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Determinants of R&D Commercialization by SMEs after Technology Transfer

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Abstract This study aims to analyze the factors that could influence business decisions of in the commercialization of R&D when technology is transferred from government research institutes (GRIs) to small and medium-sized enterprises (SMEs). We examine 353 such cases of technology transfer. The dependent variable is whether the licensee had the intention of following up with R&D after the technology has been transferred. The independent variables, classified into ex-ante factors and ex-post factors, consist of the involvement of SMEs into GRI R&D, technology readiness level, relatedness to existing technologies, and contribution to sales revenue and level-up of existing technologies. The results of the study show that the contribution to existing technologies has a positive impact on R&D commercialization. However, unlike our expectation, contribution to sales revenue, the involvement of SMEs into GRI R&D, technology readiness level, the relatedness to existing technologies of the technology transferred have no impact on follow-up R&D.

Keywords SME, GRI, open innovation, R&D commercialization, technology transfer

I. Introduction

Firms confront hyper-competition along with the trend toward global openness across the globe (D'Aveni and Gunther, 1994). This trend makes small and medium-sized enterprises (SMEs) face more difficulties because they lack human and physical resources. SMEs counteract this trend with technological competition expecting positive effects on the firm's value, business performance and strengthened competitiveness (Robert and Timothy 2002; 2005).

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To increase performance, SMEs should strengthen the relationship between technological strategy and market environment. In addition, they should mobilize outside resources and/or government policy to overcome in-house limitation based on a correct understanding and analysis of the resources acquired. Technology acquisition from government research institutes is a good way for SMEs to avoid the risk inherent in early stages of R&D and give them opportunities to find new markets. Technology acquisition from outside helps SMEs recovers from the loss of temporary competitiveness in a short period of time, showing "chains of temporary competitive advantages (D'Aveni and Gunther, 1994)".

However, technology from GRIs is not mature to be used directly into products or processes. Their technological readiness levels are low, and most of them are essentially platforms, which can be used across the board. Therefore, follow-up R&D after transfer from GRIs is inevitable. The key topic under consideration is, thus, what constitute follow-up R&D. We define follow-up R&D as R&Ds implemented after transfer from outside to turn the existing technology into one that can be used into products or processes.

This article seeks to identify the determinants of the follow-up R&D of SMEs after technology transfer from GRIs. We analyzed the survey for technological commercialization by firms who transferred technology from GRIs. We also want to find out the determinants before and after the decision to transfer technology. The analysis is organized as follows: Section 2 lays out the theoretical framework; Section 3 explains the method; Section 4 presents the results; Section 5 discusses the findings and draws conclusion.

II. Theoretical Discussion

1. R&D of SMEs

R&D activities and related investment increase the firm's value and keep sustainable growth. Researchers, however, have two different views on the efficiency of R&D given firm size. Many insist that big companies are more efficient than small ones since they have advantages in resources, economies of scale or scope, and network efficiency (Eisenhardt and Schoonhoven, 1996; Lawson and Samson, 2001; Schilling and Phelps, 2007). Further, Cooper and Kleinschmidt (1986), Graves and Langowitz (1993), Cassiman and Veugelers (2002) tested this view. Other researchers, however, take the view that SMEs are more efficient than big companies since big companies are bureaucratic and offer low compensation for personal inventor (Rothwell and Dodgson, 1994).

In general, SMEs are substantially behind in competitiveness since they lack resources such as funding, technology, manpower and information (Cohen, 1990; Jang et al., 2008). They are not active in R&D investment because of uncertainty in R&D and information asymmetry (Griliches, 1998). Therefore, SMEs are advised to seek outside sources to confront increasing uncertainty by shortening the life-cycle with level-up of technology (Zahra et al., 2000). The effect of utilizing outsource differs from each other because of licensees' effort and ability. This fact is the starting point of this article. If SMEs license technology from GRIs, what factor makes a firm successful in using the technology?

2. Follow-up R&D

Wiggins et al. (2002) documented the fact that the period of competitive advantage had been shortened and the number of recovering firms has grown after the loss of competitiveness.

Many countries provide SMEs with technology service from GRIs. The Korean government, under the Technology Transfer and Commercialization Promotion Act, actively encourages technology transfer from GRIs. This policy is not just for SMEs, but also for GRIs. This policy helps GRIs enhance the utilization of research output.

Technology transfer to SMEs itself, however, does not ensure the technological ability of SMEs. Dechenaux and Thursby (2011) and Thursby (2011) pointed out that the contract contents and moral hazard are important factors for the success of the technology transferred. They found that 93% of transferred technologies needed further R&D, and the failure ratio was 72%. Choi and Lee (1998) also confirmed that an understanding of the technological issues by the licensor, especially GRIs, is essential to the success of the transferred technology.

3. Success Factors for Technology Transfer

Transferred technologies from GRIs are not completed for any purpose. Also, the technologies are generally not under exclusive license. Therefore, many companies using this technology can become future competitors. These two facts make licensees carry out follow-up R&D. Fortunately, GRIs possess the follow-up support system after technology is transferred to SMEs. The SME licensee can take advantage of the technical support from GRIs in implementing R&D for final use.

Studies on the success factors for technology transfer pointed out factors such as absorptive ability, cooperative partnership, the role of mediation

agencies and the motive of the licensee. Min (2015) analyzed the success factors though the Logistic Regression Analysis and used the factors related to the abilities of licensor, licensee, and mediator. Park, Yoon, and Park (2015) identified factors such as readiness level, relatedness with existing technologies, and compatibility with existing technologies.

3.1 Ex-ante Factors for Technology Transfer

Santoro and Chakrabarti (2002) suggested ex-ante factors for the success of technology transfer highlighting the co-R&D. They also pointed out the importance of understanding technology and the existence of a network of technological manpower between licensor and licensee. Greiner and Franza (2003) analyzed the success and failure factors with the classification of general factors, official factors, and non-official factors. The lack of understanding of the technology is one of the failure factors. From this fact, we infer that co-R&D between licensor and licensee can be an influential factor for the success of a transferred technology (Agrawal, 2006). This research discussion leads us to consider "attending licensor's R&D" as an ex-ante factor.

In addition, the utilization pattern may impact on the success of technology transfer. Kamiyama et al. (2006) pointed out that technology transfer is an important method for the management of technology, and can be used for several purposes such as negotiation, tools for funding, new product development, and improvement of existing products. Therefore, the motive of technology transfer may be considered an ex-ante factor.

3.2 Ex-post Factor for Technology Transfer

The ex-post factors include the characteristics of the technology and the contribution of that technology to the licensed firm. Choi and Lee (1998) showed that the relationship between transferred technology and the firm's existing technologies affects the success of technology transfer. If there is no close relationship, a negative impact occurs. Kim (2005) analyzed the effect of technology transfer and found that the relatedness with existing technologies generates positive impacts. Yeo (2009) and Seo and Yang (2007) also found that the readiness level of the technology transferred gives positive impact to the success of technology transfer.

The success of commercialization of transferred technology can be affected by the internal ability of SMEs. Kim et al. (2006), based on the resource-based theory (Barney, 1991), confirmed the positive relationship of technological manpower between licensor and licensee. Yeo (2009) and Kim (2015) added that the ability of technological absorption also affects the success. In addition

to these studies, we add the contribution of technology transfer in the aspects of technology or value added to the licensee.

III. Method

1. Framework

We divide the factors according to the period before and after the transfer. These factors consist of the independent variables. The dependent variable is the intention to engage in follow-up R&D. The unit of analysis is the number of transfers. The framework is in Figure 1.

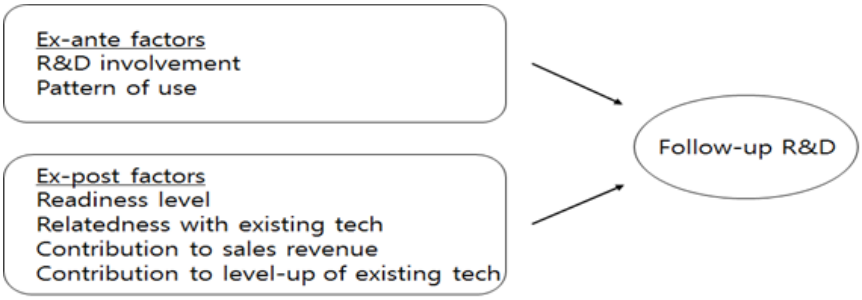

Figure 1 Analytical framework

2. Hypothesis

The variables used in prior research are summarized in Table 1. Non-Korean researchers such as Agrawal (2006) and Kamiyama et al. (2006) used the ex-ante variables. On the other hand, many Korean researchers used the ex-post variables - readiness level by Yeo (2009), relatedness with existing technologies by Kim (2006) and Choi et al. (1998), and contribution to sales revenue by Kim (2012) and Seo (2012).

H1 Ex-ante factors of technology transfer will affect Follow-up R&D of firms.
H1-1 Firms' involvement in GRI R&D will have a positive effect.
H1-2 Utilization pattern of transferred technology will affect Follow-up R&D.

H2 Ex-post factors of technology transfer will affect Follow-up R&D of

firms.

H2-1 Technology readiness level will affect Follow-up R&D.

H2-2 Relatedness to existing technologies will affect Follow-up R&D.

H2-3 The contribution of transferred technology to sales revenue will affect Follow-up R&D.

H2-4 The contribution of transferred technology to level-up of existing technology will affect Follow-up R&D.

Table 1 Existing researches

Variable			Research
Independent	Ex-ante factors	R&D involvement	Agrawal (2006)
		Pattern of use	Kamiyama et al. (2006)
	Ex-post factors	Readiness level	Yeo (2009)
		Relatedness with existing technologies	Kim (2006), Choi et al. (1998)
		Contribution to sales revenue	Kim (2012), Seo (2012)
		Contribution to level-up of existing technologies	Seo (2007)
Dependent		Follow-up R&D	

3. Data

3.1 Data Collection

We used the 2013 survey on the commercialization of technology transfer of A GRI. The survey covers 1,736 cases of technology transfer contracted in 2013 during March 20 to November 12. The survey was designed to check the effectiveness of SME support by technology transfer from GRI.

The details of the survey include the purpose, the path of existing perception, readiness for commercialization, and utilization pattern of technology transfer. It also includes areas of satisfaction with the technology, the results of commercialization efforts and the major reasons. Data collected in this survey involves 1,034 cases, 59.56% of total entries. Out of these, we selected 353 cases that had a clear purpose and commercialization use, and included information on all the items we wanted to examine.

The Firm characteristics of these 353 cases are as follows: By size – SMEs accounted for 98% of cases, medium companies 1% (4), big companies 1% (2). By industry - software (embedded or system, etc.) and IT fusion (IT car,

IT ship, IT building, etc.) accounted for 43% each followed by mobile telecommunication 8% and safety of knowledge and information 7%.

3.2 Measurement of Independent Variable

The ex-ante variables are R&D involvement by SMEs and the type of use of the transferred technology (Santoro et al., 2002; Greiner et al., 2003; Agrawal, 2006; Kamiyama et al., 2006). The R&D involvement by SMEs variable refers to whether a licensee is involved in the licensor's R&D. That is whether an SME is connected to the GRI's R&D. If that is the case, then we put 1, and if that is not the case, we put 0. The type of use of the transferred technology variable is measured by 1 or 0. If the technology is used for new product development, then it is 1. If the technology is used as level-up of existing products, then it is 0.

The ex-post variable simply refers to the satisfaction of licensee (Barney, 1991; Choi and Lee, 1998; Kim, 2005; Yeo, 2009; Kim et al., 2006). The satisfaction is measured by variables such as readiness level, relatedness with existing technologies, contribution to sales revenue, and contribution to level-up of existing technologies.

The readiness level of technology refer to the readiness for products, measured by the 5 Likert scale: very unsatisfied = 1, very satisfied = 5. The relatedness with existing technologies refers to the relationship between transferred technology and existing technologies. This relatedness is measured by the 5 Likert scale as well: no close relationship = 1, close relationship = 5. The contribution to sales revenue is also measured using the Likert scale: very unsatisfied = 1, very satisfied = 5. The measurement of the variable of contribution to level-up of existing technologies is the same as the contribution to sales revenue. All these measurements are summarized in Table 2.

Table 2 Measurement of independent variable

Variable		Measurement
Ex-ante factors	R&D involvement	Involve=1, non=0
	Pattern of use of transferred technology	Up-grade=0 New product=1
Ex-post factors	Readiness level	Very unsatisfied=1 unsatisfied=2 Average=3 Satisfied=4 Very satisfied=5
	Relatedness with existing technologies	
	Contribution to sales revenue	
	Contribution to level-up of existing technologies	

3.3 Measurement of Dependent Variable

The dependent variable is the follow-up R&D. If a licensee has the intention of following up with R&D, then we put 1, otherwise 0. We then can use the Logistic Regression Analysis. The method is detailed in Kim, Jung, and Park (2009).

Table 3 Measurement of dependent variable

Variable	Measurement
Intention for follow-up R&D	yes=1, no=0

IV. Results

1. Data Description

The basic statistics derived from the 353 cases of technology transfer are as follows: the number of R&D involvement of SMEs to GRI R&D ranges from 0 to 0.854, and the average is 0.37. The average of the pattern of use is 0.61. This number means that 61% of the purpose of technology transfer to SMEs is for new product development and 39% is for another purpose such as the upgrade of existing technologies or process innovation.

Table 4 Overview of data

Variables	N	Min	Max	Avg.	s.d.
R&D involvement	353	0	1	0.37	.484
Pattern of use	353	0	1	0.61	.488
Readiness level	353	1	5	3.61	.885
Relatedness with existing technologies	353	1	5	3.69	.769
Contribution to sales revenue	353	1	5	2.73	1.143
Contribution to level-up of existing technologies	363	1	5	3.61	.873
Follow-up R&D	363	0	1	0.22	.412

All the ex-post variables are measured by the 5 Likert scale. The average of the variable of readiness level is 3.61, and that of relatedness with existing technologies is 3.69. These numbers mean the readiness level and relatedness to existing technologies are not low. The average of the contribution to sales

revenue, however, is only 2.72, which is a low expectation. On the other hand, the average of the contribution to level-up of existing technologies is 3.61 unlike the variable of contribution to sales revenue. It is very interesting to note that technology transfer from GRIs to SMEs requires further follow-up R&D for a market success.

2. Results of Logistic Regression

The χ^2value of the Hosmer-Lemeshow Test for the result of the Logistic Regression Analysis is 14.033 with a statistical significance of 0.081. Thanks to this significance of 0.081, we regard this estimation model as acceptable (Lee and Lim, 2008).

The detailed coefficients and its statistical significance are shown in Table 5. The factors on follow-up R&D are "R&D involvement," "Contribution to sales revenue" and "Contribution to technology level-up."

Hypothesis 1-1 states that firms' involvement in GRI R&D will have a positive effect. The value of Exp (B) means the degree of a variable. In hypothesis 1-1, 0.534 means that non-involving firms are 53% higher in follow-up R&D.

Hypothesis 2-3 states that the contribution of transferred technology to sales revenue will have a positive effect on follow-up R&D. The coefficient of this variable has a statistical significance, but is negative. So, the hypothesis is rejected.

Table 5 Results of regression analysis

	β	S.D.	Wald	Sig	Exp (β)
H 1-1. R&D involvement	-.627	.308	4.139	.042	0.534
H 1-2. Pattern of use	.001	.286	.000	.998	1.001
H 2-1. Readiness level	-.201	.189	1.125	.289	0.818
H 2-2. Relatedness with existing technologies	.008	.203	.002	.967	1.008
H 2-3. Contribution to sales revenue	-.536	.130	16.940	.000	0.585
H 2-4. Contribution to technology level-up	.563	.130	8.188	.004	1.756
χ2 (d.f), Significance				24.519(6), .000	
Hosmer & Lemeshow Test: χ2 (d.f), Significance				14.033(8), .081	

Hypothesis 2-3 states that the contribution of transferred technology to level-up of existing technology will affect follow-up R&D. The coefficient of this variable of 0.563 has a statistical significance, and its Exp (B) is 1.756.

That means this hypothesis is accepted and this variable affects follow-up R&D 1.8 times. The summary of regression analysis is shown in Table 6.

Table 6 Summary of test

Hypothesis		Sig.	Judgment
H 1	Ex-ante factors of technology transfer will affect Follow-up R&D of firms.		
H 1-1	Firms' involving in GRI R&D will have a positive effect.	significant	reject
H 1-2	Utilization pattern of transferred technology will give effects Follow-up R&D.	-	-
H 2	Ex-post factors of technology transfer will affect Follow-up R&D of firms.		
H 2-1	Technology readiness level will affect Follow-up R&D.	-	-
H 2-2	Relatedness to existing technologies will affect Follow-up R&D.	-	-
H 2-3	The contribution of transferred technology to sales revenue will affect Follow-up R&D.	significant	reject
H 2-4	The contribution of transferred technology to level-up of existing technology will affect Follow-up R&D.	significant	accept

V. Discussion and Conclusion

1. Discussion

This article identifies some implications for follow-up R&D after a technology transfer. First, hypothesis 1-1 for the involvement of SMEs into GRI R&D has no statistical significance, so the hypothesis is rejected. This result is different from prior studies (Jung et al., 2008; Lee et al., 1996; Choi and Lee, 1998; Kim, 2008). However, it is similar to Park Yoon and Park (2015). The results seem to fit the general perception that the more market needs, the more R&D.

Second, the results of hypothesis 2-3 and 2-4 show that every firm conduct follow-up R&D actively if the transferred technology seems to contribute to sales revenue and the level-up of existing technologies. Furthermore, if we look at the value of Exp (β), the firm takes the view that "contribution to level-up of existing technology" is more important than "contribution to sales revenue," in follow-up R&D. This comparison leads us to infer the SMEs' motive of transfer. They want GRI technology for level-up of existing technology more than as a contribution to sales revenue. This difference may come from several facts: GRI technology has a tendency not to be used for products directly without follow-up R&D. The delay from acquisition to the utilization of the technology for products is not negligible in time and effort.

Although the just fitness of transferred technology to SMEs such as shortening and skipping follow-up R&D cannot be achieved by GRI R&D because of the main mission of GRI which ought to be to improve the effectiveness of technology transferred to SMEs. The measures will be the topic of the next research, but it may contain the following facts derived from this research: GRIs should consider the final needs of SMEs, by adjusting the final specification of the technology to be transferred to SMEs in the early stage of the transfer. Making available to SMEs the list of GRI's R&D and making access to GRI technology easy are factors to be considered.

2. Limitations

This study has limitations. First, although we analyzed 353 cases, they account for only 20.3% of the cases needed for the survey. Therefore, these 353 cases do not cover all the situations. Second, we have insufficient information about the sampled SMEs such as firm type, the existence of R&D organization, and the number of employees. Subsequent studies should include these types of control variables. Third, this is a study on a specific GRI involved with IT technology; it does not cover GRIs from all the technology fields. These fields are very diverse, as are the GRIs. Therefore, there could be differences in the time period between transfer and final utilization, that is, a market entry.

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