

# Analysis on the Factors Influencing Government's R&D Investment Outcome in the IT Industry

Ri-Shu Quan

Assistant Professor, Department of Chinese Business & Economics, Hannam University

## IT 산업에 대한 정부R&D투자의 성과에 영향을 미치는 요인 분석

권일숙

한남대학교 중국경제통상학전공 조교수

**Abstract** The purpose of this study is to analyze the effects of government's R&D investment outcome on the IT industry. The analysis of R&D investment outcome developed emphasizing qualitative outcome more than quantitative outcome. However, it is still leaning on technological outcome-centered methods, having relatively little interest in inputs that actually determine the outcome. Thus, this study intends to focus on the qualitative attributes of input resources. The results of the empirical analysis can be summarized as follows. In raising technological outcome and commercialization outcome of R&D investment, more funds per researcher and numbers of researchers and a longer development period had positive effects. However, a higher ratio of doctors had positive effects only on technological outcome (papers and patents), It is believed that leading to commercialization outcome needed a long period, but the period of task development was only an average of two years. On the contrary, collaboration had negative effects on technological process, which indicates that collaboration between two organizations having conflicting interests would lead to negative effects on the outcome. The results show that the qualitative attributes of input resources have significant effects on R&D investment outcome, and imply that it is necessary to emphasize the qualitative attributes from the input stage to promote government's R&D investment outcome in the future.

**Key Words** : IT Industry, National R&D Project, R&D Performance, Technicalization Process, Commercialization Process

**요 약** 본 논문은 정부의 R&D투자 성과에 영향을 미치는 요인을 확인하기 위하여 2009-2013년 IT산업에 투자한 670개 과제를 분석하였다. 그간 R&D투자에 따른 성과는 양적 결과보다 질적 결과를 강조하는 추세로 바뀌었다. 하지만 여전히 기술적 성과 중심의 방식에 의존하고 있으며, 실제로 투입 단계에서 질적으로 우수한 자원투자가 이루어졌는가에 대해서는 상대적으로 관심이 적었다. 따라서 본 연구에서는 투입자원의 질적인 속성에 초점을 맞추고자 한다. 실증분석의 주요결과는 다음과 같다. R&D투자의 기술적성과와 사업화성과에 출연금과 연구원수가 많을수록 개발시간이 길수록 긍정적인 영향을 미치는 것으로 확인되었다. 높은 박사비율은 기술적성과(논문, 특허)에만 긍정적인 영향을 미쳤는데, 이는 개발시간이 평균 2년 이상으로 짧았기 때문으로 판단된다. 반면 공동연구여부는 기술화에 부정적인 영향을 미쳤는데, 이는 이해관계가 상충하는 두 기관 간의 협력은 오히려 성과에 부정적임을 의미한다. 이상의 결과는 R&D투자성과에 투입자원의 질적인 속성은 매우 중요하며, 향후 정부의 R&D투자성과를 촉진하기 위해서는 투입단계의 질적 속성을 강조할 필요가 있음을 시사한다.

**주제어** : IT산업, 정부R&D투자, R&D성과, 기술화, 사업화

\*This work was supported by 2018 Hannam University Research Fund

\*Corresponding Author : Ri-Shu Quan(ilsook@hnu.kr)

Received November 1, 2018

Revised November 30, 2018

Accepted January 20, 2019

Published January 28, 2019

## 1. INTRODUCTION

As R&D investment could strengthen corporate competitiveness, develop the industry, and promote economic growth, governments of the world have invested huge resources in corporate R&D. Korean government is also investing lots of resources in R&D every year not to lag behind. Fig. 1 shows a total of R&D expense percentage compared to the GDP of the 2015 OECD countries, and Korea is in second place with 4.23% following Israel(4.25%). Considering the fact that the average ratio of OECD countries is 2.40%, Korea is investing relatively a larger amount of resources in R&D than competitors[1].

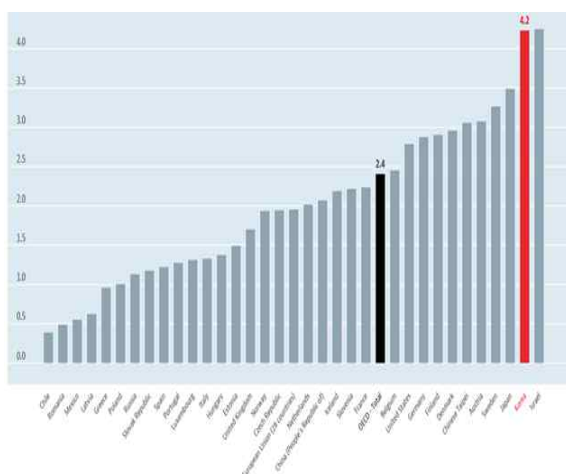


Fig. 1. Gross Domestic Spending on R&D of OECD countries, 2015.

Source: OECD Homepage(<https://data.oecd.org/rd/>)

Besides, as even the same amount of capital invested in R&D would result in a high level of outcome for some companies and a low level for others, discussions about the factors influencing the outcome have continued. For the last decade, the analysis on R&D investment outcome has developed immensely. Especially, its focus has moved from quantitative outcome to qualitative outcome. Nevertheless, the analysis is still relying on technological outcome-centered methods. As a result, this analysis focuses on judging qualitative outcome of papers or patents, showing little interest in inputs that

actually determine qualitative outcome. That is, it only has highlighted the amount of investment in R&D or numbers of researchers. However, as technological outcome emphasizes qualitative outcome, if qualitative attributes influence the outcome, management of outcome will have to focus on the qualitative attributes from the input stage in the future. Thus, this study intends to focus on the qualitative attributes of input resources, that is, funds per researcher, quality of researchers, collaboration, and so on.

In this sense, this study tries to divide R&D investment outcome into technological outcome (papers and patents) and commercialization outcome (technological process and commercialization process), examine the effects of the qualitative attributes of inputs on the outcome, and derive implications to promote R&D investment outcome.

The remaining parts of this paper are as follows. Chapter II examines preceding studies, and Chapter III introduces samples and methodologies. Chapter IV suggests the main results of the empirical analysis, and Chapter V arranges the conclusion and limitations.

## 2. LITERATURE REVIEW

As active R&D investment is the driving force to lead economic growth, governments over the globe are inputting a great deal of resources into corporate R&D. Especially Korea has recently been tending to expand government-led national R&D projects. According to the OECD, when R&D investment ratio during the 2007 was set at 100, the Korean Government's 2018 R&D investment ratio represented 18.4, which is far exceeding the OECD average ratio(115.1), the average ratio of the 28 EU member states(112.4), German average ratio(135.5), Taiwan average ratio(104.7) and Japan average ratio(103.6). The total amount of Korean government's investment in national R&D projects in 2015 was 18 trillion 874.7 billion KRW, which increased by 7.0% compared to the previous year. In addition, the amount of Korean government's

investment in national R&D projects annually grew by 6.2% on average for the last five years (2011–2015), which is 1.2 times higher than the annual average growth rate of the integrated financial size (5.3%)(Sul, 2017)[2].

Promising futuristic technologies so-called 6Ts (IT, BT, NT, ST, ET, and CT) account for the largest proportion of national R&D projects, with IT being the highest. Korean government invested 3 trillion 336.8 billion KRW in the IT area in 2015, which accounted for 19.0% of the total amount of investment in promising futuristic technologies, 17 trillion 519.9 billion KRW(KISTEP)[3].

As national R&D projects are important political projects spending a huge amount of budget, it is also important to verify if the projects were successful enough to achieve original goals. There are many domestic and foreign studies verifying government's R&D investment outcome as below.

Hsu & Hsueh (2009) proceeded with the assessment of outcomes of 110 R&D projects supported by the government in three stages (First stage: DEA, Second stage: Tobit regression analysis controlling external variables, Third stage: Comparison of R&D projects using 'adjusted data'), and contended that when the government would give a subsidy to a company, there should be an appropriate ceiling. Yoon (2013) aimed for 1,171 corporations, universities and research laboratories that completed the national R&D project from 2006 to 2011, analyzing the factors that would affect the use and spread of the outcome of national R&D field of energy. According to final multiple regression analysis, publication of treatise (non-SCI) and activity about patent (registered patent) had effects on technical commercialization, and both factors had positive effects on it. Kim, Yoo & Ryu (2013) conducted GLS regression analysis on 92,128 R&D programs supported by the Korea national government in the period of four years from 2006 to 2009. They also presented that the relationships between cooperative factors and first & second R&D

performance could be moderated by the characteristics of R&D projects such as numbers of researchers and R&D stage. Lee, Lee & Park (2015) found that government R&D support would positively influence the SMEs' technological performance. However, the level of financial support did not significantly influence the technological uniqueness. As such, it could be expected that the effects from the increase in quantity of government R&D support would be limited. Choi & Kang (2016) aimed to analyze the factors that would influence the technological performance of national R&D programs. In conclusion, different factors influenced the technological performances of the national R&D programs in the chemical and machinery technology R&D. This could imply that it would be necessary to consider the characteristics of industry-specific technology upon making science and technology policies for the national R&D programs. Choi, Oh, & Lee (2016) aimed to analyze the 212 R&D projects with 144 ones for marine and 68 for fisheries performed for 5 years, from 2010 to 2014. Based on the results, this study suggests the policy implications for the success of national R&D program, diversifying the main performing body, operating the system for sharing research infrastructures among researchers, introducing the adaptable R&D program management, expending the portion of grants without detailed requests for proposal. Carboni (2017) investigated the effects of seven European governments' support for investment and R&D expenditure. The paper found that grants would trigger the use of long-term credit, suggesting that public policies might help firms facing financial constraints and foster their growth[4–10].

Although the outcome of corporate R&D investment could be divided into technological outcome (papers, patents) and commercialization outcome (technological process, commercialization process), most preceding studies consider the outcome of corporate R&D investment to be technological outcome. In addition, although most preceding studies emphasize the qualitative attributes of technological outcome, there

are few studies examining the qualitative attributes of input resources.

### 3. RESEARCH METHODS

#### 3.1 Samples and Research Methodologies

This study intended to examine the factors influencing R&D investment outcome in the IT industry accounting for the largest proportion of Korean government's national R&D projects. Therefore, the object of the empirical analysis was IT project supported by the government R&D budget from 2009 to 2013. Data was obtained from National IT Industry Promotion Agency (NIPA), and 670 tasks containing intact data were selected as samples.

Table I shows descriptions of the final samples. The research was conducted using regression analysis with Stata 12.

Table 1. OUTLINE OF SAMPLES

Year	Information communication & media	IT convergence technology	Total
2009	77	124	201
2010	38	119	157
2011	35	95	130
2012	25	60	85
2013	33	64	97
Total	208	462	670

#### 3.2 Definition of Variables

In order to examine the inputs influencing R&D outcome, this study used technological outcome (papers and patents) and commercialization outcome (technological process and commercialization process) as dependent variables. Funds per researcher, development period, numbers of researchers, ratio of doctors, and collaborative research reflecting the qualitative attributes of input resources were used as independent variables. In addition, local infrastructure, technology life cycle, R&D stage, and main research agent were used as control variable. Table 2 shows more detailed explanations about dependent and

independent variables.

Table 2. DESCRIPTION OF VARIABLES

CL.	Variables	Description on Variables	Expected Sign
Dependent Variables	Papers	Numbers of publication in SCI and non-SCI journals	
	Patents	Numbers of application and registration	
	Technological process	Numbers of technicalization process	
	Commercialization process	Numbers of commercialization process	
	Funds per researcher	Ln (Funds / Numbers of researchers)	+
Independent Variables	Development period	Numbers of months from beginning month and ending month of task	+
	Numbers of researchers	Numbers of researchers participating in task	+
	Ratio of doctors	(Numbers of Researchers / Numbers of Doctors) * 100	+
	Collaborative research	Collaboration research=1, Non-collaboration research=0	+
	Local infrastructure	Capital area (Seoul, Gyeonggi, Incheon) and Daejeon =1, Others=0	+
Control Variables	Technology life cycle	Initial stage=1, Growing stage=2, Maturing stage=3, Declining stage=4, Others=5	+
	R&D stage	Basic research=1, Application research=2, Development research=3	+
	Main research agent	Companies=1, Institutions, Universities, Government ministries or Others=0	+

As more funds per researcher could lead to more resources that researchers could use, resulting in more papers and patents and better commercialization process, it appears to be positive (+). As a longer development period could lead to more time to spend in R&D, resulting in better outcome, it is expected to be positive (+). As more numbers of researchers could lead to more active participations in related activities, it is expected to positively influence the outcome. In addition, as a higher ratio of doctors having a larger amount of knowledge could lead to better outcome, it is expected to have positive effects. As collaborative research could bring about synergy effects by combining internal and external knowledge, it is expected to have positive effects on the outcome. For local infrastructure, a dummy variable, because local infrastructure is more solid in the capital area and

Daejeon, it is expected to have positive effects on better R&D outcome. For technology life cycle, it is highly likely that technological outcome will lead to commercialization process as the cycle moves from the introductory stage to the maturing stage, so technology life cycle appears to be positive (+). For R&D stage, as application research and development research would require more technological outcome than basic research, R&D stage is expected to have positive effects on the outcome. For main research agent, although government branches, laboratories, or universities could lean towards technological outcome (papers and patents), companies would focus on making the outcome as commercialization process through technological outcome is more important for them, and thereby main research agent is expected to have positive (+) effects.

#### 4. EMPIRICAL ANALYSIS

This study tried to verify the inputs influencing government's R&D investment outcome in the IT industry. Table 3 shows the descriptive statistics quantity of main variables and their correlations. As a result of analyzing their correlations, the coefficient between variables turned out to be below 0.4, which is appropriate.

Table 3. DESCRIPTIVE STATISTICS AND CORRELATION ANALYSIS

Descriptive statistics	1.	2.	3.	4.	5.	6.	7.	8.	9.
Mean	609	26.2	24.9	64.5	0.5	0.9	1.4	2.4	0.3
Standard deviation	1.2	18.1	26.9	25.8	0.5	0.3	0.9	0.8	0.5
Correlation coefficient									
1. Funds per researcher (million)	1.000								
2. Development period	0.071**	1.000							
3. Numbers of researchers	-0.291***	-0.107***	1.000						
4. Ratio of doctors	-0.395**	0.059	0.326***	1.000					
5. Collaborative research	0.291***	-0.127***	-0.048	-0.135**	1.000				

6. Local infrastructure	-0.068*	-0.042	-0.057	-0.014	-0.040	1.000			
7. Technology life cycle	-0.178***	-0.046	-0.020	-0.029	-0.246***	0.067**	1.000		
8. R&D stage	-0.004	0.030	0.065*	0.020	-0.033	0.001	-0.042	1.000	
9. Main research agent	-0.045	-0.039	-0.114**	-0.068*	-0.099	0.065**	0.144***	0.295***	1.000

\*, \*\*, \*\*\* indicate statistical significance at the significance level =10%, 5%, 1%, respectively.

In order to analyze the determinants of government's R&D investment outcome, regression analysis was conducted, and the analysis results are shown in Table 4. The model fit turned out to be significant at 1%.

Table 4. SUMMARY OF REGRESSION ANALYSES

CL.	Paper	Patents	Technological Process	Commercialization Process
Funds per researcher	0.001*** (7.51)	0.001*** (6.88)	0.001* (1.67)	0.001*** (3.65)
Development period	0.048*** (3.00)	0.051*** (4.51)	0.002 (1.56)	0.002* (1.82)
Numbers of researchers	0.084*** (7.48)	0.090*** (11.39)	0.006*** (6.43)	0.004*** (6.46)
Ratio of doctors	0.020* (1.66)	0.030*** (3.52)	0.001 (0.87)	0.001 (0.57)
Collaborative research	0.268 (0.44)	-0.147 (-0.34)	-0.110** (-2.00)	-0.001 (-0.94)
Local Infrastructure	1.056 (1.25)	1.911*** (3.22)	0.147* (1.95)	-0.144*** (-3.30)
Technology life cycle	-0.186 (-1.58)	-0.271 (-1.20)	0.016 (0.57)	-0.021 (-1.27)
R&D stage	-0.843** (-2.25)	-0.435* (-1.65)	0.022 (0.67)	0.010 (0.50)
Main research agent	-4.192*** (-6.43)	-1.829*** (-3.98)	-0.152*** (-2.61)	0.072* (2.17)
_cons	2.706* (1.79)	-0.563 (-0.53)	-0.261* (-1.93)	0.014 (0.18)
N	670	670	670	670
R2	0.22***	0.24***	0.09***	0.10***
F	20.261	23.716	6.934	7.943

\*, \*\*, \*\*\* indicate statistical significance at the significance level =10%, 5%, 1%, respectively.

Looking at the analysis results, more funds per researcher had positive effects on the outcome as expected. This result indicates that more funds per researcher would lead to more focus on R&D, resulting in better outcome. Although a longer development period had positive effects on papers, patents, and commercialization process, it had no effects on technological process. As a result of confirmation, an average development period was 26.2

months, and due to the short period, only 28 and 21 tasks went through technological process and commercialization process, respectively. This result came out because R&D investment should take a fairly large amount of time to lead to success of commercialization process. More numbers of researchers had positive effects on the outcome, which implies that more available manpower for creation of the outcome would result in better outcome. A higher ratio of doctors turned out to have positive (+) effects on papers and patents. As only approx. two years passed for most tasks, it seems that a higher ratio of doctors has not influenced commercialization outcome yet. Unexpectedly, collaborative research had negative effects only on technological process, which indicates that collaboration has more negative effects than synergy effects on technological process. As a result of confirmation, collaboration took approx. 52%, and it was found most at educational-industrial organizations. As universities emphasize technological outcome (papers and patents) much more, they have different interests from companies that focus on commercialization process. Although more solid local infrastructure had positive effects on patents and technological process, it had negative effects on commercialization process, which indicates that commercialization process was performed less in the capital area and Daejeon. R&D stage turned out to have negative effects on papers and patents in the early stage, which shows that application research and development research require more papers and patents than basic research. Although main research agent, a corporate dummy variable, had negative effects on papers, patents, and technological process, it had positive effects on commercialization process. This result implies that companies emphasize commercialization process more than papers, patents, or technological process outcome.

## 5. CONCLUSION

Korean government is inputting a large amount of

budget into national development projects every year, especially the IT field. Investment is important, but optimizing R&D investment outcome is even more fundamental. Thus, in order to grasp the qualitative inputs influencing government's R&D investment outcome in the IT industry, this study analyzed 670 IT tasks performed by government R&D budget.

If preceding studies focused on the qualitative assessment of technological outcome, this paper tried to highlight the qualitative attributes of input resources to examine their effects on the outcome. The results of the empirical analysis were as follows. In raising technological outcome and commercialization outcome of R&D investment, more funds and numbers of researchers and a longer development period had positive effects. However, as the average task development period was a little over two years, a higher ratio of doctors had positive effects only on technological outcome (papers and patents). This result implies that phased management is necessary to raise the outcome because R&D investment should take much time to result in success of commercialization process. On the contrary, collaboration had negative effects on technological process, which means that collaboration between two organizations having conflicting interests could negatively influence the outcome.

The results above show that the qualitative attributes of input resources have significant effects on R&D investment outcome. In other words, among input resources, especially funds per researcher, development period, numbers of researchers, and ratio of doctors have positive effects on technological outcome and commercialization outcome, which implies that it is important to emphasize the qualitative attributes from the input stage to promote government's R&D investment outcome in the future.

This study has a limitation that the average task development period is short. A follow-up study will be conducted later to overcome this limitation through reanalysis.

## REFERENCES

- [1] OECD Homepage. <https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm>
- [2] W. Sul. (2017). A proposal of new policies for improving the performance analysis on government R&D expenditure in ICT industry. *Journal of Digital Convergence*, 15(5), 151-159.  
DOI : 10.14400/JDC.2017.15.5.151
- [3] KISTEP(Korea Institute of S&T Evaluation and Planning). (2016). *2015 Survey of research and development in Korea*.
- [4] F. M. Hsu & C. C. Hsueh. (2009). Measuring relative efficiency of government-sponsored R&D projects: A three-stage approach, *Evaluation and Program Planning*, 32(2), 178-186.  
DOI : 10.1016/j.evalprogplan.2008.10.005
- [5] S. H. Yoon. (2013). *Analysis of application and diffusion effect factor of outcomes from national energy R&D project*, Master dissertation, Sungkyunkwan University, Seoul.
- [6] H. M. Kim, J. W. Yoo & J. S. Ryu. (2013). A study on the relationship between cooperative factors of national R&D projects and performance: Focusing on the moderating effect of projects' characteristics. *Korean Journal of Business Administration*, 26(3), 695-718.
- [7] H. S. Lee, J. S. Lee & J. M. Park. (2015). Technological performance analyses of SMEs based on type of government R&D support, *Korea Technology Innovation Society*, 18(1), 73-97.
- [8] J. Y. Choi & K. B. Kang. (2016). Factors that influence the technological performance of national R&D programs: in the case of the machinery and chemical technology R&D. *Journal of Korea Technology Innovation Society*, 19(1), 161-190.
- [9] S. S. Choi, I. H. Oh & D. M. Lee. (2016). A study on R&D performance analysis of marine technology, *Journal of Korean Society for Marine Environment & Energy*, 19(2), 165-171.  
DOI : 10.7846/JKOSMEE.2016.19.2.165
- [10] O. A. Carboni. (2017). The Effect of Public Support on Investment and R&D: An empirical evaluation on European manufacturing firms. *Technological Forecasting & Social Change*, 117, 282-295.  
DOI : 10.1016/j.techfore.2016.11.017

권 일 숙(Quan, Ri-Shu)

[정회원]



- 2011년 2월 : 숙명여자대학교 일반대학원(경영학석사)
- 2014년 8월 : 숙명여자대학교 일반대학원(경영학박사)
- 2014년 10월 ~ 2015년 3월 : 중국상해공정기술대학교 경영학과 조교수
- 2015년 4월 ~ 현재 : 한남대학교 중국경제통상학전공 조교수
- 관심분야 : 국제경영, 국제재무, CSR, R&D투자
- E-Mail : ilsook@hnu.kr