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THE DETERMINANTS OF INNOVATIVE ACTIVITIES IN KOREAN SMES

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Abstract. *Understanding key drivers for firm's innovation is crucial to facilitate related activities within the company, and thus boosts that company's performance. It is obvious that collective innovation activities of all companies finally improve the industrial standing of that country. Due to this substantial impact of corporate innovations, many researches have been conducted to identify the determinants of innovation activities, but most of such conventional researches are largely relying on the survey of questionnaires, which show some limitations on considering the effects of qualitative factors such as CEO's knowledge level on technology, and corporate technicians' degree of proficiency. In this study, authors examine the determinants of firm's innovative activities while considering such qualitative factors together with the traditional determinants using dataset from KOTEC (Korea Technology Finance Corporation). Multiple regression analysis shows that CEO's level of knowledge on technology, tech-employee's proficiency, firm age, firm size, net profit and export are significant factors regarding innovative activities in manufacturing firms. In case of KIS (Knowledge Intensive Service) firms, their age and size are identified as significant factors for innovative activities. This study shows that there are significant differences in the determinants of innovative activities between the manufacturing firm and KIS firm, and a wider study including qualitative factors is needed to better understand the nature of innovative activities.*
Keywords: Determinants of innovation, Qualitative data, KIS, KOTEC

1. **Introduction.** It is needless to say that innovation is very important both to company and to country. Companies with more innovative activities usually show better financial performance, higher market shares, and renowned products (or services). Countries with more innovative companies become richer and show faster industrial growth. This is because the collective innovation activities of all companies finally improve the industrial standing of that country. Due to this substantial impact of corporate innovations, many researches have been conducted to understand the nature of innovation at the company, and to foster corporate innovation by identifying the determinants of innovation activities.

A number of empirical studies have tested and found that firm size [1,9,13,14], firm age [15,16], market concentration ratio [2,20], corporate network [3,18], financial resources [4,6-8,10,12,15], and export ratio [5,15] are factors affecting innovation activities of the company. Some have also explored the influence of CEO's leadership [7] and the percentage of employees with university degree [19] over innovation activities.

However, prior researches on the determinants of firm's innovative activities have been mostly based on CIS (Community Innovation Surveys: EU) and KIS (Korea Innovation

Surveys) results. The data from these surveys have some limitations on including qualitative information about firms like CEO's level of knowledge on technology, and corporate technicians' degree of proficiency (employee ratio of university graduate). The technology rating system of KOTEC (Korea Technology Finance Corporation), however, classifies and reports these kinds of data together with firm's innovation activities. KOTEC is a public organization established to support new technology business by issuing financial guarantee to innovative Korean firms [21]. KOTEC's qualitative data are created by industry experts while assessing the amount of financing for that firm, and accumulated within KOTEC's database together with the other quantitative data. If those rich sets of data are used to examine the determinants of firm's innovative activities, then we can better understand the nature of innovation. In this paper, authors investigate the determinants of firm's innovative activities including some qualitative factors, while using KOTEC's data that is differentiated from preexisting CIS and KIS data.

The remainder of this paper is organized as follows. Literature review on determinants of innovation is briefly summarized in Section 2. The data, model and variables of this study are explained in Section 3. The empirical findings of this study are specified in Section 4. Finally, in conclusion section, the meaning of findings are discussed together with implications and limitations of this research.

2. **Literature Review.** Perhaps firm size has been most frequently tested factor as the determinants of innovation activities. After Joseph Schumpeter's thought in 1942 that large firms having resources to spend more on R&D than small firms can more favorably induce technological change in concentrated markets, there have been lots of researches studying the relationship between firm size and innovation activities. Certainly, larger firms have an advantage in some types of innovation where large amounts of equipment are required [9]. Acs and Audretsch found that large firms tended to have the relative innovative advantage in industries which were capital-intensive, concentrated, highly unionized, while the small firms tended to have the relative advantage in industries which were highly innovative, utilized a large component of skilled labor, and tended to be composed of a relatively high proportion of large firms [1]. Sung found that larger companies could achieve more patents in the Korean machinery industry, while for capital intensity, the opposite was true [13]. Sung also found that firm size defined in terms of employee number has a positive effect on R&D expenditure [14].

Firm age has also been tested with regard to innovation activities. Some found there is no statistically significant relationship between firm age and innovation activities regardless of the types of innovation [15,16], but some found that firm age was negatively related to technical quality, and that this effect was greater in technologically active areas [22]. Love and Roper found that R&D, technology transfer and networking were to be substitutes in the innovation process of UK manufacturing plants, with the latter two intensities especially important in increasing the extent of innovation [3]. The combined effect of firm size and corporate network were also reported by Audretsch and Vivarelli [18]. They found that small firms were able to innovate by exploiting firm-external knowledge. In particular, research associated with universities apparently provided a fertile environment for small-firm's innovative activity.

In addition to the above mentioned factors, many researches have been conducted to find relationships between innovative activities and various input factors such as market concentration ration [2,20], financial resources [4,6-8,10,12,15], foreigner's investment ratio [17], firm's absorptive capability [11], and export ratio [5,15]. Sung introduced CEO's leadership (measured in the percentage of shareholdings) as independent variable, and tried to verify that strong leadership is encouraging innovative activities. However, he failed to show statistically significant result between CEO's leadership and innovative activities [7]. Amaraa et al. found that the percentage of employees with university

degree did not explain any form of innovations in the KIS firms [19]. Financial guarantee from public organization was also found to facilitate firm's innovation [9,23].

Even with the large number of researches to understand the drivers of innovative activities, we still do not know much. Results of former studies are valuable, but those are still standing on narrow dataset with lots of assumptions. To better understand the nature of innovation, it is needed to test previously found results again with different datasets as well as to find additional independent factors for innovative activities. As is mentioned in Introduction, authors investigate the determinants of firm's innovative activities including qualitative factors such as CEO's level of knowledge on technology and corporate technicians' degree of proficiency while using different datasets obtained from KOTEC.

3. **Data, Model, and Specification of Variables.** A total of 9,329 SMEs (8,395 manufacturing firms and 934 KIS firms), for which KOTEC provided letter of technology guarantee during the period of 2013-2014, is analyzed for this study. To determine the empirical formula for the determinants of innovation activities, following multiple regression analysis is conducted:

$$\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X_{1i} + \hat{\beta}_2 X_{2i} + \cdots + \hat{\beta}_k X_{ki} + \epsilon_i \tag{1}$$

KTRS (KOTEC Technology Rating System) classifies firm's innovative activities as one of three types – technology commercialization (i.e., the innovation of product or service), technology development (i.e., under the construction of product or service), and product or service commercialization (i.e., lower level of innovation for product or service). These are set as technology and business evaluation index of KTRS for each company. Respecting this evaluation scheme, authors have designed three dependent variables (i.e., Y_1, Y_2, and

Table 1. Variable description and specification

	Short Name	Description and Specification
$\boldsymbol{Y_1}$	**INNO (all)**	All types of innovation activities including technology commercialization, technology development and product or service commercialization.
$\boldsymbol{Y_2}$	**INNO (high)**	Technology commercialization type only.
$\boldsymbol{Y_3}$	**INNO (low)**	Product or service commercialization type only.
$\boldsymbol{X_1}$	**Tech-CEO**	KTRS classifies CEO's level of knowledge on technology by 5 grades (A $\sim$ E).
$\boldsymbol{X_2}$	**Tech U-Emp**	The percentage of employees with university degrees in technology related department over the total number of employees.
$\boldsymbol{X_3}$	**Tech Emp**	The percentage of employees in technology related department over the total number of employees.
$\boldsymbol{X_4}$	**Age**	Firm age measured by the scale of month.
$\boldsymbol{X_5}$	**Emp (Firm Size)**	Firm size measured by the number of firm's employees.
$\boldsymbol{X_6}$	**LOAN**	Loan ratio (loan $\div$ average sales for three fiscal years). Used to express the influence of applicability of external financing.
$\boldsymbol{X_7}$	**Net Profit**	Net profit ratio (net profit $\div$ average sales for three fiscal years). Used to express the influence of applicability of internal financing.
$\boldsymbol{X_8}$	**Export**	Export as a dummy variable. A firm which had exports for 3 fiscal years is set as an export firm. Used to incorporate the effects of international competition.

Y_3) for three regression models (i.e., M_1, M_2, and M_3), respectively. Dependent variable Y_1 includes all three types of innovation activities for the past three years. However, Y_2 and Y_3 just include technology commercialization type and product (or service) commercialization type, respectively. Brief description and specification of all variables are summarized in Table 1.

4. **Empirical Findings.**

4.1. **Manufacturing firms.** Table 2 provides the descriptive statistics and correlations among measured items. It is notable that 'Y_1: INNO (all)' and 'Y_2: INNO (high)' have positive and statistically significant correlation, but there is no statistically significant correlation between 'Y_2: INNO (high)' and 'Y_3: INNO (low)'.

Table 3 presents the regression results of manufacturing firm for three models that take 'INNO (all)', 'INNO (high)' and 'INNO (low)' as dependent variables, respectively. Statistical evaluation of VIF (Variance Inflation Factor) values indicates no substantial

TABLE 2. Descriptive statistics and correlation matrix (N = 8,395)

	Mean	**S.D.**	Y_1	Y_2	Y_3	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y_1	.150	.273										
Y_2	.085	.143	.651**									
Y_3	.033	.182	.696**	.009								
X_1	3.987	1.431	−.019	−.044**	.014							
X_2	.112	.195	.028**	.019	−.024*	−.081**						
X_3	.426	.276	.002	.001	−.007	−.086**	.349**					
X_4	3.936	1.040	−.321**	−.368**	−.078**	.267**	−.123**	−.160**				
X_5	2.243	.847	.038**	.029**	.027*	.141**	−.229**	−.734**	.209**			
X_6	2.268	14.218	.047**	.045**	.004	−.068**	.044**	.060**	−.141**	−.044**		
X_7	−.060	2.271	−.018	.003	−.005	.030**	−.041**	−.026*	.071**	.025*	−.316**	
X_8	.074	.262	.010	.010	−.002	.020	.045**	−.086**	.086**	.166**	−.020	.010

Note: * correlation is significant at the $p < 0.05$ level.
** correlation is significant at the $p < 0.01$ level.

TABLE 3. Result of multiple regression analysis (manufacturing)

Variables	**Model 1 (M_1)**		**Model 2 (M_2)**		**Model 3 (M_3)**	
	Coefficient (β)	P-value	Coefficient (β)	P-value	Coefficient (β)	P-value
Constant	.346**	.000	.227**	.000	.048**	.001
Tech-CEO	.012**	.000	.005**	.000	.004**	.005
Tech U-Emp	.001	.928	−.009	.252	−.030**	.007
Tech Emp	.055**	.000	.022**	.006	.024*	.027
ln (Age)	−.094**	.000	−.056**	.000	−.017**	.000
ln (Emp)	.046**	.000	.022**	.000	.014**	.000
LOAN	9.876E-05	.637	4.727E-05	.661	−8.096E-05	.586
Net Profit	.001	.662	.002**	.007	.000	.808
Export	.021	.051	.014*	.011	.000	.965
	R^2 = .120, Adjusted R^2 = .119, F = 142.364, P = .000		R^2 = .152, Adjusted R^2 = .151, F = 186.431, P = .000		R^2 = .010, Adjusted R^2 = .009, F = 10.918, P = .000	

Note: * coefficient is significant at the $p < 0.05$ level.
** coefficient is significant at the $p < 0.01$ level.

multicollinearity because all of the VIF values are less than 10.0. All innovative activities increase significantly with the CEO's level of knowledge on technology (Tech-CEO). Employees' ratio in technology related side, including R&D employees, is also significantly positive in influencing all innovative activities. However, employees' ratio with university degrees (Tech U-Emp) is significantly negative in 'Y_3: INNO (low)'. And 'Internal financing (Net Profit)' is significantly positive in influencing 'Y_2: INNO (high)'.

4.2. **KIS firms.** Table 4 provides the descriptive statistics and correlations among measured items. It is notable that 'Y_1: INNO (all)' has positive and statistically significant correlation with the other innovation activities, but there is no statistically significant correlation between 'Y_2: INNO (high)' and 'Y_3: INNO (low)'.

Table 4. Descriptive statistics and correlation matrix ($N = 934$)

	Mean	**S.D.**	Y_1	Y_2	Y_3	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y_1	.151	.290										
Y_2	.028	.239	.839**									
Y_3	.086	.115	.476**	−.006								
X_1	3.892	1.407	.036	.046	−.019							
X_2	.551	.283	.039	.002	.054	−.058						
X_3	.335	.286	.033	−.011	.055	.034	.606**					
X_4	3.690	.909	−.217**	−.041	−.293**	.255**	−.309**	−.224**				
X_5	2.230	.863	−.019	.010	−.009	.172**	−.703**	−.388**	.385**			
X_6	1.843	8.289	.023	.005	−.021	−.076*	.050	.027	−.170**	−.100**		
X_7	−.257	3.361	−.007	.002	.022	.054	−.053	−.043	.105**	.067*	−.616**	
X_8	.022	.148	.002	−.008	.027	−.009	−.071*	−.046	.049	.122**	−.018	.013

Note: * correlation is significant at the $p < 0.05$ level.
** correlation is significant at the $p < 0.01$ level.

Table 5 presents the regression results of KIS firm for three models that take 'INNO (all)', 'INNO (high)' and 'INNO (low)' as dependent variables, respectively. However, Model 3 (M_3) that takes 'Y_3: INNO (low)' as a dependent variable, is not statistically significant ($F = .746$, $P = .651$). Tech-CEO is positively significant in encouraging innovative activities, but Tech U-Emp ratio does not provide any evidence as to increasing innovative activities.

5. **Conclusions.** Authors have examined the determinants of firm's innovation of Korean SMEs using qualitative factors such as CEO's knowledge level on technology, and corporate technicians' degree of proficiency based on the dataset from KOTEC instead of the survey questionnaires like CIS and KIS. Multiple regression analysis shows that CEO's level of knowledge on technology is a significant determinant of innovative activities at least in manufacturing SMEs. The findings of this study can be summarized as follows. First, this study shows significant differences in the determinants of innovative activities between manufacturing firms and KIS firms, and the coefficients of determination (R^2) of KIS firms are lower than those of manufacturing firms. In manufacturing firms, CEO's level of knowledge on technology (Tech-CEO), the percentage of employees in technology related department (Tech Emp), firm age (Age), firm size (Emp), net profit ratio (Net Profit), and export record (Export) are significant regarding innovative activities. However, all variables except firm age (Age) and firm size (Emp) are not significant in KIS firms. Second, it is found that 'Tech-CEO' encourages all kinds of innovative activities in manufacturing firms. This indicates that CEO's level of knowledge on technology is very important, but it is not statistically significant for KIS firms in high-level innovative

TABLE 5. Result of multiple regression analysis (KIS firms)

Variables	Model 1 (M_1)		Model 2 (M_2)		Model 3 (M_3)	
	Coefficient (β)	P-value	Coefficient (β)	P-value	Coefficient (β)	P-value
Constant	.319**	.000	.182**	.000	.028	.615
Tech-CEO	.019**	.006	.004	.173	.010	.079
Tech U-Emp	−.017	.681	−2.156E-05	.999	−.027	.442
Tech Emp	.031	.557	.023	.259	.023	.609
ln (Age)	−.085**	.000	−.045**	.000	−.018	.069
ln (Emp)	.027	.083	.020**	.001	.009	.487
LOAN	−7.005E-05	.961	−.001	.159	.000	.886
Net Profit	.001	.804	.001	.699	.001	.849
Export	.013	.834	.023	.347	−.012	.825
	$R^2 = .060$, Adjusted $R^2 = .052$, $F = 7.425$, $P = .000$		$R^2 = .108$, Adjusted $R^2 = .100$, $F = 13.963$, $P = .000$		$R^2 = .006$, Adjusted $R^2 = -.002$, $F = .746$, $P = .651$	

Note: * coefficient is significant at the $p < 0.05$ level.
** coefficient is significant at the $p < 0.01$ level.

activity (Model 2: M_2). The percentage of employees with university degrees in technology related department (Tech U-Emp) does not have any influence like Amaraa et al.'s research [19].

Since this study is conducted over innovative SMEs that have received KOTEC's technology financing, if non-innovative firms are analyzed together with those innovative SMEs, then the study result can be different. And in this model, dependent variables are confined to reflect innovative activities reported from KOTEC's rating system, so there is a limitation in finding determinants of different types of innovative activities. These weaknesses provide directions for future research, particularly for KIS firms, in which most of the independent variables were not statistically significant.

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