Determinants of External Technology Acquisition: Comparison across Sectors of Manufacturing Industry in Korea

Hoyeol Kim and Young S. Kwon

***Abstract*—Many organizations have paid much attention to the acquisition of external technology for improving their performance. In practice, this helps firms gain higher economic returns in an era of intensive competition and increasing technological complexity. Although the benefits of external technology acquisition have been emphasized in academic research, there was little effort to compare the determinants of external technology acquisition across industrial sectors. The objectives of this study are to categorize domestic manufacturing firms based on the modified industry classification and to analyze determinants of external technology acquisition of each sector by empirical analysis. Data are gathered from domestic technological innovation survey over the period from 2002 to 2004 in Korea, and logistic regression is employed for empirical analysis. As a result, each industrial sector has respectively shown a different influence on external technology acquisition. Accordingly, the government and companies should establish the governmental policies and company strategies suitable for each sector to acquire external technology.**

***Index Terms*—external technology acquisition, industrial sector, categorization, manufacturing, comparison**

I. Introduction

TECHNOLOGY acquisition plays an important role in improving a firm's competence. It is also one of the important methods of advancing an enterprise's technology and accumulating key resources [1]. Many organizations have paid much attention to the acquisition of external technology for improving their performance. In practice, this helps firms gain higher economic returns in an era of intensive competition and increasing technological complexity.

Although the benefits of external technology acquisition have been emphasized in academic research, there was little effort to compare the determinants of external technology acquisition across industrial sectors. The objectives of this study are to categorize domestic manufacturing firms based on the modified industry classification scheme and to analyze determinants of external technology acquisition of each sector by empirical analysis. Accordingly, it is expected that the government and companies establish the governmental policies and company strategies which are suitable for each industry sector to acquire external technology.

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II. Related Works

A. Influential Factors on Technology Acquisition

There have been a large number of studies on the factors that influence technology acquisition. Institutional factors may influence firms' technology acquisition in different ways, and determine the balance between internal, collaborative, and external technology acquisition [2]. These factors were also categorized into the following four sub-groups: the political, legal, and administrative environment; the availability and quality of external technological knowledge from research institutions or other firms; the availability and quality of internal resources (personnel and capital); the organization of knowledge transfer activities by the firms. Advantages associated with cooperative R&D include: better access to external business resources, achieving economies of scale and scope, synergy in R&D, reducing risk and wasteful duplication of R&D efforts, and increasing incentive for R&D investment by reducing appropriability problems [3]. Montalvo and Yafeh [4] pointed out the importance of liquidity in the firm′s decision to acquire a technology. Firms without liquidity constraints are more likely to have the chance to acquire a new technology. Building technological ability has become a must for a firm's survival and advancement [5]. Previous research concluded that the higher the firm's relation standing or existing skill capabilities, the more involvement they have in in-house R&D [6]–[8]. However, in high-tech industries such as electronics or information technology, the acquisition of technology by licensing may not always be available. As a component of its technology strategy, the firm should choose the appropriate mode for acquiring the needed technology [9]. Relying on externally procured technology allows a firm to approach advanced knowledge and technology and to focus more on its internal core capabilities [10], [11]. Firm size can be an important factor in acquiring technology [12]. Large firms are likely to be more innovative than small firms in terms of stability of internal funds as well as better developed marketing, sales and distribution channels [13].

B. Classification of Industrial Sector

Pavitt [14] proposed a taxonomy of sectoral patterns of

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innovation based on the industry-specific trajectories, and identified four distinct categories: science-based, specialized supplier, scale intensive, and supplier-dominated sectors. It has become an important pillar in evolutionary studies of industrial dynamics, and has inspired a great amount of work dedicated to exploring the sector-specific characteristics of the innovative process [15]. Since there have been some modifications of this taxonomy [16], [17], we have adopted the mixed classifications based on previous research to reflect recent trends in technological development and to compare the sector-specific characteristics of technology acquisition.

III. Data and Variables

In order to analyze the sector-specific determinants of technology acquisition, data from the Korea Innovation Survey (KIS) 2005 published by Science and Technology Policy Institute (STEPI) were used. STEPI conducted a survey of Korean firms' innovation activities from 2002 to 2004 aiming at promoting technological innovation in Korea and increasing its global competency. Each firm, which was originally classified according to Korea standard industrial classification (KSIC), has been reassigned into the corresponding categories of the modified classification scheme. Table I provides the detailed information about the number and percentage of the sample at each corresponding sector.

TABLE I
Category of Industrial Sectors

Category of firm		Corresponding sectors	Freq.	Ratio
Supplier dominated	Resource intensive	Agriculture, Food, Coating	321	20.18
	Labor intensive	Textiles, Apparel, Furniture, House fixtures	209	13.14
Production intensive	Scale intensive	Metal working, Engines and parts, Motors, Transportation	319	20.05
	Specialized supplier	Miscellaneous mechanical, Measuring and testing	336	21.12
Science based	IT based	Computer hardware and software, Information storage, Communications	185	11.63
	BT based	Organic compounds, Miscellaneous chemical	175	11.00
	NT based	Optics, Miscellaneous drugs and medical	46	2.89
Total			1,591	100.00

We have drawn the variables from the survey items based on the results of prior studies on the field of technology acquisition of a firm. Each item is rated by the degree of importance ranging from 5 ('the most important') to 1 ('the least important'). Only firm size has a continuous scale to the number of employees. Table II indicates the list of variables selected containing a total of 67 variables except for firm size.

TABLE II
The List of Selected Variables

Dimension	Survey items	Scale
Government support (8)	Tax exemption, funds support, governmental involvement, governmental technical support, technology information service, education and training program, governmental purchase, marketing support	Interval (importance)
Market and institutional difficulty (7)	Uncertain market demand, control of monopoly, excessive competition, institutional regulation, easy imitation, no additional innovation, lack of innovation demand	Interval (importance)
Regional difficulty (6)	Lack of specialist within region, lack of infrastructure, lack of business service, lack of financial institution, lack of industrial linkage, lack of innovation culture	Interval (importance)
Information source (13)	University/institute (4) Private institute, university, federal institute, nonprofit institute External firms/market (9) Affiliate of firm, competitor within business, company within industry, supplier (raw material/software), equipment supplier, customer/demanding company, business service company, new employee, CEO's unofficial network	Interval (importance)
Uncertainty and risk (1)	Hesitation of investment due to technological uncertainty	Interval (importance)
Collaborative partners (10)	Affiliate of firm, competitor within business, company within industry, customer/demanding company, business service company, supplier, Private institute, university, federal institute, nonprofit institute	Interval (importance)
Innovation cost (1)	Hesitation of investment due to innovation costs	Interval (importance)
Organizational capability (11)	Lack of R&D planning, lack of personnel, lack of excellent staffs, frequent turnover, lack of technological information, lack of market information, difficult access to business service, difficult linkage with partner, organizational rigidity, impotency of R&D department, low commitment of senior management	Interval (importance)
Acquisition source (10)	Affiliate of firm, competitor within business, company within industry, customer/demanding company, business service company, supplier, Private institute, university, federal institute, nonprofit institute	Interval (importance)
Firm size (3)	Number of employees in 2002; 2003; 2004	Continuous

( ): the number of variables belonging to each dimension

But to reduce the input variables and avoid collinearity, we use factor analysis with principal components and varimax rotation method. The analysis resulted in the extraction of 11 factors. With reference to their loadings on the initial variables related to the survey items, they were labeled. Additionally, firm size was divided into four groups as a dummy variable by the distribution of employees. The final variables for empirical analysis are represented in Table III.

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TABLE III
THE FINAL VARIABLES FOR EMPIRICAL ANALYSIS

Input variable	Definition
Factor 1 (F1)	Lack of organizational capability
Factor 2 (F2)	Information source from external firms/market
Factor 3 (F3)	External technology acquisition source
Factor 4 (F4)	Government support
Factor 5 (F5)	Collaborative partners
Factor 6 (F6)	Regional difficulty
Factor 7 (F7)	Market/institutional difficulty
Factor 8 (F8)	Information source from university/institute
Factor 9 (F9)	Lack of innovation demand
Factor 10 (F10)	Internal technology acquisition source
Factor 11 (F11)	Uncertainty and risk
Firm size Dummy	
D1	1-49 employees
D2	50-99 employees
D3	100-299 employees
D4	300 and more employees

IV. ANALYSIS AND RESULTS

Logistic regression model is used to identify how the input variables affect external technology acquisition. The dependent variable is a dummy variable that takes the value one if the firm acquires external technology from 2002 to 2004 or zero otherwise. The models have been made by each industrial sector as well as the whole industry. The three types of variable selection techniques such as enter, forward, and backward stepwise were taken. Table IV shows the results of the logistic regression analysis of each sector by the different variable selection methods. In each cell, the variables which are statistically significant are extracted with the beta coefficients and the level of significance.

For easier comparison and better understanding among sectors, we reorganized the three types of variable selection results by representing the circles at each category. Table V presents the summarized results of selected factors including the most influential factor within a sector, the factor with negative effects, and the unique factor among sectors.

TABLE IV
RESULTS OF LOGISTIC REGRESSION ANALYSIS

Variable selection	Whole industry	Supplier dominated		Production intensive		Science based		
		Resource intensive	Labor intensive	Scale intensive	Specialized supplier	IT based	BT based	NT based
Enter	F2(0.637)***	F2(0.767)***	F2(0.693)***	F2(0.919)***	F2(0.876)***	F2(0.642)***		F2(0.903)*
	F3(-0.270)***			F3(-1.133)***	F3(-0.797)***			
	F4(0.409)***	F4(0.358)***	F4(0.899)***	F4(0.514)***	F4(0.516)***			
	F5(0.246)***			F5(0.504)***			F5(0.447)**	
	F8(0.165)***	F8(0.386)***					F8(0.352)**	
Forward stepwise							F1(-0.383)**	
	F2(0.646)***	F2(0.774)***	F2(0.738)***	F2(0.891)***	F2(0.799)***	F2(0.631)***		F2(0.713)*
	F3(-0.269)***			F3(-1.027)***	F3(-0.733)***			
	F4(0.414)***		F4(0.746)***	F4(0.581)***	F4(0.528)***			
	F5(0.242)***						F5(0.455)**	
	F8(0.167)***						F8(0.332)**	F8(0.592)*
		F10(0.351)***						
	D4(-0.445)***			D4(-1.041)***				
Backward stepwise							F1(-0.383)**	
	F2(0.646)***	F2(0.774)***	F2(0.738)***	F2(0.871)***	F2(0.799)***	F2(0.631)***		F2(0.713)*
	F3(-0.269)***			F3(-1.101)***	F3(-0.733)***			
	F4(0.414)***		F4(0.746)***	F4(0.580)***	F4(0.528)***			
	F5(0.242)***			F5(0.485)***			F5(0.455)**	
	F8(0.167)***						F8(0.332)**	F8(0.592)*
		F10(0.351)***						
	D4(-0.445)***			D4(0.889)***				

( ): beta coefficients; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE V
THE SUMMARIZED RESULTS OF SELECTED FACTORS

Factors	Whole industry	Supplier dominated		Production intensive		Science based		
		Resource intensive	Labor intensive	Scale intensive	Specialized supplier	IT based	BT based	NT based
F1							●*	
F2	●1	●1	●	●	●1	●1		●1
F3	●			●-,1	●-			
F4	●	●	●1	●	●			
F5	●			●			●1	
F8	●	●					●	●
F10		●*						
D4	●-			●-,*				

[1] The highest value of coefficients within a sector; [-] The negative sign of coefficient; [*] A unique variable across sectors.

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Through above table, we note that there are sector-specific characteristics on external technology acquisition by the categories of firms. Taken as a whole, external technology acquisition in manufacturing industry is determined by several factors such as external information source (F2; F8), external technology acquisition source (F3), government support (F4), collaborative partners (F5), and firm size. In particular, external information source from firm or market (F2) has positive effects on technology acquisition in all except for BT based sector. There are, however, different characteristics in acquiring external technology in each category.

Firms in supplier dominated industry including both resource and labor intensive sector are affected by government support, external information source from firm or market as well as university or institute. They can be found mainly in traditional sectors of manufacturing, and are generally small with weak R&D and engineering capabilities. Most of them do not develop their innovations internally, but rather introduce cost-saving process innovations by acquiring and implementing advanced technologies, equipment and materials produced in other sectors. The noteworthy point, however, is that they are also affected by internal sources of technology or information acquisition from the result of analysis. It implies they not only have external technology acquisition from suppliers but also make an effort to acquire technology internally.

Production intensive firms are subdivided into two categories: scale intensive and specialized supplier. Since scale intensive industries interact intensively with the specialized suppliers by acquiring precision instruments and other specialized machineries and by integrating the related design capabilities in their own R&D and production engineering departments, they have positive relationships with external information source and collaborative partners. Moreover, since they are usually large such as automobile or steel manufacturers, and frequently have their own in-house R&D facilities, they have negative relationships with external technology acquisition source and a large size of firms.

Specialized suppliers such as small mechanical and instrumental engineering firms produce a high proportion of their own process technologies but the main focus of their innovative activities is the production of product innovations for use in other sectors by making use of internal sources such as engineering and design capabilities, and by interacting with the advanced users of new technologies. This explanation is confirmed by a negative sign of coefficient with external technology acquisition source and a positive impact with external information sources.

Science-based sectors are typically large, and make great use of internal sources (e.g. R&D labs) to produce innovations, and their innovation processes stay close to the scientific advances continuously achieved by universities and other public research institutes. According to the result of this study, except for IT based sector, information sources from university or institute have positive effects on technology acquisition in BT or NT based firms. In case of BT based industry, organizational capability and collaborative partner are considered as influential. It implies that cooperation between biotechnology and pharmaceutical companies plays a crucial role for each other in complementing their own organizational or technological capabilities.

V. Conclusion

We analyzed the determinants of external technology acquisition and compared the results with each sector by empirical analysis. As a result, there have been sector-specific characteristics on external technology acquisition in comparison with each category. It implies that government or companies should establish policies or strategies on technology acquisition which are customized or suitable for their own sector. There are some limitations from the results of this study. We utilized KIS data for analysis, but we didn't consider a variety of variables, and capture how the influence of input variables changes in time because of the limited data availability. Therefore, various variables and the dynamic characteristic of each sector should be taken into account for future research.

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