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Analyzing Government Support Program for R&D Collaboration and Distribution for Korean SMEs: A Case for Equipment Leasing Program

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Abstract

Purpose: This study attempted to identify determinants affecting research collaboration and R&D distribution activities, especially regarding facility and equipment leasing of small and medium enterprises (SMEs) in South Korea. The objective of this study was to find the most significant firm characteristics that affect firms participating in an R&D collaboration and distribution program and investing in R&D in terms of leasing payment for equipment. **Research design, data, and methodology:** This study analyzes which SMEs' characteristics influence external research cooperation activities by examining the SMEs that received government support for equipment leasing using multiple regression analysis and residual plots. The survey combined two databases: 1) a fact-finding survey of participating firms by the Ministry of SMEs and Startups, and 2) leasing information by the Korea Association of University, Research Institute and Industry. **Results:** The study found that firm size positively impacts R&D investment, R&D collaboration and distribution. **Conclusions:** The study provided evidence to policymakers and government officials that firms with more employees will more likely participate in government support programs. The study results also prove that government officials believe firm location does not impact R&D investment, R&D collaboration and distribution.

Keywords: R&D Collaboration, R&D Distribution, Small And Medium Enterprises (SMEs), Equipment And Facility Leasing, Government Support Program

JEL Classification Code: O32, O36, Q55

1. Introduction

SMEs are the backbone of the overall economy of a country. The importance of small and medium-sized enterprises (SMEs) is being emphasized internationally to promote economic vitality, as SMEs play an important role in innovation and job creation. SMEs are dominant business organizations representing 95% of all enterprises worldwide (Pilar et al., 2018). While solving the unemployment problem is emerging as the biggest policy task in recent years, the importance of SMEs as 'job creators' is being emphasized more and more. In addition, SMEs are structurally flexible in organizational management and thus help SMEs in emerging markets (Zhang et al., 2014). SMEs contribute up to 40% of the national income, and the impact of SMEs could be even higher if informal SMEs are

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considered (Ndiaye et al., 2018).

The technological competitiveness of SMEs is considerably lower than that of large enterprises. The widening gap between big firms and SMEs is becoming a key policy task in many countries. Although the share of employment and innovation related to SMEs has increased rapidly over the past few years, the increase in productivity and technological competitiveness has also fallen short of big firms, especially in South Korea (hereinafter referred to as "Korea").

SMEs are vulnerable to economic fluctuations due to their integrated structure with big firms in rapid industrialization and cannot survive globally**.** As a result, SMEs need to improve their productivity through technological innovation and strengthen market competitiveness. Considering SMEs' management and technological innovation capabilities, the government's continuous R&D support and efforts to strengthen external cooperation should also be made concurrently.

This study targets small and medium-sized enterprises (SMEs) that have received the relevant government support project. The SMEs focus on analyzing the relationship between research facilities and equipment utilization of external universities and research institutes depending on the company's characteristics. The results explain that, among the programs carried out by policy in Korea, SMEs improve their technological competitiveness by using research equipment owned by universities and research institutes and creating research results for SMEs through external cooperation. Based on the case of the policy support program, it was confirmed that the utilization of external facilities and Equipment varies according to the various characteristics of SMEs. As a result, the relationship between research cooperation with the outside according to the characteristics of SMEs was analyzed. In addition, the study attempted to understand the purpose of using external facility equipment. Finally, the study analyzed whether there was a change in the relationship of external research cooperation according to the characteristics of SMEs by classifying the use of external facilities and Equipment.

Furthermore, this study distinguished between a group of SMEs active in external research cooperation to strengthen technological competitiveness and a vulnerable group, and the characteristics of this relationship can also be identified by facility and equipment use. According to the results of the impact relationship, the study can confirm that policy support and investment for vulnerable groups are necessary to strengthen the technological competitiveness of SMEs in Korea. The rest of the study is organized as follows: Section 2 presents a literature review on SMEs and the importance of support for R&D collaboration and distribution. Then section 3 shows the case study & the research hypotheses. Next, sections 4 and 5 present the data and models used for this study and the result of the regression analysis. Finally, it closes with a conclusion in Section 6.

2. Literature Review

2.1. Definitions of Small and Medium Enterprises

Small and Medium Enterprises (SMEs) and their definition and measures vary from country to country (Ayyagari, Beck & Demirguc-Kunt, 2007). There is no static definition of SMEs (Altman et al., 2008), but Bracker and Pearson (1986) defined small businesses as those with annual sales of less than 5 million dollars. According to Ayyagari et al. (2007), the commonly used measures to differentiate SMEs from other firms are the number of employees, the total net assets, sales and investment level.

2.2. SMEs' Barriers to Innovate

SMEs are under extreme pressure and uncertainty when conducting innovative activities due to a lack of finances and unknown returns on investment (Ceccagnoli, 2009). However, the only way for SMEs to survive is to innovate and find their competitiveness. Zhu et al. (2012) conducted a face-to-face interview with SME representatives and found that competition fairness, support systems, access to financing, laws and regulations, and tax burdens as key barriers for SMEs in China to engage in innovation activities.

Barriers can be largely divided into four areas: economic, knowledge, market and reason to innovate (Duarte et al., 2017). Economic factors include a lack of funds within and outside the firm and finances to invest in innovation. Knowledge factors include a lack of qualified employees and information on the technology and market. Market factors include uncertainty of demand and high competition. Finally, the reason to innovate includes whether the developed technology becomes useless due to lack of demand.

Hvolkova et al. (2019) conducted a qualitative analysis of the barriers to innovation in SMEs and found two types of barriers. The internal barriers are the lack of financial resources and inappropriate human resources. In addition, barriers can occur outside the firm when the firms interact with different actors, such as competitors, customers, and the government.

Therefore, the government needs to support R&D. When sales of SMEs reach a critical mass due to government R&D support; the SMEs continue to grow in a virtuous cycle structure of R&D investment - sales & profit - R&D investment, resulting in an economic ecosystem that creates quality jobs. Therefore, it is a political agenda to create an

environment where the SMEs support the big firms with their technological innovation, and the big firms strengthen their economic ecosystem by expanding their production scale and increasing their efficiency (Kang et al., 2019).

2.3. Government Support for Korean SMEs

The government's role is to supplement R&D investment capacity until it reaches a critical scale for autonomous technological innovation, laying the groundwork to compete with the world's leading groups in the global market and strengthening the competitiveness of SMEs. In this regard, the Korean government has promoted a support policy that induces investment expansion through the government's preemptive expansion of R&D support and tax support, given the low technological level of SMEs and insufficient self-investment capacity. Furthermore, SMEs' R&D investment is also very low compared to advanced countries, and as the economic crisis is expected to reduce SMEs' R&D investment, it was decided to strategically foster SMEs by inducing private investment through the government's preemptive expansion of R&D investment.

Doh and Kim (2014) highlighted 3122 thousand SMEs with 12,263 thousand employees in 2010. With the growing number of startups and spinoffs (the number of SMEs and employees should be higher in 2022), the Korean government has invested heavily in supporting SME innovation. The main reason for this heavy investment in SME innovation is to help enhance competitiveness so that SMEs can self-sustain and independently develop their competencies.

SMEs still have difficulties discovering knowledge and face challenging tasks in response to the fourth industrial revolution and digital transformation. Furthermore, the Korean government failed to create the foundation for open innovation and external innovation to support individual SMEs. Collaboration between industry-university-research innovation actors for SMEs is centered on short-term, one-time R&D. There is an insufficient ecosystem capable of continuous development of technological innovation.

2.4. Importance of R&D Collaboration, Distribution and Open Innovation for SMEs

Why do SMEs need the cooperation of external innovation organizations? First, the technological competitiveness of SMEs is lower than large enterprises, and second, there is a limit to improving the technological competitiveness of SMEs with just in-house R&D and internal efforts. Furthermore, globalization has made SMEs use external resources to reduce the innovation cycle time, cost, and risks (Narula, 2004). In addition, while SMEs are more flexible and can rapidly respond to changes (Narula, 2004), only a few SMEs can manage the whole innovation process, and thus, many SMEs are encouraged to collaborate with other firms (Edwards et al., 2005).

Kim and Park (2010) examined the impact of open innovation activity on SMEs' innovation output. First, open innovation originated from large firms that can invest heavily in R&D; therefore, successful open innovation cases were hard to find among SMEs. Second, the authors found that not all open innovation activities of SMEs positively affect innovation activity. In addition, Suh and Yoon (2012) examined the effects of different SME collaborations on R&D in Korean SMEs. The authors found that R&D collaboration positively correlates with product/service innovation, patenting activity and process innovation.

Since the 1990s, policy attention has focused on enhancing the innovation capacity of SMEs, and the need for strengthening the competitiveness of the SME group has increased. Furthermore, as autonomy and openness occurred throughout the economy, the overall economic policy shifted toward strengthening industrial competitiveness. At the same time, with the progress of globalization, the era in which local Korean SMEs must directly compete with foreign SMEs has arrived. Accordingly, the policy of SMEs has also shifted to strengthening competitiveness through cooperation.

3. Case Study: Support Program for SMEs to Joint Use R&D Equipment

Technological networks, such as collaboration and partnership, among actors are an important source of innovation (Doh & Kim, 2014), but Korea lacks experience in open innovation, competence, and insufficient policy support for SMEs. The proportion of industry-university-research collaboration and innovation actors and innovation capabilities was low because Korean SMEs preferred to develop their own (independent) technology, and only a few preferred to conduct joint development or consignment development because many SMEs are reluctant to disclose detailed R&D information (Lee et al., 2010). Lee et al. (2010) highlighted that one of the effective ways to facilitate open innovation among SMEs is through networking.

Therefore, from 2007 to the present, the Korean government has been promoting policies to support SMEs to utilize the excellent human resources and research equipment of universities and research institutes by utilizing the infrastructure of universities and research institutes. One program the Korean government initiated was the "Joint Use of Research Equipment" project, which provided SMEs an environment to cooperate and utilize research equipment in public institutions.

The government examined how many SMEs have invested in R&D equipment and facilities and found that most SMEs do not have the equipment and the facilities to carry out R&D. Therefore, the main purpose of the government support program was to support SMEs in the form of online vouchers coupons so that they could use the services of research equipment and equipment specialists. There were two types of support: support for using research facilities and equipment owned by universities and research institutes within a maximum of 5 million Korean Won (KRW) or support within a maximum of 70 million KRW for the use of research equipment and professional workforce for in-depth R&D.

Therefore, different firms applied and were selected to participate in this program. There were mainly two types of firms, SMEs and startups, with various employees and annual sales. In addition, there were two types of businesses, manufacturing-focused and knowledge-based-focused firms, with four different purposes for participating in the program (process development, product development, data acquisition, and testing for certification).

3.1. Research Hypotheses

The study intended to examine the relationship between the firm characteristics, such as the location of the firm, annual sales, type of business, firm type, number of employees and the reason for participating in the R&D collaboration and distribution project, and the investment to R&D, in terms of total leasing payment. The total leasing payment is the sum of the total government support fund received by the firm to lease the equipment and the additional payment made with their budget.

As stated, the program classified the participating firms as manufacturing-focused or knowledge-based. Korean companies' facility and equipment investment was 180.4 trillion KRW, an 8.4% increase from 2020. In addition, firms in the semiconductor industry increased their facility and equipment investment in the booming memory semiconductor industry and increased demand for IT products. Furthermore, the facility and equipment investment in the manufacturing industry was 10.2 trillion KRW, compared to the non-manufacturing industry investment of 8.2 trillion KRW in 2020. Therefore, firms in the knowledge-based sector are more likely to participate in the program due to less investment in equipment and facility than manufacturing firms. Therefore, the following hypothesis was derived:

H1: Knowledge-based firms will have a higher leasing payment than manufacturing firms

Korea defines "metropolitan areas" as regions near Seoul, including Incheon and Gyeonggi. Therefore, non-metropolitan areas are regions other than Seoul, Incheon and Gyeonggi. Lee et al. (2020) examined 16 local governments' R&D performance and found that Seoul, Gwangju, Daegu, and Gangwon showed better performance than the average performance level between 2010 and 2016. Furthermore, the R&D efficiency, which is the ratio of R&D input and R&D output, for metropolitan cities was higher than in non-metropolitan cities.

H2: Firms in the metropolitan area will have a higher leasing payment than firms in the non-metropolitan area

Yang and Lin (2007) examined the relationship between innovation and the number of employees in Taiwan. The authors found that R&D investment and patent innovation positively impact the firm's size. Table 1 shows the R&D expenses and R&D personnel by the firm size of Korean firms. While SMEs have much higher R&D expenses, startups have a higher R&D expense ratio to annual sales. Startups also have more R&D personnel to total employee ratio compared to SMEs. In addition, since startups tend to have fewer employees, the startups will lack both the equipment and staff.

Coad and Rao (2010) examined the co-evolution of sales growth, employment growth, profit growth, R&D expenditure growth and R&D investment. The authors

found that while profit growth had a minor relationship with R&D investment, the R&D expenditure increased following the growth in sales and employment. Therefore, the following hypotheses were derived:

H3: Firms with more employees will have a higher leasing payment

H4: Startups will have higher leasing payments than SMEs.

H5: Firms with higher annual sales will have a higher leasing payment

Table 1: Startup's Intellectual Property Analysis

R&D Activity	Large Firms	Mid-Size Firms	SMEs	Startups
R&D expenses (100 million KRW)	564.9	153.7	13.5	2.9
Ratio of R&D expenses to annual sales (%)	1.0	3.5	5.1	12.8
R&D personnel	217.9	70.7	13.1	4.4
Ratio of R&D personnel to total employees (%)	6.4	12.8	15.8	33.2

Source: Lim (2019)
Note: Original in Korean, translated into English

Hall et al. (2009) found that firm size, R&D intensity, and equipment investment increase the likelihood of both process and product innovation. Therefore, the following

hypothesis was derived:

H6: Firms developing processes and products will have a higher leasing payment than firms participating in data acquisition and testing

3.2. Research Gap

From the literature, two gaps can be identified.

First, previous studies examined different government support programs focusing on various R&D characteristics such as the number of research personnel, collaboration, and other innovative processes, but none of the studies tried to examine R&D collaboration, distribution and R&D investment in leasing equipment.

Second, most Korean firms do not have the facility or the equipment to carry out R&D. This study tried to examine the effectiveness of R&D collaboration and distribution and the firms' R&D investment in equipment leasing payment.

4. Research Methods and Materials

This study analyzes which SMEs' characteristics influence external research cooperation activities by examining the SMEs that received government support for equipment leasing using multiple regression analysis and residual plots. Using the results, the study analyzed whether there is a difference in the use of leased equipment and hopes to offer policy implications on improving collaborative activities in Korea.

4.1. Data Description

The survey combined two databases: 1) a Fact-finding survey of participating firms and 2) leasing information. The Ministry of SMEs and Startups collected the first database through the fact-finding survey on the SMEs and startups participating in the equipment leasing program. The survey consisted of questions about the purpose of participating, what the firms wish to get out of the program, and information about the participating firms such as the number of employees, annual sales, number, type of business, main product or service, location, as well as the information about the equipment leasing institutions. AURI collected the second database, which consisted of detailed information on what equipment each participating firm leased, how many times the firm leased, how much the firm paid to lease the equipment, and how much the government-funded the leasing activity.

The two databases were combined and preprocessed, and a total of 2,324 SMEs and startups and 42,800 equipment leasing cases were collected and used in the analysis. Interestingly, most firms were manufacturing-based firms with less than 50 employees. The study used the total lease payment by the firms as the dependent variable to examine which firm characteristics impacted the investment in equipment leasing. Five independent variables were used. In addition, firm characteristics were used, such as the annual sales of 100 million KRW, the number of employees, the business and firm types, and the firm's location. How the variables were coded is shown in Table 2.

The study predicted the total lease payment based on the following equation. Total lease payment was created by combining each leasing case by the firm. Sales, employees and location variables were recoded as categorical variables used in the analysis. Sales and employees were originally numeric variables

$$\begin{aligned} \text{total\_lease\_payment} = {} & B0 + B1(\text{SALES}) + B2(\text{employees}) + \\ & B3(\text{business\_type}) + B4(\text{firm\_type}) + \\ & B5(\text{location}) \end{aligned} \quad (1)$$

In addition, the study filtered the dataset to examine how firm characteristics differ by the purpose of participation. As a result, the dataset had five different values, but the study omitted the "others" category and conducted the analysis using four values.

Table 2: Independent Variable Definitions

Variables	Definition	Categories	N
Sales Won	Annual sales of the firm that leased the equipment. In 100 million won	<1	418
		1 ~ 5	291
		6 ~ 10	182
		11 ~ 50	556
		51 ~ 100	260
		101 ~ 300	274
		>300	343
Employees	Number of Employees of the firm that leased the equipment	<10	1092
		11~50	868
		51~300	343
		>300	21
Business Type	Business type of the firm that leased the equipment	Manufacturing	2076
		Knowledge-based	248
Firm Types	Firm type of firm that leased the equipment	SMEs	1275
		Startups	1049
Location	Location of the firm that leased the equipment	Metropolitan	1084
		Non-Metropolitan	1240

Source: Startup's Intellectual Property Analysis (Lim, 2019)
Note: Original in Korean, translated into English

4.2. Empirical Models

The study conducted five models, as shown in Table 3. Model 1 is the main model that examined all the firms participating in the program. Model 2 to Model 5 conducts the regression analysis by filtering for the specific

participation purpose.

Table 3: Variables and Filters Used for Each Model

Variables		Model 1	Model 2	Model 3	Model 4	Model 5
Sales		●	●	●	●	●
Employees		●	●	●	●	●
Business Type		●	●	●	●	●
Firm Type		●	●	●	●	●
Location		●	●	●	●	●
Purpose of Lease		●				
FILTER	Process Development		●			
	Data Acquisition			●		
	Testing				●	
	Product Development					●

Source: Startup's Intellectual Property Analysis (Lim, 2019)
Note: Original in Korean, translated into English

5. Results and Discussion

5.1. Regression Results

The study conducted the regression analysis using the Rattle package from R programming. Table 4 shows the regression result for Model 1. The result tells that the average equipment leasing payment for a manufacturing SME located in a metropolitan area with less than ten employees and less than 100 million KRW in annual sales and participation in the program for process development purposes is 19,158,086 KRW. However, if the SME participated in the program for data acquisition or testing purposes, their leasing payment would go down by 9,797,041 and 14,801,791 KRW, respectively. Similarly, the result showed that the leasing payment increased if the number of employees increased. However, other variables, such as location and sales, were not significant in determining the leasing payment of firms.

Figure 1 shows the diagnostic plots for Model 1 that show residuals in four different ways. Plot A is the residuals vs. fitted graph and can help detect non-linearity, unequal error variances and outliers. The data distribution seems like a random scatter; thus, the residuals do not contradict the linear assumption. There is no discernible trend; thus, the study can state that the linear regression found in Table 4 is a good model of this data. Plot B is the Normal Q-Q plot, showing if the residuals are normally distributed. While a good plot for the Normal Q-Q plot should follow the dotted line, the Normal Q-Q plot for this study does show some non-linear characteristics; therefore, Plots C and D are created. Plot C is a scale-location plot that shows whether the residuals are spread equally along with the predictors' ranges and homoscedasticity in the data. While the line in Plot C is not horizontal and shows a slanted line, residuals appear to be randomly spread out. Plot D is a residual vs. leverage plot that helps find influential cases and outliers. Some outliers, known as anomalies, are influential data points to the dataset,

Table 4: Regression Analysis Result for Model 1

Constructs	All Firms			
	Beta	***Std. Error***	***T value***	***Pr(>|t|)***
Constant	19102865	2981239	6.408	**1.94e-10*** **
(Business type) Knowledge-based	4050744	2082705	1.945	0.0520.
(Firm Type) Startup	950890	1451748	0.655	0.5126
(Location) Non-metropolitan	-1834668	1273626	-1.441	0.1499
(Purpose) data acquisition	-9729627	2363697	-4.116	**4.05e-05*** **
(Purpose) testing	-14798755	2386021	-6.202	**7.06e-10*** **
(Purpose) product development	-4772076	3079770	-1.549	0.1215
(Employees) 10~50	3756186	1623551	2.314	**0.0208***
(Employees) 50~300	12352440	2430826	5.082	**4.18e-07*** **
(Employees) 300+	49497511	7547322	6.558	**7.31e-11*** **
(Sales) 100~500 million KRW	3190161	2354765	1.355	0.1757
(Sales) 500~1000 million KRW	3382771	2685236	1.260	0.2079
(Sales) 1000~5000 million KRW	2649538	2088832	1.268	0.2048
(Sales) 5000~1000 million KRW	121848	2617182	0.047	0.9629
(Sales) 1000~3000 million KRW	1200772	2728176	0.440	0.6599
(Sales) 3000+ million KRW	887482	2559337	0.347	0.7288

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
Note: Observation – 2,324; Adjusted R-Squared – 0.06722

but others could provide meaningless information and be excluded from the analysis.

Stevens (1984) explained four diagnostics to identify outliers, and one method is using Cook's distance. A data point influences the regression results if it has a large Cook's distance. Conversely, the results will be altered if these data points are excluded from the analysis. From Plot D, several data points (on the top left corner) are outside Cook's distance, indicating influential data points.

Figure 1: Regression Plots

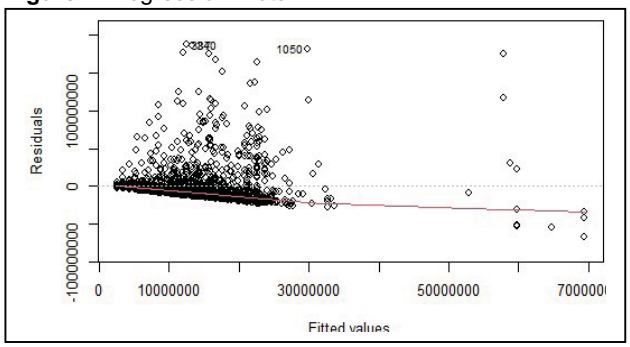

Figure 1a: Residuals vs. Fitted Plot

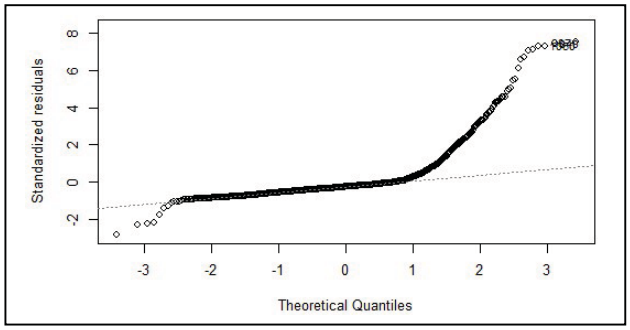

Figure 1b: Normal Q-Q Plot

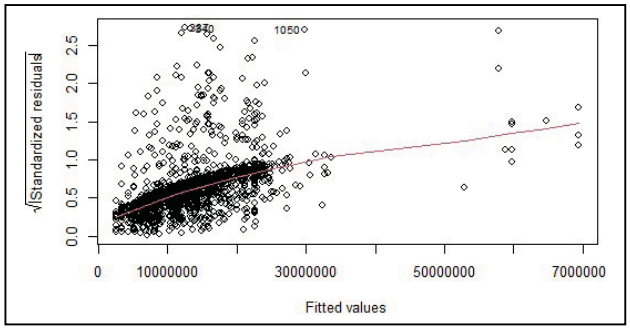

Figure 1c: Scale Location Plot

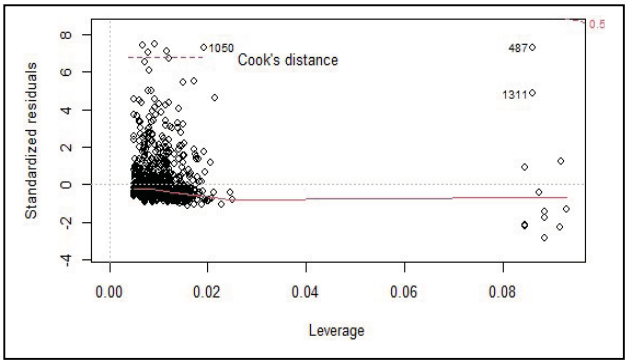

Figure 1d: Residuals vs. Leverage Plot

Table 5 shows the results of Models 2 through 5. Instead of analyzing the firms as a whole, Models 2 through 5 filtered the firms by the different purposes of participation. For example, model 2 examined firms that focused on process development, accounting for 188 firms. Surprisingly, most variables were insignificant, but the study found that firms with 50 to 300 employees spent 31,610,309 KRW more than firms with less than ten employees. Model 3 examined firms that focused on data acquisition through the use of the equipment and accounted for about 45% of the participating firms. The study found that manufacturing SMEs located in the metropolitan area with less than ten employees and less than 100 million KRW in annual sales and participated in the program for data acquisition spent 12,387,254 KRW to lease R&D equipment. In addition, firms with more than 300 employees spent 55,963,528 more than those with less than ten. Model 4 examined firms focused on testing to get their product certified and accounted for about 38% of the participating firms. The study found that manufacturing SMEs in the metropolitan area with less than ten employees and less than 100 million KRW in annual sales and participated in the program for testing certification purposes spent 9,323,528 KRW. The study also found that the leasing payment increased as employees increased. For example, firms with more than 300 employees spent 39,252,500 more than those with less than ten.

Finally, Model 5 examined firms that focused on further developing their products but accounted for just 183 firms. The result shows that firms with 100 to 500 million KRW and 500 to 1000 million KRW in sales spent 24,443,672 KRW and 21,359,929 KRW, respectively, more than firms with less than 100 million KRW in sales.

Table 5: Regression analysis results for Models 2 through 5

Constructs	Model 2	Model 3	Model 4	Model 5
	Process Dev Focused	Data Acquisition Focused	Testing Focused	Product Dev Focused
Constant	12,302,118 (0.15471)	12,387,254 (**4.93e-05** ***)	9,323,528 (**3.02e-06** ***)	9,988,413 (0.27701)
(Business type) Knowledge-based	11,791,418 (0.18247)	12,387,254 (0.0710 .)	3,861,890 (0.098356 .)	9,988,413 (0.92665)
(Firm Type) Startup	3,514,672 (0.56346)	-1,283,996 (0.5415)	-1,182,800 (0.383155)	5,433,011 (0.42493)
(Location) Non-metropolitan	-1,411,831 (0.79747)	-3,745,971 (**0.0369** *)	-2,498,607 (**0.046568** *)	-8,963,648 (0.14513)
(Employees) 10~50	1,942,435 (0.78504)	3,214,110 (0.1747)	329,435 (0.829416)	7,411,810 (0.38188)
(Employees) 50~300	31,610,309 (**0.00214** **)	6,050,540 (**0.0691 .**)	11,562,336 (**1.72e-06** ***)	-4,489,343 (0.81563)
(Employees) 300+	12,919,541 (0.54757)	55,963,528 (**2.01e-11** ***)	39,252,500 (**0.000275** ***)	-176,306 (0.99614)
(Sales) 100~500 million KRW	12,397,488 (0.10836)	3,293,063 (0.3453)	-3,524,782 (0.143075)	24,443,672 (**0.00204** **)
(Sales) 500~1000 million KRW	13,595,556 (0.13807)	4,961,373 (0.2338)	-3,228,368 (0.225490)	21,359,929 (**0.02257** *)
(Sales) 1000~5000 million KRW	12,387,697 (0.14454)	2,882,310 (0.3289)	-1,208,912 (0.549622)	10,745,914 (0.28318)
(Sales) 5000~1000 million KRW	16,108,055 (0.26760)	-2,290,108 (0.5236)	-687,068 (0.791876)	16,092,215 (0.23281)
(Sales) 1000~3000 million KRW	-5,404,975 (0.62153)	549,494 (0.8837)	2,015,681 (0.445418)	5,378,334 (0.77054)
(Sales) 3000+ million KRW	-3,624,659 (0.71290)	2,794,434 (0.4349)	1,051,710 (0.671864)	125,893 (0.99407)
Observations	188	1065	888	183
Adjusted R-Squared	0.02824	0.05977	0.08039	0.02639

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.'

5.2. Discussions

The study conducted a multiple regression analysis to examine how the different firm characteristics related to R&D investment in terms of leasing payment of equipment. In addition, the study examined if there are any major differences between firms focused on process development, product development, data acquisition, and testing for certification. The results show that firms focused on data acquisition and testing for certification spent less than firms focused on process development. In addition, it was evident that firms with more employees will invest more in R&D collaboration and distribution. This result provides meaningful information as SMEs with fewer employees will invest less in R&D collaboration and distribution, thus, causing the lack of technical information and lack of equipment to conduct R&D. Furthermore, firms focused more on data acquisition and testing for certification rather than process or product development and showed greater investment in R&D collaboration and distribution as the number of employees increased.

Table 6 shows whether the analysis results for Model 1 presented in the study support the hypotheses in Section 3. The study results supported hypotheses 1, 3, and 6 that knowledge-based firms spent more than manufacturing firms, firms with more employees, and firms focused on the process, or product development spent more on leasing the equipment. However, the study failed to support hypotheses 2, 4 and 5 because the results were insignificant.

The result of the study offers several policy implications. First, even though SMEs and startups play an important role in a country's economic development, firms with more employees are more likely to invest in R&D and, thus, are more likely to have competitiveness over those with fewer employees. Therefore, the Korean government should allocate part of the national R&D funding to support SMEs and Startups with more employees and innovative technology, not by firm location or annual sales. Second, R&D collaboration is an important factor, especially for SMEs and Startups that do not have the best environment for R&D. Despite the importance, Korea does not emphasize R&D collaboration. Therefore, more support programs and funding must be allocated to this area of R&D. One area that can be focused on is the technology transfer and commercialization from universities and public research institutes to firms. The university-industry collaboration can be better supported to create an environment where collaboration becomes voluntary instead of forced. A

voluntary collaboration will help firms and public research institutes flourish by decreasing the number of developed technologies going unutilized and unused and help firms transition to be more independent rather than depending on government support.

Table 6: Hypotheses Results

Hypotheses	Results	Reason
H1 – Knowledge-based firms will have a higher leasing payment than manufacturing firms	Supported	The result shows that knowledge-based firms spent 4,050,744 KRW more, meaning these firms participated more than manufacturing firms.
H2 – Firms in the metropolitan area will have a higher leasing payment than firms in the non-metropolitan area	Failed to Support	The result shows that firms in non-metropolitan areas spent 1,834,668 KRW less than firms in metropolitan areas. However, the result was not significant.
H3 – Firms with more employees will have a higher leasing payment	Supported	The result shows that the leasing payment increased as employees increased.
H4 – Startups will have higher leasing payments than SMEs.	Failed to Support	The results show that the startups spent 950,890 KRW more than SMEs, but the result was insignificant.
H5 – Firms with higher annual sales will have a higher leasing payment	Failed to Support	The result shows no relationship between annual sales and the leasing payment, but the result was not significant.
H6 – Firms developing processes and products will have a higher leasing payment than firms participating in data acquisition and testing	Supported	Even though product development did not have a significant P-value, firms focused on process development and product development did have a higher leasing payment than firms focused on data acquisition and testing for certification

6. Conclusions

The objective of this study was to find the most significant firm characteristics that affect firms participating in an R&D collaboration and distribution program and investing in R&D in terms of leasing payment for equipment. The study found that firm size does have a positive impact on R&D investment, R&D collaboration and distribution. Furthermore, the results show that firms focused on data acquisition and testing for certification were more likely to participate in such a program. The study proved to policymakers and government officials that firms with more employees would more likely participate in government support programs. The study results also prove that government officials believe firm location does not impact R&D investment and R&D collaboration and distribution. Therefore, the study recommends dividing the R&D expenditure by the number of employees and the purpose of participation. Furthermore, the Korean government should focus on finding innovative programs to help startups and small firms grow and compete with international firms by assisting them in finding their core competencies.

The study has several limitations. First, the study conducted a simple regression analysis on firms and the total leasing payment by the firms. However, future research remains on how the program helped the R&D of the firms. The firms' annual sales change after the program can be examined. Second, the data used in the study were collected during the initial stage of the program. Therefore, whether the firm developed its process and products, acquired data, or tested for certification is unknown. A questionnaire to the firms should be considered to provide more accurate information in future research. Despite these limitations, the study provided meaningful results in improving SMEs' distributed collaboration and cooperation activity to improve the R&D process of Korean SMEs.

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