their external information network heterogeneity and technology commercialization capability. Therefore, this study raises the research questions about the mediating impacts of small and medium venture firms' manufacturing capability and testing and inspection capability as follows:

- (i) What is the influence of small and medium venture firms' manufacturing capability on the relation between their external information network heterogeneity and technology commercialization capability?
- (ii) What is the impact of small and medium venture firms' testing and inspection capability on the relation between their external information network heterogeneity and technology commercialization capability?

2. Theory and Research Model

This research builds the research model made up of the two hypotheses about the mediating effects of small

and medium venture firms' manufacturing capability and testing and inspection capability on the relation between their external information network heterogeneity and technology commercialization capability as indicated in the [Fig. 1].



[Fig. 1] Research Model

The hypothesis 1 treats the mediating impact of small and medium venture firms' manufacturing capability in the research model. Various information and knowledge are essential to developing the resources and capabilities of enterprises [5, 6, 7]. Hau(2016) [3] has empirically shown that small and medium firms' external information network heterogeneity positively influences their technology commercialization capability, which is perfectly mediated by their new technology development capability [3]. Using diverse external information and knowledge sources is one of effective ways of developing firms' resources and capabilities [5, 8, 9] and manufacturing capability is one of the crucial capabilities of firms [6, 10, 11, 12], which can make small and medium venture firms' manufacturing capability positively influenced by their external information network heterogeneity. In this sense, Hau(2015) [13] has empirically shown that the external information network heterogeneity of small and

medium firms in the information technology (IT) sector positively impacts their manufacturing capability. Successful technology commercialization requires the good quality of products or service which embodies technologies [1]. Firms' manufacturing capability can contribute to increasing the quality of the technologies realized into products or services [1, 6, 10, 11, 12], which can make small and medium venture firms' manufacturing capability positively impact their technology commercialization capability. Therefore, considering the positive effect of small and medium venture firms' external information network heterogeneity on their manufacturing capability that positively impacts the technology commercialization capability, this research develops the hypothesis 1 as follows:

H1 : Small and medium venture firms' manufacturing capability mediates the effect of small and medium venture firms' external information network heterogeneity on their technology commercialization capability.

The hypothesis 2 covers the mediating effect of small and medium venture firms' testing and inspection capability in the research model. According to Hau(2016) [3], small and medium firms' external information network heterogeneity positively influences their technology commercialization capability. Firms' testing and inspection capability are based on various and information and knowledge from science and engineering, and statistics [6, 10, 12, 13], which can be beyond their internal knowledge network [6, 8, 9]. Using diverse external information is an effective way of supplying the lack of the information and knowledge that can not be covered by firms' internal knowledge [3, 6, 8, 9], which can make the external information network heterogeneity positively impact small and medium venture firms' testing and inspection capability. Moreover, small and medium firms' testing and inspection capability has been found out to

positively influence their technology commercialization capability by Hau(2017)[2]. Therefore, this study hypothesizes the mediating impact of the testing and inspection capability in the following hypothesis 2 reflecting the positive impact of small and medium venture firms' external information network heterogeneity on their testing and inspection capability which positively influences the technology commercialization capability;

H2 : Small and medium venture firms' testing and inspection capability mediates the effect of small and medium venture firms' external information network heterogeneity on their technology commercialization capability.

3. Research Methodology

This study analyzed the 683 data of the South Korean small and medium venture firms in the 2014 Small and Medium-Sized Enterprises' Technology Statistics (2014 SMETS) to test the hypotheses in this research. The 2014 SMETS was a survey of small and medium firms' technology R&D and was conducted by the Korea Federation of Small and Medium Business (KBIZ) and the Small & Medium Business Administration in 2014. The <Table 1> summarizes the features of the 683 data analyzed for this study in regard to the number of employees, the size of R&D staffs, and the amount of R&D investment in 2013.

<Table 1> The features of the data in this research

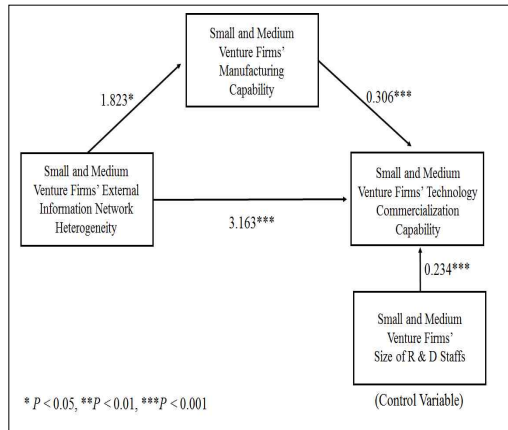
Variable	Mean	Standard Deviation	Max	Min
The Number of Employees	40.26	50.01	209	5
The Size of R & D Staffs	8.10	13.88	197	1
The Amount of R & D Investment (South Korean Million Won in 2013)	709.88	1,436.08	26,817	5

To measure the causal variable, small and medium firms' external information network heterogeneity, this study used the adapted Watson (2007)[14]'s measurement for the conditions of South Korean small and medium firms' technology R&D. More specifically, this study gauged th how many different kinds of the exterior information sources were used to develop technology by each small and medium venture firm in 2013. The kinds of the external information sources were categorized into such eight types as (1) suppliers, (2) customers (3) universities, (4) rivals in the same business area, (5) international or domestic special books or journals, (6) international or domestic expositions, conferences, seminars, (7) national or private research organizations, and (8) private service organizations such as consulting firms or private research institutes. To measure the two mediating variables, small and medium venture firms' manufacturing capability and testing and inspection capability, and the resultant variable, small and medium venture firms' technology commercialization capability, a 100 % point scale was used. For instance, the value of 100 for the manufacturing capability of a small and medium venture firm in this scale meant that its manufacturing capability was the highest level in the world but the value of 10 for one small and medium venture firms' technology commercialization capability in this scale meant that there was the difference of 90 between the level of the small and medium venture firm's technology commercialization capability and the highest level of technology commercialization in the world. To measure the control variable, the size of R&D staffs, this study gauged the number of R&D workers for each small and medium venture firm in 2013.

The ordinary least squares (OLS) regression was carried out to test the research mode with IBM SPSS version 23. The Sobel test [15] and the Baron and Kenny test [16] were performed to look into the significance of the respective mediating effect of the two mediators in the research model.

4. Analysis Results

4.1 Mediating Effect I Testing Results



[Fig. 2] Mediating Effect I Testing Results

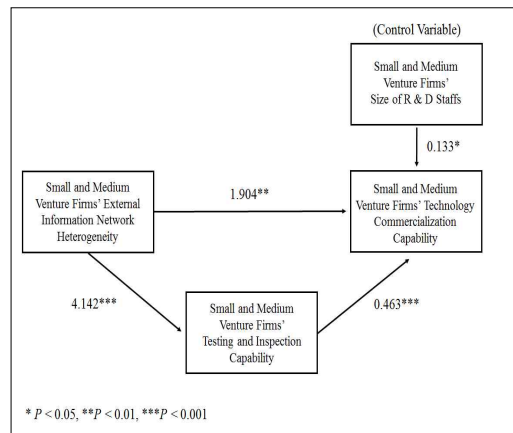
The mediating effect I testing results from this study have proven that small and medium venture firms' manufacturing capability significantly mediates the relationship between their external information network heterogeneity and technology commercialization capability, supporting the hypothesis 1 as illustrated in the [Fig. 2]. The Sobel test [15] has resulted in the z-value of 2.210, confirming the significant mediating role of small and medium venture firms' manufacturing capability.

The Baron and Kenny test [16] has indicated that small and medium venture firms' manufacturing capability is a partial mediator. The OLS regression analysis results have shown that small and medium venture firms' external information network heterogeneity positively influences their technology commercialization capability ($\beta = 3.808$, t-value = 5.301, p-value = 0.000). But the results indicate that this impact of the small and medium venture firms' external information network heterogeneity has been reduced by 16.9% ($\beta = 3.163$, t-value = 4.655, p-value = 0.000) after the impact of it is mediated by the manufacturing capability, which confirms that the manufacturing

capability is a significant and partial mediator [16].

The OLS regression analysis results reveal that small and medium venture firms' external information network heterogeneity positively influences their manufacturing capability ($\beta = 1.823$, t-value = 2.277, p-value = 0.023) and technology commercialization capability ($\beta = 3.163$, t-value = 4.655, p-value = 0.000) at the significant level of 5%. And, they show that the manufacturing capability positively impacts the technology commercialization capability ($\beta = 0.306$, t-value = 9.427, p-value = 0.000).

4.1 Mediating Effect II Testing Results



[Fig. 3] Mediating Effect II Testing Results

Small and medium venture firms' testing and inspection capability has turned out to be a significant mediator between their external information network heterogeneity and technology commercialization capability by the mediating effect II testing results from this study, supporting the hypothesis 2. The z-value produced by the Sobel test [15] is 4.930, which has empirically confirmed the significant mediating effect of the testing and inspection capability [15]. The Baron and Kenny test [16] has indicated that the testing inspection capability is a significant and partial mediator. The positive impact of the external

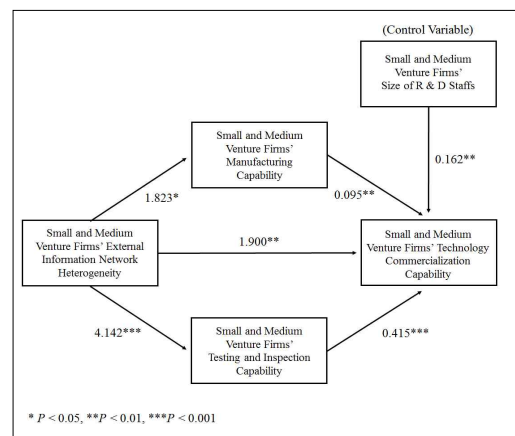
information network heterogeneity on the technology commercialization capability ($\beta = 3.808$, $t\text{-value} = 5.301$, $p\text{-value} = 0.000$) has been reduced by 50% ($\beta = 1.904$, $t\text{-value} = 3.037$, $p\text{-value} = 0.002$) after the testing and inspection capability mediates this effect of the external information network heterogeneity, which confirms the testing and inspection capability is a partial mediator [16].

The mediating effect II testing results show that small and medium venture firms' external information network heterogeneity positively impacts their testing and inspection capability ($\beta = 4.142$, $t\text{-value} = 5.183$, $p\text{-value} = 0.000$) and technology commercialization capability ($\beta = 1.904$, $t\text{-value} = 3.037$, $p\text{-value} = 0.002$). They reveal that the testing and inspection capability positively influences their technology commercialization capability ($\beta = 0.463$, $t\text{-value} = 15.756$, $p\text{-value} = 0.000$). The [Fig. 3] reports the mediating effect II testing results.

4.3 Joint Mediating Effect Testing Results

This study has tested the joint mediating role of the manufacturing capability and the testing and inspection capability in the addition to checking their respective mediating impact by applying the Baron and Kenny test [16]. The impact of the external information network heterogeneity on the technology commercialization capability ($\beta = 3.808$, $t\text{-value} = 5.301$, $p\text{-value} = 0.000$) has been reduced by 50.1% ($\beta = 1.900$, $t\text{-value} = 3.046$, $p\text{-value} = 0.002$) after the manufacturing capability and the testing and inspection capability jointly mediate this positive effect of the external information network heterogeneity, which confirms the significance of the joint and partial mediating impact of the manufacturing capability and the testing and inspection capability [16] as seen in the [Fig. 4]. The joint mediating effect testing results empirically show that small and medium venture firms's external information network heterogeneity positively influences their manufacturing capability (β

$= 1.823$, $t\text{-value} = 2.277$, $p\text{-value} = 0.023$), technology commercialization capability ($\beta = 1.900$, $t\text{-value} = 3.046$, $p\text{-value} = 0.002$), and testing and inspection capability ($\beta = 4.142$, $t\text{-value} = 5.183$, $p\text{-value} = 0.000$). And they empirically reveal that the technology commercialization capability is significantly and positively influenced by their manufacturing capability ($\beta = 0.095$, $t\text{-value} = 2.800$, $p\text{-value} = 0.005$) and testing and inspection capability ($\beta = 0.415$, $t\text{-value} = 12.255$, $p\text{-value} = 0.000$).



[Fig. 4] Joint Mediating Impact Testing Results

5. Conclusion

5.1 Implication

This study has attempted to empirically test the mediating effects of small and medium venture firms' manufacturing capability and testing and inspection capability on the relation between their external information network heterogeneity and technology commercialization capability by using the 683 data of the small and medium venture firms in the Republic of Korea with a view to diversifying the research stream on the influential factors to small and medium firms' technology commercialization capability.

This study provides the three empirical findings and implications based on them, contributing to widening

the recent research stream on small and medium firms including Hau(2016)[3], Hau(2015)[13], Hau(2017)[17], Hau(2017)[18], Sohn, Lee, and Kim(2017)[19], Kim and Hwang(2016)[20], Hau(2015)[21], and Lee and Kim(2016)[22]. First, small and medium venture firms' manufacturing capability partially mediates the positive effect of their external information network heterogeneity on their technology commercialization capability. This finding means that small and medium venture firms' using more diverse external information sources is a useful way of increasing not only their manufacturing capability but also their technology commercialization capability. Second, small and medium venture firms' testing and inspection capability partially mediates the effect of the external information network heterogeneity on their technology commercialization capability. This finding suggests that small and medium venture firms use more diverse external information sources so as to increase their technology commercialization capability as well as testing and inspection capability. Third, small and medium venture firms' manufacturing capability and testing and inspection capability jointly and partially mediate the positive effect of their external information network heterogeneity on the technology commercialization capability. This finding reveals that it is effective increasing small and medium venture firms' external information network heterogeneity in growing their testing and inspection capability, manufacturing capability, and technology commercialization capability.

The three implications from this research can make the following two contributions, emphasizing the significant mediating effects of the manufacturing capability and the testing and inspection capability. First, the findings from this study are expected to make a contribution to deepening the findings from Hau(2016)[3] by empirically revealing other significant mediators such as small and medium venture firms' manufacturing capability and testing and inspection capability in the relation between their external

information network heterogeneity and technology commercialization capability. Hau(2016)[3]'s findings have empirically confirmed the significant mediating role of small and medium firms' new technology development capability in the relation. But the findings from this study have empirically revealed other significant mediators such as manufacturing capability and testing and inspection capability in the relation especially in the context of small and medium venture firms. Second, the finding from this research can make another good contribution to widening the findings from Hau(2015)[13] by illuminating the role of small and medium venture firms' manufacturing capability. Hau(2015)[13] empirically shows that IT small and medium firms' manufacturing capability mediates the impact of the diversity of their external information network on the production management capability. This research has revealed that small and medium venture firms' manufacturing capability mediates the effect of their external information network heterogeneity on the technology commercialization capability.

5.2 Limitation

This research has several limitations despite the implications from the three findings revealed by this study. First, reflecting potential contingent variables into the research model will be able to produce more insightful findings. Second, considering other probable intervening variables and examining them empirically will be useful to providing more meaningful implications. Third, controlling the effects of more exogenous variables will make the empirical analysis more rigorous.

REFERENCES

- [1] V. K. Jolly "Commercializing New Technologies, Cambridge", 1997, Harvard Business School Press.
- [2] Y. S. Hau, "The mediating impacts of the product

- interior design capability and testing and inspection capability on the association between SMEs' external technology collaboration network diversity and technology commercialization capability: an empirical study based on the open innovation perspective", *Journal of Product Research*, Vol. 35, No. 3, pp. 89-93, 2017.
- [3] Y. S. Hau, "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", *Journal of Digital Convergence*, Vol. 14, No. 5, pp. 149-156, 2016.
- [4] Y. S. Hau, "SMEs' process design and technology commercialization capabilities: the moderating role of testing and inspection capability", *Journal of the Korean Data Analysis Society*, Vol. 18, No. 3, pp. 1253-1258, 2016.
- [5] R. M. Grant, "The knowledge based on the firm: Implications for management practice", *Long Range Planning*, Vol. 30, No. 3, pp. 450-454, 1997.
- [6] P. Trott "Innovation Management and New Product Development", Prentice Hall, 2012.
- [7] A. Afuah "Innovation Management", Oxford University Press, 2003.
- [8] H. W. Chesbrough, "The era of open innovation", *MIT Sloan Management Review*, Vol. 44, No. 3, pp. 35-41, 2003.
- [9] H. W. Chesbrough, "Open Innovation-The New Imperative for Creating and Profiting from Technology", Harvard Business School Press, 2006.
- [10] W. J. Stevenson, and S. C. Chuong, "Operations Management", McGraw-Hill, 2014.
- [11] L. J. Krajewski, L. P. Ritzman, and M. K. Malhotra "Operations Management : Process and Supply Chain", Pearson, 2010.
- [12] F. Betz "Managing Technological Innovation: Competitive Advantage from Change", Wiley, 2011.
- [13] 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, pp. 99-104, 2015.
- [14] J. Watson, "Modeling the relationship between networking and firm performance", *Journal of Business Venturing*, Vol. 22, No. 6, pp. 852-874, 2007.
- [15] M. E. Sobel, "Asymptotic confidence intervals for indirect effects in structural equation models", *Sociological Methodology*, Vol. 13, pp. 290-312, 1982.
- [16] R. M. Baron and D. A. Kenny, "The moderator-mediator variable distinction in social psychological research : conceptual, strategic, and statistical consideration", *Journal of Personality and Social Psychology*, Vol. 51, No.6, pp. 1173-1182, 1986.
- [17] Y. S. Hau, "IT SME ventures' external information network diversity and productivity improvement : the mediating role of the production period reduction", *Journal of Society of Korea Industrial and Systems Engineering*, Vol. 40, No. 1, pp. 144-149, 2017.
- [18] Y. S. Hau, "IT SMEs' external information network diversity and product quality improvement in the era of technology convergence : The mediating role of the production process improvement", *Journal of Digital Convergence*, Vol. 15, No. 4, pp. 199-204, 2017.
- [19] D. Sohn, J. Lee, and Y. Kim, "The effects of government support and regulation on SMEs technology innovation", *Journal of Digital Convergence*, Vol. 15, No. 4, pp. 117-125, 2017.
- [20] J. K. Kim and K. T. Hwang, "A study on the factors affecting technological innovation of innovative IT SMEs ", *Journal of Digital Convergence*, Vol. 14, No. 11, pp. 201-224, 2016.
- [21] Y. S. Hau, "IT SMEs' product planning capability and manufacturing capability in the context of digital convergence: The mediating impacts of the product exterior and interior design capabilities", *Journal of Digital Convergence*, Vol. 13, No. 12, pp. 55-62, 2015.
- [22] D. Y. Lee and S. G. Kim, "Determinants of technology transfer for convergence management strategy of small and medium enterprises", *Journal of Digital Convergence*, Vol. 14, No. 3, pp. 83-94, 2016.

허 용 석(Hau, Yong Sauk)



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

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