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Effect of R&D competence of Materials · Parts · Equipment Corporations on management performance

Sun-Young YU[1] , Sun-Jung YOON[2] , Jong-Hyen SEO[3]

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Abstract

Purpose: This study aims to examine the effect of SMEs' R&D competence on management performance. **Research design, data, and methodology:** The empirical data of this study are derived from 2,375 SMEs that participated in the material, parts, and equipment research and development support project conducted from 2014 to 2018. Among them, 2,230 data were analyzed by classifying them into high-tech and low-tech fields. SPSS 24.0 was used for statistical analysis and correlation analysis and T-TEST were applied. **Results:** It was analyzed that the level of R&D organization, research personnel, and the number of patent registrations all affected operating profit and sales. In particular, it has been proven that research personnel have a greater impact on management performance among the level of R&D organization, research personnel, and the number of patent registrations. In addition, there was a difference between high-tech and low-tech industries in the impact on operating profit and sales, which are indicators of management performance. **Conclusions:** This study suggests that R&D competence are strengthened to advance the material, parts, and equipment industries and to promote future growth, while differentiated support is needed according to each company's R&D competence and technology level.

Keywords: Materials·Parts·Equipment Corporations, Technology Industry, R&D Competence, Management Performance

JEL Classification Code: M11, M15, M19, M31

1. Introduction

The influence of the materials · parts · equipment industries on the Korean economy is expanding constantly. This is because the materials · parts · equipment industries serve as the foundation for all other industries, playing a critical role in the competitiveness of finished products and manufacturing industries. Korea produced consumer goods concentrated on light industry in the 1950s and 1960s, but by the late 1960s, the significance of heavy and chemical industries had been acknowledged.

Through a shift in perception, Korea sparked a drive to bolster the steel industry's global competitiveness, culminating in the founding of Pohang Steel in 1973. Following that, Korea joined the chemical material and display industries in the 1980s and 1990s, respectively, and has been leading the global market since the 2000s. It indicates that businesses such

[1] First Author. Director of Strength Management Research Institute, Email: dreamsecret@naver.com
[2] Second Author. Head of Yong-in Branch Department, Korea Technology Finance Corporation, Email: 542@kibo.or.kr
[3] Corresponding Author. Professor, Department of Business Administration, Tech University of Korea, Email: jhseo@tukorea.ac.kr

as automobiles, semiconductors, and displays are expanding externally, and that significant progress has been made in creating the groundwork for industrial development.

However, the high foreign dependency in the materials·parts·equipment industry, the decline of core technology development, and the failure to develop a cooperative business model between demand companies and supply companies all acted as impediments to industrial advancement and growth of future-oriented manufacturing industries. This demonstrates that Korea's industrial technology sector is vulnerable in terms of competitiveness, technology transfer, and technology protection. Furthermore, it is observed that the fundamental technological gap was most severe in the materials·parts·equipment industries.

Fortunately, as the significance of the basic industrial sector became evident in the 2010s, the government started announcing initiatives aimed at boosting the industry's competitiveness. Moreover, as a result of the trade frictions between Korea and Japan in 2019, the materials·parts·equipment industries reached a great turning point. Since then, the government has invested all of national resources and capabilities, for example, contributing more than KRW 1 trillion per year, to support the materials·parts·equipment industries. The Act on Special Measures was adopted on April 1, 2020, to enhance global competitiveness in the materials·parts·equipment industries (Press Release on January 21, 2020, Ministry of Trade, Industry and Energy). This is primarily to improve national industrial competitiveness by enhancing industrial structure in a manner that lowers foreign dependency in the materials·parts·equipment industries through technical innovation and SMEs' R&D. (Kim, 2021; Yun & Seo, 2021).

In this context, this study investigates the relationship between R&D competence and management performance, both of which are indicators of mid- to long-term success in the materials·parts·equipment industries. Furthermore, this study compares high·medium-tech, and low-tech industries in order to suggest R&D strategies for the materials·parts·equipment industries.

2. Literature Review

2.1. Materials · Parts · Equipment Corporations

Article 「Act on Special Measures for Reinforcing Competitiveness in the materials・parts・equipment Industry」 define materials・parts・equipment corporations. Materials・parts are raw materials or intermediate products utilized in the manufacturing process of products. Equipment refers to manufacturing of materials·parts or machinery or equipment that manufactures products using materials·parts, as defined by Presidential Decree. Kim (2008) defined material parts as products of intermediate processes required for the manufacture of finished products, and materials as products made by processing raw materials and an element that comprises the finished product. He also described parts as objects that are employed in components and operate as a part of products such as machinery and equipment. Materials or parts, according to Lee, Jung, and Moon (2010), cannot make value for a product on their own, but may be manufactured by combining with other materials or parts and serving as a core component of the finished product. Lee and Bae (2016) defined the materials・parts・equipment industries as typical intermediate goods industries. They considered material parts as either a component of the finished product or a component utilized in a part of the finished product and described the material parts industry as an industry that can operate in conjunction with other material parts rather than the finished products. In other words, the material part is an intermediate product that is employed as a component of the finished product. According to Kim and Park (2017), material parts are part of the finished product and serve a specific role including value creation, advanced technology, and core advanced technology. Furthermore, they argued that material parts are the basis of the finished products industry, and that there is a strong association between industries. Clare (1996) highlighted that material parts are significant elements such as quality, competitive advantage, and finished product pricing, and they impact management performance.

Kim and Park (2017) argued that the development of materials and parts has an impact on the creation of new products, considering that new product development necessitates the development and enhancement of material parts utilized in new products, and the competitiveness of new products influences the competitiveness of material parts.

Korea established the first plan for parts and materials development in 2001 and started to support it in order to foster and advance the materials·parts·equipment industry. According to Baek (2019), it is critical to establish a policy for sustainable growth and development of materials and parts in the technological field, and ongoing government support, given that Korea's materials industry has a competitive advantage in relations with the United States but is inferior to Japan and China. Kwon, Park, and Kim (2020) suggested that technological development in material and parts industries does not result in short-term outcomes, but rather in mid-to-long-term outcomes.

2.2. R&D Competence

R&D competence refers to a company's capacity to conduct research and development. Companies use their R&D competence to develop new technologies and new products, commercialize them, and improve existing products to meet customer requirements to achieve sustainable growth. According to Madey and Dean (1992), mid-to-long-term research strategies and product development are required in order to grow the company with their limited resources.

Jang (2002) indicated that new product development should be implemented by the construction of a mid-to-long-term management strategy and R&D plan. According to Irwin and Klenow (1994), Park and Yang (2010), it is essential for a company to rapidly acquire and apply the core technology of a new product in order to consistently grow. Kim, Kim, and Og (2011) suggested that acquiring technology through technology transfer may shorten the time necessary to develop technology and accomplish the desired outcome. Song (2010) indicated that securing the core technology of a product affects product development, product improvement, and process improvement. According to Jang (2002), R&D for new products may underperform if the company's R&D workforce is insufficient compared with the size of the company. Park and Yang. (2018) proposed that organizational development achievement fosters a feeling of accomplishment and promotes job stability, resulting in a high level of satisfaction. According to Kim (2021), network building improves entrepreneurial performance. Cho et al. (2020) demonstrated that dynamic capabilities such as information search capability, information acquisition capability, and resource reconstruction capability all impact management performance. Kim (2021) proposed that the innovative behavior of organizational members has an effect on director's leadership and relationships.

According to Farris and Cordero (2002), management and remuneration of a company's key R&D experts are critical elements in product development. Kim and Park (2017) considered core human resources as "critical workforce that has knowledge and experience in product technology development and process optimization for product development and technology commercialization." Eberhart, Maxwell, and Siddique (2004) demonstrated that companies who raised their investment in SMEs technology development considerably enhanced their operating profit. According to Tubbs (2007), corporate investment in technical innovation has an impact on management performance. Zahra and George (2002) indicated that the more researchers, the more active the creation of new technologies and products is, and the more profit is generated. Pakes (1985) suggested that the number of patent applications and the expenditures associated with technical innovation influence company valuation and that as the number of patents grows, corporate value increases.

2.3. Management Performance

Given that a business's purpose is sustainable growth and profit production, establishing performance indicators may be a crucial issue. Ohlson (1995) emphasized the importance of future corporate value and financial performance in representing the flow of management performance in terms of management performance assessment. In relation to the management performance, profitability is measured by Return on Assets (ROA) and Return on Equity (ROE), as well as growth is represented by Sales Growth Rate (GRW).

According to Kwon et al. (2010), the difference between return on assets and return on equity is determined by the amount of equity capital and the capital composition ratio. Hwang (2014) emphasized that the CEO of a company values the return on assets and prioritizes the efficient use of total assets, while stockholders prioritize the company's sales development and profit production, as well as the return on equity. Previous studies showed that the majority of management performance indicators employ the return on assets and the return on equity (Jo, Hong, & Jung, 2019). Venkatraman and Ramanujam (1986) characterized management performance as three indicators: financial performance, non-financial performance, and organizational effectiveness. According to their research, financial performance can be quantified by ROI, ROA, ROS, and ROE, while non-financial performance can be measured by market share, growth rate, diversification, and product innovation. Organizational effectiveness can be measured by work level, standard of living, satisfaction, and corporate social responsibility. Stuart and Abetti (1987) assessed the success of SMEs based on financial and non-financial performance (recruitment of human resources, learning process, and social responsibility). Lee and Yang (2016) measured management performance as sales, net profit growth rate, and profit margin. In addition, Lee and Yoo (2018), Yoon and Seo (2021) defined management performance as sales (growth) and operating profit margin (profitability). It is vital for companies to consider both the growth rate of sales (GRW) for their sustainable growth and profitability that create profits. In this context, sales and operating profit margin of the materials · parts · equipment corporations were employed as management performance factors in this research.

3. Research Design, Data and Methodology

3.1. Research Design

This research explored the difference between high·medium-tech industries and low-tech industries, in terms of influence of materials·parts·equipment corporations' R&D competency on management performance. To this purpose, the R&D competence was subdivided into four sub-elements: R&D organization level, research workforce, R&D costs, and patent registrations. Following that, the effect of these factors on sales and operating profit, which are sub-factors of management performance, was evaluated. Furthermore, it was examined if a difference exists between high- and medium-tech industries and low-tech industries. In this regard, the following research models and hypotheses were developed based on previous researches for high·medium-technology, low-technology and R&D competence.

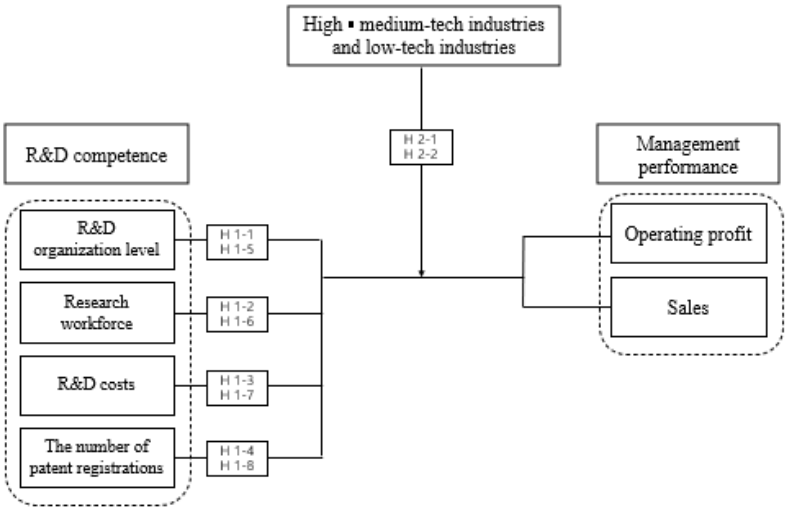

Figure 1: presents a research model including substances

Current market instability and digital transformation in the fourth industrial revolution era encourage the global market to ensure competitiveness by boosting the materials·parts·equipment industries. Demand for material parts is determined by the demand for the finished product. Due to the fact that material parts have a significant role in the quality, performance, and price of finished products, it is necessary to develop appropriate material parts to enhance new or current products. It implies that material parts and finished product have an interdependence, and that the competitiveness of material parts may lead to the competitiveness of finished products. Further, the development of material parts entails a high risk and high return. In this regard, if the development of material parts is successful, it may establish a monopolistic position in the market, and since the new material parts can be applied to a wide variety of end products, it may maintain dominance for an extended period of time and have a ripple effect on other industries. According to Chauvin and Hirschey (1993), corporate R&D contributes to long-term growth, resulting in increased company value. Dutta (1999) suggested that a company's R&D competence is a factor in the success of a new product on the market and a management performance, which is a crucial component of the company's sustainable growth. Keizer, Dijkstra, and J. Halman (2002) argued that, for SMEs to grow consistently, their fundamental competitive advantage should be cultivated, and R&D activities are a critical indicator of management performance. Lev and Sougiannis (1996) demonstrated that R&D is critical to the survival and sustainable development of businesses with their analysis of manufacturing companies. In this context, the following hypotheses were established based on previous research.

H1: The R&D competence of materials・parts・equipment corporations will have a positive effect on operating profit.

H1-1: The R&D organization level of materials・parts・equipment corporations will have a positive effect on operating profit.

H1-2: The research workforce of materials・parts・equipment corporations will have a positive effect on operating profit.

H1-3: The R&D costs of materials・parts・equipment corporations will have a positive effect on operating profit.

H1-4: The number of patent registrations of materials・parts・equipment corporations will have a positive effect on operating profit.

H1-5: The R&D organization level of materials · parts · equipment corporations will have a positive effect on sales.

H1-6: The research workforce of materials · parts · equipment corporations will have a positive effect on sales.

H1-7: The R&D costs of materials · parts · equipment corporations will have a positive effect on sales.

H1-8: The number of patent registrations of materials · parts · equipment corporations will have a positive effect on sales.

H2: There will be differences in management performance depending on the technology industry of materials · parts · equipment corporations.

H2-1: There will be differences in operating profit depending on the technology industry of materials · parts · equipment corporations.

H2-2: There will be differences in sales depending on the technology industry of materials · parts · equipment corporations.

3.2. Data and Methodology

The empirical data for this research derives from a total of 2,375 SMEs that participated in the R&D support project for material · parts · equipment corporations from 2014 to 2018 implemented by the Korea Technology and Information Promotion Agency for SMEs. Among them, 2,230 extracted data were analyzed by categorizing companies as high-tech, medium-tech, and low-tech sectors. Regarding the R&D competence, empirical studies were conducted by Farris and Cordero (2002), Irwin and Klenow (1994), Madey and Dean (1992). Only corporate research institutions and research departments registered with the Korea Industrial Technology Association were regarded as R&D organization level. The research workforce, which refers to the number of human resources in research institutions/R&D departments, was limited to those who are entirely charge of R&D. R&D costs were calculated by summing the Total Increased Amount on Development Costs and the Amortization Expenses on Development Costs on the balance sheet, as well as Ordinary Development Expenses, research expenses, and ordinary development expenses on manufacturing costs on the income statement. For the number of patent registrations, the value for the number of registered patents was used.

The analysis in this research was conducted by standardizing each variable to a 'z-value' using a standard normal distribution. The acquired data were analyzed using SPSS 24.0, and descriptive statistical analysis was conducted to examine the characteristics of variables. Reliability was confirmed by Cronback's α value, which tests internal consistency. Correlation analyses were conducted between each variable and multi-group analyses were performed to test hypotheses. Following that, t-test analyses were conducted to establish the difference between high·medium-tech and low-tech sectors.

4. Results

4.1. Basic Statistical Analysis

Basic statistics for the sample group are as follows: R&D organization level (minimum value: 0, maximum value: 1), research workforce (minimum value: 1, maximum value: 113), R&D costs (minimum value: 0, maximum value: 12,423,866), the number of patent registrations (minimum value: 0, maximum value: 79). The company distribution, which is a group variable, was classified according to the OECD categorization standards into high-tech, medium-tech, and other sectors. 1,390 companies were categorized as high · medium-tech technology sectors, whereas 840 companies were classified as other technology sectors.

4.2. Correlation Analysis

Correlation analysis findings are shown in Table 1 to validate the association and direction of variables and to assess discriminant validity.

Table 1: Results of Correlation Analysis (n=2,230)

	1	2	3	4	5	6
R&D organization level	1					
Research workforce	.053*	1				
R&D costs	.037	.562**	1			
The number of patent registrations	.047*	.341**	.332**	1		
Operating profit	.156**	.366**	.232**	.210**	1	
Sales	.117**	.405**	.254**	.198**	.788**	1

Note: * p<.05, ** p<.01

4.3. Statistical Hypothesis Test

To test the hypothesis, regression analysis was performed after controlling for innovative, start-up, and local businesses that have a relationship among statistical attributes. To test (hypothesis 1), factors affecting operating profit and sales were analyzed. As a result of the analysis, the R&D organization level (β=.121, p<.001), research workforce (β=.315, p<.001), and the number of patent registrations (β=.121, p<.001) have a statistically significant positive effect on operating profit. On the other hand, it was observed that R&D costs (β=.016, p >.05) had no statistically significant effect on operating profit. In addition, it was found that the R&D organization level (β=.086, p<.001), research workforce (β=.362, p<.001), and the number of patent registrations (β=.058, p<.01) have a statistically significant positive effect on sales. Whereas R&D costs (β=.023, p>.05) had no statistically significant effect on sales. Hence, hypothesis 1 was partially accepted. Specifically, <Hypothesis 1-1>, <Hypothesis 1-2>, <Hypothesis 1-4>, <Hypothesis 1-5>, <Hypothesis 1-6>, <Hypothesis 1-8> was accepted, but <Hypothesis 1-3> and <Hypothesis 1-7> were rejected.

To test (Hypothesis 2), it was examined whether or not a difference in operating profit and sales exists between high · medium-tech sectors and low-tech sectors. Operating profit was (t=3.796, p<.001), while sales were (t=2.695, p<.05), indicating a difference between high · medium-tech sectors and low-tech sectors. According to group statistics, the average operating profit for high · medium-tech sectors was (5.569), while it was (5.480) for low-tech sectors, showing that high · medium-tech sectors had a greater impact on operating profit than low-tech sectors. Therefore, (Hypothesis 2) was also accepted.

Table 2: The difference in operating profit between high-tech and medium-tech industries and low-tech industries

Variable	Average		SD		t	p
	high · medium-tech (n=1390)	low-tech (n=840)	high · medium-tech (n=1390)	low-tech (n=840)		
Operating profit	5.569	5.480	0.525	0.553	3.796	<.001

Table 3: The difference in sales between high-tech and medium-tech industries and low-tech industries

Variable	Average		SD		t	p
	high · medium-tech (n=1390)	low-tech (n=840)	high · medium-tech (n=1390)	low-tech (n=840)		
Sales	6.876	6.818	0.485	0.495	2.695	.007

5. Conclusions

5.1. Contribution

This research examined the materials · parts · equipment industries that are critical in the fourth industrial revolution era, as well as their research and development competence. This study aimed to investigate the effect of R&D competence in high · medium tech sectors and low-tech sectors on management performance, as well as the difference between high · medium tech sectors and low-tech sectors.

As a result of the analysis, it was confirmed that the level of R&D organization, research workforce, and patent registration had an effect on sales, and among the level of R&D organization, research workforce, and patent registration, research manpower had a great influence on operating profit and sales. It can be seen that companies in the materials, parts, and equipment industries should grow their R&D competence to achieve sustainable growth of companies.

Specifically, the competence to enhance current products and technology through the establishment of a research institution or research department is critical in terms of R&D organization level. The existence of a research institute or research and development department focuses a company's R&D efforts, which results in an increase in management performance. The result of this study contrasts with prior study by Lee (2016), Yoon and Seo (2021), which concluded that it is more necessary to create actual profits than to simply have a research center or R&D department.

The number of patent registrations was found as a factor affecting management performance, which is consistent with the findings of Cockburn and Griliches (1988), Chauvin and Hirschey (1993). It can be observed that the efforts of companies to develop new technologies and products through constant research and development and to increase their patent registrations enhance their management performance as a consequence.

R&D costs are those expended to develop new products, new technology, or improvements to current products. It was found that in order to improve management performance, it is critical to spend R&D expenses appropriately for the company's circumstances, rather than merely increasing R&D expenses.

Furthermore, the difference between the two sectors, high · medium-tech and low-tech, was observed. It was found that R&D competence had an effect on operating profit and sales both in the high · medium-tech industries such as electronic products, medical devices, aerospace, medical and pharmaceutical products, chemicals, electrical machinery, and automobiles, and in the low-tech industries such as clothing, wood furniture, publishing, and recycled products. However, R&D competence had a greater effect on operational profit and sales in the high-tech and medium-tech industries. Given that high-tech and medium-tech sectors require more technology than low-tech industries, it can be seen that high-tech and medium-tech corporations place an emphasis on enhancing their profitability and sustainable growth via the enhancement of R&D competence.

In conclusion, it was found that corporations in the materials · parts · equipment sectors should prioritize and strengthen their R&D competence in order to boost the management performance that is critical for survival and sustainable growth. In addition, this study suggests that the government should support to strengthen R&D competence in order to facilitate the sophistication and future growth of the materials · parts · equipment industries, while also providing differentiated support based on each component of R&D competence and the technological level of each company.

5.2. Limitations and Future Research Direction

The limitation of this study is that first, what R&D competence of materials, parts, and equipment companies can be defined differently for each era. In this study, it was not possible to contain independent variables containing all the changes of the times. The second constraint is that this study's sample is constrained to companies that have received research and development support from the Korea Technology and information Promotion Agency for SMEs. Therefore, it is expected to contain more diverse examples of companies in the future. It is expected that more in-depth results can be derived if the era of R&D competence can be broadly captured, and more diverse corporate data can be used.

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