The Relationship between Corporate Patents and the Cost of Debt

Assistant Professor Jaepil Yu
Department of Management Engineering,
Sangmyung University, Cheoan, Korea
E-mail: jaepilyu@smu.ac.kr

Associate professor Sooeun Kim
Department of Global Finance and Management,
Sangmyung University, Cheoan, Korea
E-mail: sekim@smu.ac.kr

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Abstract
This study was conducted to analyze the impact of corporate patents on the cost of debt for companies listed on the securities market of the Korea Exchange from 2010 to 2021. It was found that corporate patents have a significant impact on the borrowing rate and the interest rate spread, and the results were consistent in the robustness test that took into account endogeneity. This showed the positive impact of innovation activities on reducing the cost of debt and the effect of innovation on reducing the cost of debt, suggesting that active innovation efforts can increase the profitability and financial stability of companies and that innovation can contribute to business sustainability and reduce the risk of insolvency, thereby improving the credit rating and reducing the cost of debt. Through continuous innovation activities such as research and development, firms can send positive signals to the stock market, which in turn facilitates financing and reduces the cost of capital, and this helps increase the competitiveness of the company and lower the risk of insolvency.

Keywords*: Corporate patents, innovation, cost of debt, borrowing rate*

1. Introduction and Literature Review

Companies in Korea want to make active investments in anticipation of the global economic recovery ahead, but are reluctant to do so due to uncertainties such as rising inflation, increased volatility in the U.S. bond market, and interest rate hikes. Korean companies, which tend to use debt to finance their investments, have to consider the high cost of debt incurred by raising capital from others, and the volatility of the exchange rate is also making them currently avoid investing. During the COVID-19 pandemic, they engaged in emergency management due to widening deficits and social distancing policy and practiced conservative management by reducing investment and securing cash. In such rapidly changing business environment, companies experienced a decline in profitability and an increase in debt, and there was a growth in the number of marginal companies and those with deteriorated financial condition. However, with the easing of COVID-19 restrictions, companies took on more debt to make investments as a means to increase their market share and profitability in anticipation of economic recovery. With a high reliance on the borrowing capital from others, firms are holding onto their cash

reserves due to macroeconomic instability and increased uncertainty related to investment as a result of wars occurring in various parts of the world. Eberhart, Maxwell and Siddique (2008) and Shi (2003) examined the relationship between investment in research and development (R&D) and corporate bond ratings. Eberhart et al. (2008) found a significant positive relationship between R&D investment and corporate bond rating, whereas Shi (2003) argued that when a company increases its R&D investment, creditors tend to demand an additional risk premium, which can lead to a decline in corporate bond ratings. Eberhart et al. (2008) and Shi (2003) reported contrasting findings, which may be a result of the contradictory nature of the creation of future returns implied by R&D expenditures and the losses associated with increased uncertainty. Atanassov (2013) also mentioned that patents are more appropriate than R&D to measure the degree of innovation achieved by a firm. Except for Hsu, Lee, Liu, and Zhang (2015), it is difficult to find previous studies that investigate the impact of patents on the cost of debt. They analyzed the relationship between patents and the cost of debt for listed companies in the United States for the period from 1976 to 2006 and found a significant inverse relationship Chan et al. (1990) and Doukas and Switzer (1992) found that R&D investment generates excess returns in the stock market, and that R&D investment by high-tech firms has a greater impact on stock prices. These results provide strong evidence that R&D investment affects the company's value by driving an increase in profitability or leading to the creation of intangible assets. Based on the Tobin-q theory, Toivanen et al. (2002) found that R&D investment is an innovative driver that affects the value of the company, and the intangible assets created through R&D investment are future growth engines and innovative knowledge.

The aim of this study was to empirically analyze the relationship between corporate patents and the cost of debt for companies listed on the securities market in Korea. This study has academic significance in that it analyzed the relationship between corporate innovation and the cost of debt, the related studies of which have been limited, and it is also meaningful in that the number of registered patents was used to compensate for the limitations of R&D expenditures in measuring corporate innovation. This study is organized as follows. Section 1 provides an introduction and a review of previous studies, Section 2 describes the model and variables, and Section 3 describes the data. Section 4 presents an empirical study and an analysis of the results, and Section 5 presents the conclusions and implications of the empirical analysis are presented.

2. Sample and Research Methodology

2.1 Sample

In this study, companies were sampledin accordance with the following criteria from among the companies listed on the Korea Exchange from January 1, 2000 to December 31, 2021. First, companies whose financial and stock price data from January 1, 2000 to December 31, 2021 were not available in the KIS Value Library, FnGuide, or TS2000 were excluded. Financial institutions engaging in banking, securities, or insurance business were excluded because they differ from general manufacturing businesses in terms of capital structure, business operation methods, and government regulation and supervision. Companies that were delisted during the analysis period and those who underwent a merger or designated as issues for administration during the analysis period were also excluded from the sample pool due to

issues with continuity of financial data. In addition, companies with total assets of less than KRW 1 billion or no sales were excluded because they may lead to outliers for the variables, and each variable was winsorized at the 1st and 99th percentile to control the impact of outliers on the analysis results. The number of firm-year observations for the firms that fulfilled the above conditions was 6,038. Corporate patent registration data were used to measure innovation, and the data for this study were manually extracted from the patent information search service provided by the Korean Intellectual Property Office (KIPO).

2.2 Research Model and Variables

In order to analyze the relationship between corporate patents and the cost of debt according to the research methodology of Atanassov (2013), a regression model as shown in Equation (1) and Equation (2) was set up.[1]

$$DEBT_{i,t+1} = \beta_0 + \beta_1 PAT_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 PROF_{i,t} + \beta_4 MTB_{i,t} + \beta_5 BETA_{i,t} + \beta_6 OWN_{i,t} + \beta_7 LEV_{i,t} + \epsilon_{i,t} \quad (1)$$

$$DEBTS_{i,t+1} = \beta_0 + \beta_1 PAT_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 PROF_{i,t} + \beta_4 MTB_{i,t} + \beta_5 BETA_{i,t} + \beta_6 OWN_{i,t} + \beta_7 LEV_{i,t} + \epsilon_{i,t} \quad (2)$$

The dependent variable in Equation (1) and Equation (2) is the cost of debt, which consists of borrowing rate ($DEBT_{i,t+1}$) and interest rate spread ($DEBTS_{i,t+1}$). The borrowing rate ($DEBT_{i,t+1}$) was calculated by dividing the total financing cost by the average interest-bearing debt, and the interst rate spread ($DEBTS_{i,t+1}$) was calculated by subtracting the 3-year maturity interest rate of government bonds from the borrowing rate (COD). The explanatory variable, corporate innovation ($PAT_{i,t}$), was measured by adding one to the number of registered patents of an individual firm in each year and converting it into a natural logarithm, and it was used as a proxy for corporate innovation.[2]

There are six control variables: firm size ($SIZE_{i,t}$) was measured by the natural logarithm of total assets, operating profit ratio ($PROF_{i,t}$) was measured by dividing total assets by operating profit, market-to-book ratio ($MTB_{i,t}$) was used as a proxy for firm growth measured by the ratio of market capitalization to total equity, beta ($BETA_{i,t}$) was used as a proxy for systematic risk, major shareholders' ownership stake ($OWN_{i,t}$) was measured by the percentage of shares held by major shareholders including related parties, and debt ratio ($LEV_{i,t}$) was measured by the ratio of total debt to total assets. In addition, the firm effect, year effect, and industry effect were used to consider the impact of individual firm, year, and industry characteristics on the results, and winsorizing was performed at the 1st and 99th percentiles to reduce the impact of extreme values.

[1] Considering the time lag effect between patents and the cost of debt, the dependent variable was set at time t+1 and the explanatory variable was set at time t.

[2] To avoid excluding firms with no registered patents from the sample pool, one was added to the number of registered patents and the natural logarithm was obtained.

3. Empirical Results

3.1 Descriptive Statistics and Correlation Analysis

This section presents an empirical analysis of the relationship between corporate patents and the cost of debt. Table 1 shows the basic statistics of the variables used in this study.[3] The mean (median) borrowing rate ($DEBT_{t+1}$) is 0.049 (0.040), the mean (median) interest rate spread ($DEBTS_{t+1}$) is 0.026 (0.018), and the mean (median) corporate innovation (PAT_t) is 0.970 (0.001). The mean (median) firm size ($SIZE_t$) is 26.843 (26.642), the mean (median) operating profit ratio ($PROF_t$) is 0.031 (0.038), the mean (median) market-to-book ratio (MTB_t) is 1.199 (0.872), and the mean (median) beta ($BETA_t$) is 0. 768 (0.716), the mean (median) of major shareholders' ownership stake (OWN_t) is 0.453 (0.465), and the mean (median) of debt ratio (LEV_t) is 0.479 (0.467), suggesting the deviation between the mean and median of the variables is not significant.

Table 1 Descriptive Statistics Analysis

	Average	P50	S.D.	P25	P75
$DEBT_{t+1}$	0.049	0.040	0.045	0.030	0.056
$DEBTS_{t+1}$	0.026	0.018	0.042	0.008	0.030
PAT_t	0.970	0.001	1.476	0.001	1.390
$SIZE_t$	26.843	26.642	1.540	25.859	27.705
$PROF_t$	0.031	0.038	0.061	0.014	0.068
MTB_t	1.199	0.872	1.138	0.568	1.390
$BETA_t$	0.768	0.716	0.411	0.453	1.012
OWN_t	0.453	0.465	0.166	0.341	0.573
LEV_t	0.479	0.467	0.197	0.322	0.605

Note) All variables are presented by winsorizing 1% extreme values from top and bottom

Table 2 shows the correlation between the variables in terms of Pearson's correlation coefficient. Borrowing rate ($DEBT_{t+1}$) and interest rate spread ($DEBTS_{t+1}$) both have a significant negative effect on corporate innovation (PAT_t) at the 1% level. This shows that, as expected in this study, innovation activities can have a significant impact on reducing the cost of debt. However, the above results do not take into account the various other company characteristics that affect the cost of debt, so it is necessary to examine the interrelatedness through regression analysis.

Table 2 Correlation Coefficients Analysis

Varible	1)	2)	3)	4)	5)	6)	7)	8)	9

[3] In the process of analyzing the results, the subscript (i) indicating companies with respect to the variables were omitted for simplicity.

									)
1)$DEBT_{t+1}$	1								
2)$DEBTS_{t+1}$	0.989*** (0.000)	1							
3)PAT_t	-0.066*** (0.000)	-0.059*** (0.000)	1						
4)$SIZE_t$	-0.114*** (0.000)	-0.114*** (0.000)	0.603*** (0.000)	1					
5)$PROF_t$	-0.124*** (0.000)	-0.151*** (0.000)	0.113*** (0.000)	0.170*** (0.000)	1				
6)MTB_t	0.120*** (0.000)	0.141*** (0.000)	0.117*** (0.000)	-0.018 (0.280)	0.157*** (0.000)	1			
7)$BETA_t$	-0.001 (0.975)	0.029** (0.044)	0.215*** (0.000)	0.195*** (0.000)	-0.041*** (0.006)	0.141*** (0.000)	1		
8)OWN_t	-0.152*** (0.000)	-0.159*** (0.000)	-0.180*** (0.000)	-0.049*** (0.000)	0.105*** (0.000)	-0.144*** (0.000)	-0.181*** (0.000)	1	
9)LEV_t	0.042*** (0.001)	0.031** (0.015)	0.080*** (0.000)	0.138*** (0.000)	-0.211*** (0.000)	0.086*** (0.000)	0.135*** (0.000)	-0.129*** (0.000)	1

Note) The above are Pearson's correlation coefficients of major variables, and ** and * indicate significance at 1% and 5% levels (both sides), respectively.

3.2 Difference Test

Table 3 shows a mean difference test of the main variables carried out to check for a difference in the mean between the group that actively engage in innovation activities and the group that does not, using an innovation activity dummy (PATD).[4] The mean borrowing rate

[4] The innovation activity dummy (PATD) was classified as 1 if the value of corporate innovation (PAT) was greater than the median, and 0 if it was less than or equal to the median.

and interest rate spread for the high and low innovation groups were 0.053 and 0.059 and 0.025 and 0.030, respectively, and the difference between the two groups was found to be significant at the 1% level with a low difference. This shows that the high innovation group bears a lower cost of debt than the low innovation group, which suggests that creditors, who are the providers of the borrowed capital, have a positive perception of corporate innovation.

Table 3 Mean Difference Test of Main Variables

	PATD=1		PATD=0		Difference
	Mean	S.D.	Mean	S.D.	t-value
$DEBT_{t+1}$	0.053	0.047	0.059	0.051	-4.12***
$DEBTS_{t+1}$	0.025	0.042	0.030	0.046	-3.64***
$SIZE_t$	27.576	1.687	26.514	1.304	26.53***
$PROF_t$	0.044	0.055	0.032	0.066	7.95***
MTB_t	1.442	1.362	1.203	1.105	7.44***
$BETA_t$	0.841	0.413	0.725	0.406	11.18***
OWN_t	0.432	0.161	0.459	0.165	-6.02***
LEV_t	0.467	0.175	0.422	0.213	8.63***

3.3 Impact of Corporate Patents on the Cost of Debt

Table 4 presents an analysis of the impact of corporate innovation on the borrowing rate. Corporate innovation (PAT_t) was found to have a significant negative impact on the borrowing rate ($DEBT_{t+1}$) at the 5-10% level in Model 1, Model 2, and Model 3, and most of the control variables also had a significant impact on the borrowing rate. This is consistent with the findings of Hsu et al. (2015), who analyzed U.S. firms and found that innovation had a positive effect on reducing the cost of debt. This suggests that active innovation efforts can increase a company's profitability and financial stability, and that innovation can help business sustainability and even contribute to lowering the cost of debt by reducing the risk of insolvency, thereby improving the company's credit rating. Companies can thus send positive signals to the stock market through ongoing innovation activities such as R&D, which can make it easier to raise capital and reduce the cost of capital.This in turn helps enhance the company's competitiveness and reduce the risk of insolvency.

Table 4 Impact of Corporate Patents on the Borrowing Rate

Variables	$DEBT_{t+1}$		
	Model 1	Model 2	Model 3
PAT_t	-0.005** (-2.18)	-0.003* (-1.90)	-0.004** (-2.46)
$SIZE_t$	-0.007** (-2.43)	-0.005*** (-3.05)	-0.007*** (-3.15)
$PROF_t$	-0.035*** (-2.90)	-0.035** (-2.68)	-0.029** (-2.24)

MTB_t	0.001** (2.32)	0.001* (1.73)	0.001* (1.69)
$BETA_t$		0.006** (2.47)	0.005** (2.08)
OWN_t	-0.048*** (-6.17)		-0.046*** (-6.24)
LEV_t		0.020*** (2.79)	0.019*** (2.65)
Constant	Included	Included	Included
Firm Effect	Included	Included	Included
Year Effect	Included	Included	Included
Industry Effect	Included	Included	Included
Observations	6,038	6,038	6,038
R-squared	0.086	0.072	0.083

Note) ( ) indicates the t-value to which White-corrected standard errors of White(1980) are applied considering the heteroscedasticity of the White (1980)' errors, and ***, **, and * indicate the significance at the level of 1%, 5%, and 10% levels (both sides), respectively.

Table 5 presents an analysis of the impact of corporate innovation on the interest rate spread. Corporate innovation (PAT_t) was found to have a significant negative impact on the interest rate spread ($DEBTS_{t+1}$) at the 5-10% level in Model 1, Model 2, and Model 3, which is consistent with the results shown in Table 4. As with Table 4, the results suggest that innovation activities have a positive ipmact on reducing the cost of debt, and this is consistent with the findings of Hsu et al. (2015), who analyzed U.S. firms and found that innovation had a positive effect on reducing the cost of debt. In other words, it suggests that active innovation efforts can increase a company's profitability and financial stability, and that innovation can help business sustainability and even contribute to lowering the cost of debt by reducing the risk of insolvency, thereby improving the company's credit rating. Companies can thus send positive signals to the stock market through ongoing innovation activities such as R&D, which can make it easier to raise capital and reduce the cost of capital.This in turn helps enhance the company's competitiveness and reduce the risk of insolvency.

Table 5 Impact of Corporate Patents on the Interest Rate Spread

Variables	$DEBTS_{t+1}$		
	Model 1	Model 2	Model 3
PAT_t	-0.004** (-2.16)	-0.003* (-1.90)	-0.004** (-2.35)
$SIZE_t$	-0.007*** (-2.89)	-0.005*** (-3.18)	-0.005*** (-3.26)
$PROF_t$	-0.032*** (-3.32)	-0.035*** (-3.06)	-0.031*** (-2.63)

MTB_t	0.002** (2.27)	0.001* (1.68)	0.001 (1.59)
$BETA_t$		0.005*** (2.63)	0.004** (2.11)
OWN_t	-0.049*** (-6.85)		-0.046*** (-6.54)
LEV_t		0.020*** (3.05)	0.018*** (2.86)
Constant	Included	Included	Included
Firm Effect	Included	Included	Included
Year Effect	Included	Included	Included
Industry Effect	Included	Included	Included
Observations	6,038	6,038	6,038
R-squared	0.064	0.059	0.069

Note) ( ) indicates the t-value to which White-corrected standard errors of White(1980) are applied considering the heteroscedasticity of the White (1980)' errors, and ***, **, and * indicate the significance at the level of 1%, 5%, and 10% levels (both sides), respectively.

3.4 Robust Test

Table 6 presents an analysis of the impact of corporate innovation on the cost of debt, and the 2SLS analysis method was used to mitigate the endogeneity issue due to the reverse causality between corporate innovation and the cost of debt. This is because although innovation activities may reduce a firm's cost of debt, it is also possible that firms with lower cost of debt may engage in innovation activities more actively. The results of the analysis showed that the estimated corporate innovation (INS_PAT_t) had a significant negative impact on the borrowing rate ($DEBT_{t+1}$) and the interest rate spread ($DEBTS_{t+1}$) in both Model 1 and Model 2 at the 1% level. This is consistent with the results in Table 4 and Table 5, indicating that the findings in this study were robust even after taking endogeneity into consideration.

Table 6 Impact of Corporate Patents on the Cost of Debt: 2SLS

Variables	$DEBT_{t+1}$ Model 1	$DEBTS_{t+1}$ Model 2
INS_PAT_t	-0.008*** (-5.08)	-0.007*** (-4.73)
$SIZE_t$	0.001 (1.35)	0.001 (1.26)
$PROF_t$	-0.107*** (-8.58)	-0.134*** (-11.62)
MTB_t	0.004*** (9.86)	0.004*** (10.88)

$BETA_t$	-0.002 (-0.96)	0.003 (1.52)
OWN_t	-0.047*** (-10.76)	-0.040*** (-9.75)
LEV_t	0.001 (1.05)	-0.001 (-0.66)
Constant	Included	Included
Observations	5,741	5,741
R-squared	0.095	0.106

Note) ***, **, and * indicate the significance at the level of 1%, 5%, and 10% levels (both sides), respectively.

4. Conclusions

This study analyzed the impact of corporate patents on the cost of debt for companies listed on the Korea Exchange from 2010 to 2021. The results of this study are as follows: Corporate patents have a significant impact on the borrowing rate and the interest rate spread, and the results were consistent in the robustness test that took endogeneity into account. This showed the positive impact of innovation activities on reducing the cost of debt and the effect of innovation on reducing the cost of debt, suggesting that active innovation efforts can increase the profitability and financial stability of companies and that innovation can contribute to business sustainability and reduce the risk of insolvency, thereby improving the credit rating and reducing the cost of debt. By engaging in ongoing innovation activities such as research and development, firms can send positive signals to the stock market, which in turn makes it easier for them to raise capital and reduces the cost of capital, and this helps increase the competitiveness of the firm and mitigate the risk of insolvency. In consideration of these results, management must formulate a management strategy to pursue business continuity and stability at the same time by making long-term investments and plans rather than seeking short-term profits. They should also continuously engage in innovative activities such as research and development to generate continuous profits while reducing the risk of insolvency.

This study has limitations due to the limited number of samples used and the fact that detailed data on companies' patents were not available, so detailed analyses could not be conducted and the quality of innovation could not be considered. However, this study analyzed the impact of corporate patents on the cost of debt, a topic that has not been adequately researched in Korea, and drew an implication that innovation activities reduce the risk of default and improve competitiveness. Once more detailed data are obtained in the future, it will be possible to carry out various studies on the relationship between corporate patents and the cost of debt.

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