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Article

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Article

The Effects of Patents on the Relationship between R&D Activities and Business Management Performance: Focus on South Korean Venture Companies

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Abstract: Today, innovation is achieved by challenging the existing paradigm through cross-field collaboration, and R&D innovation plays a particularly crucial role. This study analyzed the effects of R&D innovation activities on business management performance in South Korea and examined the role that patents play in various R&D innovation activities. Panel regression and moderating effect analyses were conducted on small- and medium-sized venture enterprises that undertook new technology projects over five years (2015–2019). The results showed that R&D innovation activities had a significantly positive effect on both revenue, an indicator of business growth, and operating profit, an indicator of profitability. This implies that such activities play a positive role in management activities. Thus, enterprises should consider R&D innovation activities from a business growth strategy perspective. Additionally, the analysis showed that a firm’s capacity to hold patents on R&D innovation activities has a positive moderating effect on business management performance. This study is significant, as it reveals the cause-and-effect relationship between R&D innovation activities and business management performance as well as the role of various types of innovation. The results could help enterprises to seamlessly implement innovation activities in the future.

Keywords: business performance; R&D activities; panel data analysis; patents



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1. Introduction

Korean industry has recently faced multiple difficulties, including a massive restructuring of its shipping industry and the GM Korea crisis, which have had severe economic ripple effects across the country. These challenges have caused a sense of crisis to spread throughout the manufacturing sector [1]. According to the December 2019 Annual Industrial Activity Trends Report released by Statistics Korea, the average operating rate in the domestic manufacturing sector fell 0.7 to 71.9% year-over-year—the lowest since 1998, when the rate fell to 67.6% due to the International Monetary Fund financial crisis that was in full swing [1].

As a strategy to overcome this domestic industry crisis and advance the country’s existing industries, the government has begun to promote the development of venture enterprises [2]. Venture enterprises include venture capital investment firms, technology-intensive start-ups, and new-technology-based start-ups [2,3]. A venture enterprise refers to an independent enterprise that is highly technical and adventurous, with a frontier spirit [3]. More specifically, it is a new type of enterprise that varies from conventional enterprises in terms of the scope of its business, which can be determined on a quantitative basis (e.g., total assets, number of employees, capital, or sales) or on a qualitative basis (e.g., the life cycle of a product or business motive) [2,3]. Venture enterprises are considered leaders in product innovation during the early stages of a new industry because they attempt revolutionary technological innovation—rather than simple improvements or imitations—while contributing substantially to major technological changes [3]. In particular, it is

believed that fostering venture enterprises associated with new growth-engine areas, such as nanotechnology, information technology, biotechnology, and environmental technology, can drastically improve national competitiveness through synergistic convergence and will contribute to advancing the country's industrial structure [4]. In the early stages of development, new technologies, such as nanotechnology or robotics, played a foundational role in existing industries, but they have since developed into major, independent industries in the country as their importance and industrial ripple effects have grown. As such, they are highly likely to develop into new engines of growth [5]. In this study, the efforts required to advance South Korean industry at the new-technology venture-enterprise level are investigated. Furthermore, to help new-technology venture enterprises develop successful growth strategies, this study analyzes the effect of patents held by enterprises (in addition to their R&D innovation capacity) on business management performance.

This study differs from existing research by conducting panel regression analyses using unique panel data collected from a venture industry survey conducted between 2015 and 2019 and corporate financial data provided by Korea Enterprise Data Co., Ltd. This allows business performance to be validated with changes in unit time rather than with business circumstances at a specific time. The study further contributes to the research by investigating the moderating effect of holding relevant industrial patents on an enterprises' performance. This study is different from previous research for R&D by focusing on R&D activities, patents, and business performance of small- and medium-sized venture enterprises in Korea of the four major industrial sectors, Nano, Information, Bio, and Environment that the Korean government wants to foster through panel analysis.

This paper proceeds as follows: the research hypotheses are derived in Section 2 based on a review of the current literature. The research method is explained in Section 3, and the results of the empirical analyses are presented in Section 4. Finally, the conclusions, implications, and limitations of the study are addressed in Section 5.

2. Literature Review

2.1. R&D Activities and Innovation Performance

R&D activities affect enterprise innovation performance [6]. Internal and external R&D serve as an enterprise's innovation index, promoting an increase in these activities [6]. Despite the recent increase in strategic partnerships centered around R&D outsourcing, internal R&D appears to have a defining relationship with product innovation as it "introduces a market for new products or services or functionally improves products or services significantly" [7,8]. In addition, the acquisition of devices, equipment, and software has a significant positive impact on developing new innovative processes [8]. Process innovation can be improved gradually through new equipment and equipment suppliers [8]. In fact, many enterprises prefer R&D collaborations with others or the introduction of new technologies and equipment from external sources rather than developing their own process innovation. Supporters of this innovation system approach argue that enterprises drive innovation through continuous interaction with other enterprises and organizations, not through isolation [9–11]. Thus, enterprises often rely on external technologies through partnerships with other enterprises rather than through existing arm's-length markets. Interactions between enterprises and customers, suppliers, public research institutes, foundations, and industry associations can also deliver external sources of innovation that cannot be easily developed by the enterprises themselves. The purpose of these interactions is to supplement the internal learning process by acquiring information on technology, markets, or other resources [12–14]. Moreover, R&D collaboration between enterprises can boost innovation activities by creating synergy between internally owned knowledge (technology) and externally owned knowledge (technology) [15]. Enterprises in the high-tech industry in particular tend to pursue innovation activities through R&D collaboration, as technology advances very quickly compared to other industries [16]. In the case of SMEs (small- and medium-sized enterprises), not only do they possess fewer technologies than larger companies, but they also face more challenges with regard to R&D funds

and workforce. A competitive edge through R&D collaboration should be established to overcome these challenges, as innovation performance improves when there is more R&D cooperation between SMEs [17]. The analysis conducted by Cheung et al. on SMEs demonstrated that R&D collaboration has a positive effect on technical performance, emphasizing the importance of industry–academic collaboration for SMEs [18]. As such, R&D collaboration is recognized as a key strategy for acquiring important external knowledge (technology) [19].

2.2. Patent and Business Performance

An enterprise can protect its exclusive rights to the technology it develops and expect to generate stable profits by applying for patents [20]. The reasons for an enterprise to obtain a patent are as follows. First, if an enterprise applies for a patent, competition in the market will decrease as competitors try to develop other technologies to avoid infringing on that particular patent. Second, the transaction and cross-licensing of technology will allow other enterprises to buy it or partner with the patent-holding enterprise without having to develop the technology on their own. Third, applying for numerous patents gives the impression to shareholders and investors that the enterprise is very innovative. Fourth, researchers in enterprises that apply for patents can be rewarded for their inventions, giving them a sense of motivation [21]. Moreover, enterprises can effectively deploy strategies for maintaining, growing, and liquidating patents to realize high returns [22]. This maintenance strategy includes identifying the overall asset structure of patents and technologies and determining how to classify and sell these assets in the market, similar to other products [23]. Additionally, enterprises can either force cross-licensing through aggressive patent lawsuits or use a strategy to push for package licensing. Further, other enterprises' products and technologies must be analyzed to confirm infringement. In this context, the main focus of growth strategies is to utilize patents held by other enterprises [24,25]. These strategies include buying patents with a high potential for profit growth from licenses and mediating patented technology. This implies that the production and sale of products are not the only ways to maximize the commercial benefit of technology [24,25]. For example, an enterprise that holds only patent assets may emerge. Furthermore, a liquidation strategy can also simultaneously serve as an acquisition strategy. Businesses with poor management performance or no future vision can find opportunities to generate profits through various liquidation strategies [26]. Thus, patents can provide useful means of financing for venture enterprises with limited financing options, unlike large enterprises with diverse methods of financing. Lee examined the correlation between enterprise-related variables, such as R&D spending, market value, and the number of patents, using Tobin's Q ratio as the dependent variable [27]. The result indicated that number of patents and R&D spending had a significantly positive effect on enterprise value; the result remained positive with the addition of the time lags of Tobin's Q [27]. Cohen, and others have studied and reported the relationship between patent and enterprise value [28].

This study explored the effects of various R&D activities, internal R&D, collaborative R&D, external R&D by SMB in Korea on business performance, and also the moderating effect of having patents between the relationship between R&D activities and business performance through panel analysis with data from 2015–2019 for 5 years.

3. Design and Methodology

3.1. Research Model and Hypotheses

Xu and Sim identified four types of R&D activities: intramural R&D, extramural collaborative R&D, external knowledge, and technology adoption [29], and a study by Yun on small- and medium-sized businesses indicated a significantly positive correlation between enterprise technology innovation and R&D activities [30]. However, enterprises cannot create all the technology and knowledge required to establish a competitive advantage by themselves, especially in the absence of the necessary technology. Consequently, they should explore and adopt technology and knowledge externally [30]. A study by Ches-

brought found that joint R&D activities have a significantly positive effect on both product and process innovation [31,32]. Meanwhile, Yun, Won, Park, and Yang divided enterprise R&D activities into three components: internal integration of R&D, cross-functional collaboration of R&D, and internal integration and cross-functional collaboration of R&D, among which knowledge exchange through internal integration of R&D departments and cross-functional collaboration improved the performance of technological innovation [32].

Several existing studies have emphasized how R&D collaboration can help companies increase their absorptive capacity to internalize external knowledge (technology) and generate results [32–34]. The importance of having a government support system to support R&D innovation and collaboration activities at the national level has also been emphasized [34]. While absorptive capacity and government support systems are important for R&D collaboration and innovation activities, organizational innovation is also required for members to flexibly adopt R&D collaboration and strive for innovation activities. Enterprises should rationally handle the various conflicts that occur between the enterprises by openly accepting changes in the environment and exchanging diverse information through communication between internal members [35]. In other words, enterprises should undertake organizational innovation to create a culture that is friendly to exploring and developing new knowledge (technology) [35]. To overcome resistance to R&D collaboration, innovation, or organizational inertia, enterprises need to introduce a new organizational management method that is different from the conventional one. In this context, Pesaran et al. suggested that organizational innovation could contribute to enhancing an enterprise's financial performance through product innovation [36], and Li also explained that enterprises should consider organizational innovation when conducting innovation activities [37].

Therefore, based on the above classifications of R&D activity structures and the discussion above, this study presents Hypotheses 1 and 2.

Hypothesis 1 (H1). *R&D activities will have a positive outcome on enterprise revenue growth.*

Hypothesis 1a (H1a). *Internal R&D activities will have a positive outcome on enterprise revenue growth.*

Hypothesis 1b (H1b). *Collaborative R&D activities will have a positive outcome on enterprise revenue growth.*

Hypothesis 1c (H1c). *External R&D activities will have a positive outcome on enterprise revenue growth.*

Hypothesis 2 (H2). *R&D activities will have a positive outcome on enterprise profitability.*

Hypothesis 2a (H2a). *Internal R&D activities will have a positive outcome on enterprise profitability.*

Hypothesis 2b (H2b). *Collaborative R&D activities will have a positive outcome on enterprise profitability.*

Hypothesis 2c (H2c). *External R&D activities will have a positive outcome on enterprise profitability.*

Patents are an important factor in the rapid growth of enterprises [35]. Studies on enterprise patents and performance [34] have found that patents have a significantly positive effect on the financial performance of companies. A study by Yun, Yang, and Park showed that holding patents has a positive impact on South Korean enterprises [35]. Yoo compared enterprises that own patents with those that do not and found that enterprises that own patents perform better in management innovation than those that do not [36]. Yoo and Hug analyzed the relationship between business management performance and

patents for innovative companies, and the results showed that patents (intellectual property rights) had a positive effect on business revenue [36].

Therefore, it is assumed in this study that patents play an important role in the relationship between the financial performance of companies and R&D activities and Hypotheses 3 and 4 are presented.

Hypothesis 3 (H3). *The capacity to hold patents will have a positive moderating effect on revenue growth based on the R&D activities of venture enterprises conducting new technology projects.*

Hypothesis 3a (H3a). *The capacity to hold patents will have a positive moderating effect on revenue growth based on the internal R&D activities of venture enterprises conducting new technology projects.*

Hypothesis 3b (H3b). *The capacity to hold patents will have a positive moderating effect on revenue growth based on the collaborative R&D activities of venture enterprises conducting new technology projects.*

Hypothesis 3c (H3c). *The capacity to hold patents will have a positive moderating effect on revenue growth based on external R&D activities of venture enterprises conducting new technology projects.*

Hypothesis 4 (H4). *The capacity to hold patents will have a positive moderating effect on operating profit based on the R&D activities of venture enterprises conducting new technology projects.*

Hypothesis 4a (H4a). *The capacity to hold patents will have a positive moderating effect on operating profit based on the internal R&D activities of venture enterprises conducting new technology projects.*

Hypothesis 4b (H4b). *The capacity to hold patents will have a positive moderating effect on operating profit based on the collaborative R&D activities of venture enterprises conducting new technology projects.*

Hypothesis 4c (H4c). *The capacity to hold patents will have a positive moderating effect on operating profit based on the R&D activities of venture enterprises conducting new technology projects.*

Figure 1 depicts the proposed research model.

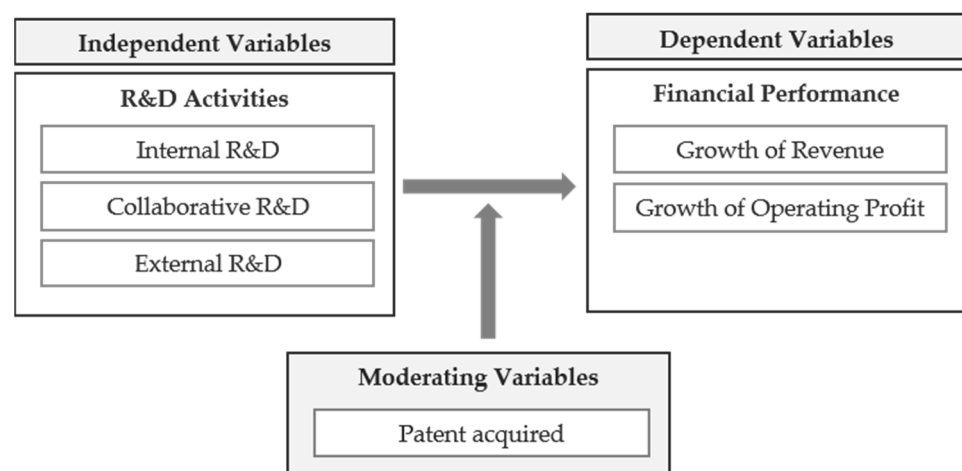


Figure 1. Research model.

3.2. Data Collection

In this study, the effect of R&D activities on the enterprise management achievement of South Korean venture companies and the moderating effect of patent holding on the improvement of management performance were analyzed. The relationship between enterprise performance and R&D innovation activities was analyzed using the Survey of Korean Venture Firms (2015–2019) and technological innovation survey data from the Ministry of SMEs and Startups. The Technological Innovation Survey is intended to explore the current status and characteristics of Korean enterprises’ overall innovation activities and to establish the basic data necessary for national innovation policymaking and innovation research. According to the internationally recognized OECD’s Oslo Manual, the survey provides reliable statistics on innovation that can be compared internationally. The analysis targets the 800 venture enterprises registered with the Ministry of SMEs and Startups and the venture enterprise disclosure system, VentureIn, as well as new technology R&D service venture enterprises in the Korean Enterprise Innovation Survey. The analysis period spans from 2015 to 2019, and the information on the target enterprises in our study is explained in Table 1. The descriptive statistics and correlations of the variables used in this study are summarized in Tables 2 and 3. No issue was found with multicollinearity between the independent variables.

Table 1. Description of companies (venture companies).

Category		Venture	
Observation		800	100%
Type	Nano Technology	160	20%
	Information Technology	256	32%
	Biotechnology	240	30%
	Environment Technology	144	15%

Table 2. Main variables.

Variables	Definition
Dependent Variable	
Measurement for Growth (REV)	Revenue growth improvement
Measurement for Profitability (PRF)	Operating profit growth improvement
Independent Variable	
Internal R&D (IRD)	No. of internal R&D activities
Collaborative R&D (CRD)	No. of Collaborative R&D activities
External R&D (ERD)	No. of R&D activities with external entities
Moderating Variable	
Patent acquired (PAT)	Patent companies acquired for the business
Control Variable	
Location (LOC)	Capital region/Non-capital region
Company Age (AGE)	Year of established vs Current Year (2019)

Dataset: 2015–2019, (kostat.go.kr, accessed on 30 August 2020). Source: Science and Technology Policy Institute, VentureIn Korea, Ministry of SMEs and Startups.

Table 3. Descriptive statistic results of main variables.

Characteristic	REV	PRF	IRD	CRD	ERD	PAT	LOC	AGE
Min. Value	8.161	1.658	1.172	0.693	0.405	0.020	0.000	2.000
Max. Value	15.042	4.407	4.377	4.248	5.193	2.000	1.000	27.000
Average	12.721	3.014	3.118	2.729	3.446	0.447	0.863	8.655

Table 3. Cont.

Characteristic	REV	PRF	IRD	CRD	ERD	PAT	LOC	AGE
Standard Deviation	1.259	0.535	0.593	0.660	0.633	0.339	0.345	4.639
Skewness	−0.892	−0.263	−0.459	0.067	−0.818	1.482	−2.108	1.732
Kurtosis	4.034	2.793	3.160	2.950	6.737	5.579	5.445	6.282
Observation	4000	4000	4000	4000	4000	4000	4000	4000
Characteristic	REV	PRF	IRD	CRD	ERD	PAT	LOC	AGE
REV	1							
PRF	0.178 *	1						
IRD	0.182 *	0.437 ***	1					
CRD	0.367 **	0.143 **	0.371 ***	1				
ERD	0.287 ***	0.311 *	0.104 *	0.501 ***	1			
PAT	0.187 ***	0.163 *	0.164 ***	0.185 ***	0.271 ***	1		
LOC	0.140 *	0.441 *	0.163 ***	0.075	0.105 *	0.268 ***	1	
AGE	0.311 ***	0.303 ***	0.199 ***	0.149 **	0.168 ***	0.137 **	0.01	1

Note: REV: indicator for growth; PRF: indicator for profitability; IRD: internal R&D; CRD: cooperation R&D; ERD: external R&D; LOC: company; AGE: Company age. ***, **, * represent the significance at the level of 1, 5, and 10%, respectively.

3.3. Econometric Methodology

In this study, the effect of R&D activities on business management outcomes, and the moderating effect of patents on this correlation, were analyzed through panel analysis. The panel analysis was conducted with a two-year time gap between the dependent and independent variables and a five-year cross-sectional data structure from 2015 to 2019. The reason for the time gap between the dependent and independent variables is that the effect of R&D innovation activities, the independent variable, requires a certain amount of time before it will be reflected in the actual enterprise performance. A moderating effect analysis was conducted along with the panel analysis to verify the varying relationship between enterprise management performance and R&D activities with the moderating variable of whether an enterprise holds patents in a statistical model, as shown below. For this analysis, explanatory variables were introduced, including R&D activities, whether patents are held, and an interaction term that multiplies R&D activities and whether patents are held, to explain the dependent variable of business management performance. Finally, a statistical program, STATA 14.2, was used for the empirical analysis of the impact of R&D collaboration on innovation activities and the moderating effect of organizational innovation.

$$Y = \alpha + \beta_1X + \beta_2R + \beta_3XR + \varepsilon \tag{1}$$

Generally, the presence of a moderating effect on the relationship between dependent and independent variables implies that the significant effect of the independent variable on the dependent variable varies with the level of the moderating variable. The intent of our study is to identify whether the effectiveness of R&D activities, as an independent variable, on business management performance, as a dependent variable, varies depending on whether an enterprise holds patents

4. Results and Findings

4.1. Panel Regression Analysis Results

In this study, Stata 14.2 was used to analyze Hypotheses 1, 2, and 3 through panel regression and moderating effect analyses. In the panel regression analysis, a fixed-effect model and random-effect model were implemented through a one-way error component model, and a Hausman test was conducted to select the appropriate model between the two. The Hausman’s test result (p -value < 0.00) rejected the null hypothesis at a 1% significance level, explaining that the fixed-effect model was more relevant than the random-effect model. According to the test results of Hypotheses 1 and 2 in Table 4, Hypothesis 1, analyzed using the fixed-effect model, was found to be significant as the null hypothesis

was rejected based on the regression equation ($R^2: 56.7\%$, $p\text{-value} < 0.00$). This indicates that the R&D activities performed by an enterprise (internal/collaborative/external R&D) had a positive (+) effect on the overall revenue of the venture enterprise at the internal R&D ($\beta = 0.286$, $p\text{-value} < 0.01$), collaborative R&D ($\beta = 0.272$, $p\text{-value} < 0.01$), and external R&D ($\beta = 0.130$, $p\text{-value} < 0.05$) levels. This means that the overall revenue increases as a venture enterprise undertakes R&D innovation activities, including internal R&D, collaborative R&D, and external R&D. Second, the test results of Hypothesis 2, through panel regression analysis, showed that the model was significant as the null hypothesis was rejected based on the regression equation ($R^2: 71.7\%$, $p\text{-value} < 0.00$). This indicates that the R&D activities performed by an enterprise (internal/collaborative/external R&D) had a positive (+) effect on the operating profit of the venture enterprise at the internal R&D ($\beta = 0.180$, $p\text{-value} < 0.01$), collaborative R&D ($\beta = 0.300$, $p\text{-value} < 0.01$), and external R&D ($\beta = 0.173$, $p\text{-value} < 0.05$) levels. This implies that, similar to Hypothesis 1, the R&D innovation activities of a venture enterprise contribute to increasing the operating profit of the enterprise.

Table 4. Panel regression analysis results.

Characteristic		Revenue (REV)	Operating Profit (PRF)
Internal R&D	IRD	0.286 *** (0.055)	0.180 *** (0.037)
Collaborative R&D	CRD	0.272 *** (0.059)	0.300 ** (0.040)
External R&D	ERD	0.130 ** (0.055)	0.173 ** (0.037)
Patent	PAT	0.126 ** (0.157)	0.169 ** (0.105)
Location	LOC	0.432 * (0.497)	0.195 ** (0.198)
Company Age	AGE	0.201 ** (0.012)	0.146 ** (0.008)
_con		11.00 ***	1.438 ***
F		51.63	100.94
R ² (within)		0.564	0.717
Hausman Test (Prob > chi2)		11.33 **	11.03 *
N		4000	4000

Note: Standard errors are reported in brackets. REV: revenue growth; PRF: operating profit growth. ***, **, * represent the significance at the level of 1, 5, and 10%, respectively.

4.2. Moderating Effect Analysis Result

In this study, Hypothesis 3 on the moderating effect of venture enterprises' capacity to hold patents was verified. The moderating effect of the capacity to hold patents was analyzed through R&D innovation activities (internal/collaborative/external R&D), patent-holding capacity, interaction term (R&D innovation activity \times patent-holding capacity), and a panel regression analysis based on business management performance. First, the analysis of the moderating effect of patent-holding capacity on the relationship between business management outcomes (revenue and operating profit) and internal R&D innovation activities found that the interaction term between internal R&D innovation activities and patent-holding capacity had a statistically significant effect on revenue ($\beta = 0.497$, $p\text{-value} < 0.01$) and operating profit ($\beta = 0.725$, $p\text{-value} < 0.01$). In addition, the analysis results shown in the moderating effect graph indicate that, while enterprise management performance increased with internal R&D capacity, the effect of internal R&D capacity on

business management performance varied with patent-holding capacity. In other words, business management performance would increase more drastically as venture enterprises with high patent-holding capacity conducted internal R&D activities. Therefore, H3-1 was accepted (Table 5).

Table 5. Panel regression estimation results for revenue (model 1) and operating profit (model 2).

Variables		Model 1 (REV)	Model 2 (PRF)
Internal R&D	IRD	0.261 *** (0.066)	0.495 *** (0.145)
Patent	PAT	0.474 *** (0.516)	0.785 *** (0.257)
Internal R&D × Patent	IRD×PAT	0.497 *** (0.132)	0.725 *** (0.151)
Location	LOC	0.165 ** (0.021)	0.275 * (0.018)
Company Age	AGE	0.022 ** (0.010)	0.041 ** (0.019)
_con		11.66 ***	1.686 **
F		58.83 ***	66.54 ***
R2 (within)		0.540	0.570
N		4000	4000

Note: Standard errors are reported in brackets. REV: revenue growth; PRF: operating profit growth. ***, **, * represent the significance at the level of 1, 5, and 10%, respectively.

Second, the analysis of the moderating effect of patent-holding capacity on the relationship between collaborative R&D innovation activities and business management outcomes (revenue and operating profit) showed that the interaction term between collaborative R&D innovation activities and patent-holding capacity had a statistically significant positive effect on revenue ($\beta = 0.269$, p -value < 0.05) and operating profit ($\beta = 0.288$, p -value < 0.01). Further, analysis results shown in the moderating effect graph indicate that, while business management performance increased with collaborative R&D capacity, the effect of collaborative R&D capacity on business management performance varied with patent-holding capacity. In other words, business management performance would increase more drastically as venture enterprises with high patent-holding capacity conducted collaborative R&D activities. Therefore, H3-2 was accepted (Table 6).

Table 6. Panel regression estimation results for revenue (model 1) and operating profit (model 2).

Variables		Model 1 (REV)	Model 2 (PRF)
Collaborative R&D	CRD	0.399 *** (0.051)	0.423 *** (0.032)
Patent	PAT	0.527 ** (0.529)	1.21 *** (0.356)
Collaborative R&D × Patent	CRD × PAT	0.269 ** (0.140)	0.288 *** (0.860)
Location	LOC	0.014 ** (0.003)	0.032 (0.214)

Table 6. Cont.

Variables		Model 1 (REV)	Model 2 (PRF)
Company Age	AGE	0.010 ** (0.011)	0.027 (0.007)
	_con	12.088 *** (0.503)	1.474 (0.230)
	F	202.821 ***	447.685 ***
	R2 (within)	0.511	0.701
	N	4000	4000

Note: Standard errors are reported in brackets. REV: growth in revenue, PRF: growth in operating profit. ***, ** represent the significance at the level of 1 and 5%, respectively.

Third, the analysis of the moderating effect of patent-holding capacity on the relationship between external R&D innovation activities and business management performance (revenue and operating profit) showed that the interaction term between collaborative R&D innovation activities and patent-holding capacity had a statistically significant effect on revenue ($\beta = 0.173$, p -value < 0.05) and operating profit ($\beta = 0.173$, p -value < 0.05). In addition, the analysis results shown in the moderating effect graph indicate that, while business management performance increased with external R&D capacity, the effect of external R&D capacity on business management performance varied with patent-holding capacity. In other words, business management performance would increase more drastically as venture enterprises with high patent-holding capacity conduct external R&D activities. Therefore, H3-3 was accepted (Table 7).

Table 7. Panel regression estimation results for revenue (model 1) and operating profit (model 2).

Variables		Model 1 (REV)	Model 2 (PRF)
External R&D	ERD	0.259 *** (0.065)	0.718 *** (0.028)
Patent	PAT	0.814 * (0.101)	0.926 ** (0.407)
External R&D × Patent	ERD × PAT	0.195 ** (0.297)	1.966 ** (0.256)
Location	LOC	0.036 * (0.017)	0.202 * (0.022)
Company Age	AGE	0.020 ** (0.014)	0.046 *** (0.001)
	_con	10.97 *** (0.290)	7.710 *** (0.026)
	F	29.99 ***	97.47 ***
	R2 (within)	0.374	0.660
	N	4000	4000

Note: Standard errors are reported in brackets. REV: revenue growth; PRF: operating profit growth. ***, **, * represent the significance at the level of 1, 5, and 10%, respectively.

5. Discussion

This study empirically analyzed the effect of R&D collaboration and innovation activities by new technology venture enterprises in South Korea on the management outcomes. The moderating effect of patents was also empirically investigated. R&D can be generally divided into internal R&D, external R&D, and collaborative R&D, with a recent emphasis on R&D innovation for enterprise innovation [2]. The analysis results in this study can be summarized as follows: first, the panel analysis of R&D innovation activities and business

management performance showed that internal, collaborative, and external R&D all affected revenue and operating profit, corresponding to the management performance of an enterprise. This is consistent with numerous previous studies that indicate R&D innovation activities are the most common method to acquire new knowledge or technology [17]. Therefore, enterprises can expect to improve management performance and develop a competitive edge through internal R&D and collaborative R&D with other enterprises or organizations in various fields [17–20]. In addition, the analysis of the moderating effect of patents showed that R&D innovation activities had a significantly positive effect on the revenue and operating profit of enterprises. Moreover, the intent of R&D innovation is to introduce and apply new technologies or operating systems to organizations in order to respond flexibly to a rapidly changing environment [23–25]. Therefore, enterprises can strengthen their collaborative structure with external organizations and improve their working relationship through R&D innovation, which will also contribute positively to efforts to enhance their competitiveness, including financial performance. Venture enterprises aiming to strengthen their competitiveness and viability in the future should examine whether patent development and acquisition activities are being undertaken appropriately, that is, this study confirmed the potential of patent acquisition in relevant areas, indicating that firms should consider this when making decisions regarding R&D innovation activities as it will have a significantly positive impact on the performance of a company [33]. Our study confirmed that R&D collaboration could positively affect business management performance by creating synergy between internally owned knowledge (technology) and externally owned knowledge (technology), as reported in previous studies (Table 8). In particular, in the high-tech venture industry, which integrates new technologies, the development of technology occurs at a much faster rate compared to other industries, and enterprises actively collaborate on both internal and external R&D activities to meet various goals [38–40]. It was confirmed that the more small- and medium-sized venture companies participated in performing R&D activities and differentiated themselves from other enterprises through patents, the better their performance would be, as concluded in previous studies. As discussed in these various studies, R&D activities and the acquisition of patented technologies are considered to be key strategies for venture enterprises to grow and survive.

Table 8. Hypothesis testing result.

Hypothesis	
H1: R&D activities will have a positive outcome on revenue growth.	Accepted
H1-1: Internal R&D activities will have a positive outcome on revenue growth.	Accepted
H1-2: Collaborative R&D activities will have a positive outcome on revenue growth.	Accepted
H1-3: External R&D activities will have a positive outcome on revenue growth.	Accepted
H2: R&D activities will have a positive outcome on profitability.	Accepted
H2-1: Internal R&D activities will have a positive outcome on profitability.	Accepted
H2-2: Collaborative R&D activities will have a positive outcome on profitability.	Accepted
H2-3: External R&D activities will have a positive outcome on enterprise profitability.	Accepted
H3: The capacity to hold patents will have a positive moderating outcome on revenue growth based on the R&D activities of venture enterprises conducting new technology projects.	Accepted

Table 8. Cont.

Hypothesis	
H3-1 The capacity to hold patents will have a positive moderating outcome on revenue growth based on the internal R&D activities of venture enterprises conducting new technology projects.	Accepted
H3-2 The capacity to hold patents will have a positive moderating outcome on revenue growth based on the collaborative R&D activities of venture enterprises conducting new technology projects.	Accepted
H3-3 The capacity to hold patents will have a positive moderating outcome on revenue growth based on external R&D activities of venture enterprises conducting new technology projects.	Accepted
H4: The capacity to hold patents will have a positive moderating outcome on operating profit based on the R&D activities of venture enterprises conducting new technology projects.	Accepted
H4-1 The capacity to hold patents will have a positive moderating outcome on operating profit based on the internal R&D activities of venture enterprises conducting new technology projects.	Accepted
H4-2 The capacity to hold patents will have a positive moderating outcome on operating profit based on the collaborative R&D activities of venture enterprises conducting new technology projects.	Accepted
H4-3 The capacity to hold patents will have a positive moderating outcome on operating profit based on the R&D activities of venture enterprises conducting new technology projects.	Accepted

6. Conclusions

This study conducted a panel regression analysis using panel data collected from 800 new-technology venture small- and medium-sized enterprises (SMEs) in South Korea over the past five years (2015 to 2019) to verify the effect of R&D innovation activities by these enterprises on business outcomes. A moderating panel regression analysis was also conducted to identify whether the patents held by small- and medium-sized venture companies would have a moderating effect. Our study is significant in that the data used for the panel and moderating effect analyses comprised small- and medium-sized venture companies pursuing new technology projects, as such projects are critical for national growth. In particular, the results of our study are meaningful in that the effect of R&D innovation activities on the management outcomes of South Korean SMEs involved in new technology projects, such as nano-fusion, robotics, and genetics, was identified, and in-depth results were acquired by adopting enterprises' capacity to hold patents as a variable in the analysis in addition to R&D innovation activities, an approach unlike any previous study.

Moreover, our study is significant in that the relationship between the different types of R&D innovation activities (internal, collaborative, and external R&D) and business outcomes was demonstrated, and the moderating effect of expertise's capacity to hold patents capacity was empirically verified, which could serve as the basis for additional research in the future. In addition, the outcomes of our study could contribute to the seamless implementation of various innovation activities by SME ventures in the future.

However, the limitations of our study are as follows. First, business management performance was analyzed in our study only with respect to R&D innovation activities. In the future, the relationship between business management performance and various other enterprise innovation activities should be examined. Second, the study only targeted SME ventures; in the future, it would be helpful to classify companies by type, in terms of company structure and type, for separate analysis to identify differences. Third, only South Korean companies were subject to analysis in our study. Comparative analyses should be conducted using the data from this study as well as those from other countries.

Fourth, while this study verified the effectiveness of R&D innovation activities and patent-holding companies, it failed to provide specific measures for SME ventures to establish future growth strategies. Therefore, it will be necessary to conduct additional case studies for specific factor analysis that can aid enterprises in establishing future growth strategies. Fifth, since this study only targeted small- and medium-sized venture companies, it is deemed important to research the R&D innovation activities and patent capacities of large companies that form the foundation of the national industry in addition to small- and medium-sized companies that are still in the early stages and the limitations for the employees to work with.

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