Library Progress International *Print version ISSN 0970 1052*
Vol.44 No.2,July-December 2024: P.141-155 *Online version ISSN 2320 317X*

Original Article *Available online at www.bpasjournals.com*

Changes in Firm Value According to Patent Acquisition Announcement

Gwang Yong Kim

Lecturer, Department of Industrial Management, Gyeongsang National University, Republic of Korea

How to cite this article: Gwang Yong Kim (2024). Changes in Firm Value According to Patent Acquisition Announcement. *Library Progress International*, 44(2), 141-155

ABSTRACT

Patents play a vital role in securing technological competitiveness for companies. Acquisition of such means the definitive acquisition of exclusive rights that substantially contribute to the improvement of firm value, so it is appropriate to observe changes in firm value. This study examines the change in firm value according to the announcement of patent acquisition based on data disclosed by companies from February 2009 to January 2017, when the acquisition of patent rights was changed from ad-hoc disclosure to voluntary disclosure. After estimating the abnormal return through the market model of the event study methodology, the factors affecting firm value were analyzed through regression analysis with the cumulative abnormal return as a dependent variable. The main empirical analysis results of the study are as follows. First, in the patent application, the average abnormal return appears positive before the announcement, and then the AAR turns negative on D-0. As for patent acquisition, the AAR appears positive on D-0 and then turns negative after the announcement. Before it is officially announced, information about a patent application is already reflected in stock prices by market forecasts or insider trading, while the information about patent acquisition is reflected in stock prices at the time of public announcement. There is a difference in the reaction time of investors in the stock market depending on patent application and patent acquisition. In particular, although a patent acquisition announcement is self-disclosure, investors still perceive a company's patent acquisition as useful information, which eventually enhances firm value. Second, because of the identifying factors that affect firm value, significant differences were found in firm value depending on the country in which a patent was obtained. As for corporate characteristics, the lower the R&D expense, the leverage ratio, and the operating profit-to-sales ratio, the higher the firm value whereas the higher the beta, the higher the firm value.

KEYWORDS

Patent acquisition, announcement effect, firm value, abnormal return, event study

1. INTRODUCTION

As society changes to informatization, the creation, diffusion, and utilization of knowledge are becoming essential to economic activities. Hence, the importance of intangible assets is emphasized daily as intangible assets based on knowledge and information act as key factors in driving corporate growth (Jo et al., 2014). The creation, protection, management, and utilization of intangible assets are emerging as important strategies for business management (Sung and Jo 2009). How to efficiently manage and utilize intangible assets will lead the knowledge-centered management environment in the future, and companies will be able to achieve their ultimate goals (Ethie and Olibe 2010).

Patents are assets that companies can efficiently cope with in a rapidly changing business environment (Kamiyama 2006). A patent plays an important role in securing technological competitiveness for companies and provides useful information to determine firm value to external information users. Acquisition of patent rights means that it is possible to escape from the defensive means of being granted exclusive rights to past R&D results. Besides, it is a key element of corporate strategy as a means of expanding market competitiveness and market share by exclusively using that right (Kim 2016; Lim 2021). At the same time, since the acquisition of patent rights means the definitive acquisition of monopoly and exclusive rights that substantially contribute to improving firm value, it is also suitable for

observing changes in firm value (Lee and Kim 2016). Both the increase in trading volume after the date of patent acquisition and the increase in the stock price return on the date of patent acquisition provide important information about the patent to the market (Kogan et al., 2017).

Until now, there have been many studies examining the effect of corporate patent announcements on the capital market in the Korean stock market. Starting with a study that analyzed the effect of patent application disclosure on stock value, there is a study that examines the announcement effect of patent acquisition in the aspect that patent acquisition reflects the actual value of a patent better than patent application (Kim and Jeong 1995; Kim et al., 2004). In addition, considerable progress has been completed in recent studies examining the effects of innovation activities, innovation performance, and innovation efficiency on firm value through studies that empirically investigate the effects of a patent application and patent acquisition announcement on stock prices at the same time (Cho 2005; Kim and Nam 2019).

Summarizing previous studies in Korea, most of these were on patent acquisition announcements in listed companies, and it was confirmed that the disclosure of patent acquisitions in companies listed on the KOSDAQ market showed a positive response. In contrast, there are mixed research results that the disclosure of patents obtained by companies listed on the stock market is recognized as useful information in the stock market and research results that there is no information effect. Therefore, this study used an event study to examine the following.

First, based on the patent application date, the change in firm value along with the patent application announcement of companies listed on the KOSPI market was confirmed.

Second, this study examined the changes in firm value according to patent acquisition announcements from 2009 to 2017, when the acquisition of patent rights was changed from ad-hoc disclosure to voluntary disclosure. The financial authorities (i.e., Financial Supervisory Service) clarify that the reason for the revision is that there is no practical benefit to distinguish it from the transfer of patent rights (self-disclosure), and the details of acquired patents are announced through the Korean Intellectual Property Office. Moreover, most of the preceding studies have a relatively short sample period, and the sample period is before 2012, so it is confirmed that there are no studies on the effect of patent acquisition disclosure for companies listed on the stock market after 2013. Furthermore, about the content included in the patent disclosure, such as the country where the patent was obtained, the number of patent disclosure cases, and the number of patentees, it is divided into two groups and compared, and a difference analysis between groups is conducted.

Finally, a cross-sectional regression analysis was conducted to identify the factors that affect the stock price response by patent acquisition disclosure.

The structure of this study to verify the change in firm value according to the patent acquisition announcement is as follows. Following the introduction in Chapter 1, Chapter 2 examines previous studies on the relationship between patents and stock prices. Chapter 3 explains the research data and research method, and Chapter 4 provides an empirical analysis. Finally, Chapter 5 summarizes the findings and presents the implications and limitations of the study.

2. LITERATURE REVIEW

2.1. Announcement effects on a patent application

Since the late 1900s, studies have been conducted to analyze whether disclosure of patent rights affects firm value (Pakes 1985; Cockburn and Griliches 1987; Chan et al., 1990; Chaney and Devinney 1992). Pakes (1985) studied the relationship between the number of patent applications, R&D expenditure, and annual stock return targeting 120 companies from 1968 to 1975. Results revealed that changes in patent rights positively affect firm value. Chaney et al. (1992) studied the relationship between R&D and new product-related patents and firm value [16]. On average, companies that disclosed new products or service innovations gained approximately 0.6% of excess return over the three days centered on the product announcement date.

A patent application means applying to the Korean Intellectual Property Office by describing an invention carried out to obtain a patent, and there are few studies examining the announcement effect of a Korean company's patent application on the capital market. Kim and Jeong (1995) examined the value effect of patent disclosure using a sample of 47 companies that disclosed patent applications from 1989 to 1994 [9]. The cumulative average abnormal return (CAAR) for the period from t = -30 days to t = +10 days based on the announcement date is about 6.05%, which is statistically significant.

These results argued that the public disclosure of patent applications in the Korean stock market acts as a favorable factor in increasing stock prices on average. Afterward, Cho (2005) analyzed 57 companies that published patent applications from 2000 to 2003. The average abnormal return (AAR) at the 1% significance level showed a distinctly positive effect on D-0 day and D+1 day. Despite not disclosing patent applications, in a society where information technology is developed, useful information is quickly and strongly reflected in a firm value. Accordingly, companies and investors need to pay attention to the fact a patent application affects firm value.

As the patent application announcement is expected to positively influence the company's stock price, the following hypothesis 1 is established.

Hypothesis 1. Patent application announcement will have a positive (+) effect on firm value.

2.2. Announcement effects on patent acquisition

On the other hand, studies examining the effect of disclosure of patent acquisition by Korean companies on the capital market are steadily progressing. Kim et al. (2004) investigated how the disclosure of patent acquisition, which is the result of a company's R&D activities, affects the company's stock price using the event study. As a result of analysis based on a total of 352 samples made by 65 companies from 1990 to 2000, a significantly positive Abnormal Return (AR) of 1.41% was demonstrated on the date of patent acquisition publication, and CAR (-1 to +1) was also 1.46%, showing a significantly positive value at the 1% level. AR was insignificant during the rest of the period, excluding the disclosure date, implying that the Korean stock market is semi-strong efficient.

Lee et al. (2007) observed companies that disclosed their patent acquisition in the Korea Investor's Network for Disclosure System (KIND) from 1999 to 2005. 77 companies listed on the KOSPI market disclosed 543 patent acquisitions, and 240 companies listed on the KOSDAQ market disclosed 1,525 patent acquisitions and 2,068 cases from a total of 317 companies were used as samples. Patent acquisition announcement of KOSDAQ-listed companies has a significantly positive effect, whereas patent acquisition announcement of KOSPI-listed companies is not statistically significant. This is the result of the stock market reacting mechanically to the announcement of patent acquisition by companies listed on the KOSDAQ market.

Kwon and Yoo (2011) studied 172 small and medium-sized venture companies that announced patent acquisitions in the KOSDAQ market between January 1, 1999, and June 30, 2010, as a sample. The disclosure of patent acquisition supports the value of the company in a positive direction, and investors support the value maximization that can enjoy economic benefits for patent acquisition.

Na and Kwack (2011) used the event study method to test the value relevance of patent acquisition announcements for 323 KOSPI-listed companies and 74 KODAQ-listed companies that disclosed patent acquisition information from 2004 to 2007. In the case of the KOSDAQ market, a significantly positive excess return was statistically verified according to the disclosure of patent acquisition, but in the case of the KOSPI market, this was not. Accordingly, the patent acquisition disclosure information was recognized as useful information to investors in the KOSPI market, and the information effect was manifested in the KOSDAQ market.

Kim et al. (2016) explored the short-term price effect of patent disclosure on 486 samples of 124 companies that were publicly disclosed from 2000 to 2012 on the KIND. Patent disclosure was causing a positive market response. Then, Kim and Nam (2019) checked the patent acquisition of 439 KOSDAQ companies from 2009 to 2017. An excess return rate of 0.59% occurred on the date of the public announcement of the patent acquisition, showing a significantly positive market reaction.

Summarizing previous studies related to patent announcement, most are on patent acquisition announcement, and it is confirmed that patent acquisition announcement is generally positive in the stock price response. As such, Table 1 summarizes previous studies on the effect of corporate patent applications and patent acquisition announcements in the Korean stock market.

Table 1: **Summary of prior research on patent application and acquisition**

Division / Researcher	Subject		Market		Sample Period	Result	
	(1)	(2)	KOSPI	KOSDAQ		KOSPI	KOSDAQ
Kim and Jeong (1995)	○		[47]		1989~1994	+	
Kim et al. (2004)		○	65 firms [352]		1990~2000	+	

Cho (2005)	○	○	57 firms		2000~2003	Δ	
Lee et al. (2007)		○	77 firms [543]	240 firms [1,525]	1999~2005	×	+
Kwon and Yoo (2011)		○		[172]	1999~2010		+
Na and Kwack (2011)		○	[323]	[74]	2004~2007	×	+
Kim et al. (2016)		○	124 firms [486]		2000~2012	+	
Kim and Nam (2019)		○		439 firms [1,461]	2009~2017		+

(1): application, (2): acquisition, [ ]: number of samples

+: a significant positive response, ×: no significant response

Δ: patent application announcement is significant, but patent acquisition announcement is not significant.

As the announcement of patent acquisition is expected to positively influence the company's stock price, the following hypothesis 2 is established.

Hypothesis 2. Patent acquisition announcement will have a positive (+) effect on firm value.

3. METHODOLOGY

3.1. Data and sample

Since all information related to patents reflected in the notes of financial statements is not disclosed depending on the company's choice, patent acquisition disclosure data were collected through the KIND website of the Korea Exchange. The data collection process and method for this study are as follows.

First, after setting the December settlement of accounts, marketable securities, and patents in the detailed search column on the KIND website, yearly data was extracted. Next, the number, time, company name, disclosure title, submitter, chart/stock price, and patent-related contents such as patent name, main content of patent, patent holder, patent acquisition date, patent activity plan, confirmation date, and other important matters associated with investment judgment were collected by clicking on the disclosure title. A total of 845 cases of patent acquisition were disclosed after the self-disclosure was applied in 2009. Based on this, 679 samples disclosed by 74 companies were obtained, excluding the number of cases in which companies posted patent acquisition disclosures on the same date.

Second, to control the contamination of information due to public disclosure, the samples obtained so far were excluded from the samples that fall under other patent acquisition announcements within at least 4 months after the patent acquisition announcement, and samples of delisted. In previous studies, only the first disclosure was observed for companies that disclosed more than once during the sample period or samples that disclosed patent acquisition in February and March, when financial statements are intensively released, were excluded (Kim and Jeong 1995; Na and Kwack 2011). Moreover, samples that announced the acquisition of another patent right within 4 months before or after the date of the patent acquisition announcement or samples of companies that were delisted and announced another patent acquisition within six months of the patent acquisition announcement were excluded (Kim et al., 2015; Na and Kwack 2011).

Third, to establish an accurate event day, the companies that announced the acquisition of patent rights provided by the KIND and the samples released after the stock market closed were adjusted to the event day the day after the event day. For example, since the closing time of the Korean stock market was extended from 15:00 to 15:30 in August 2016, the event date was set in consideration of the changed time. Meanwhile, as a result of investigating electronic disclosure data, it was confirmed that companies disclose only when patents are acquired and do not disclose when patent applications are filed. Since the company does not disclose the patent application, the patent application date was confirmed by checking the contents of the disclosure when obtaining a patent. The patent application date was individually obtained in 'Other Important Matters Related to Investment Decisions'. 88 specimens were provided the patent application date, but a total of 74 samples were obtained, excluding 14 samples for which stock price data could not be collected through FnGuide. In the same way, the country in which the company obtained the patent right and the number of patent holders were respectively confirmed. In the case of

the former, the number of patents acquired in Korea is 199, and the number of patents acquired in countries other than Korea, such as the United States, Europe, Canada, Japan, and China, is 58. In the case of the latter, the number of patent rights gained independently is 240, and the number of patent rights acquired jointly is 17.

It was also distinguished whether the company disclosed that it had acquired patent rights in one day, whether it was one, two, or more. The number of cases where companies announced that they had acquired one patent right per day was 223, and the number of times when they announced that they had attained two or more patent rights per day was 34 cases.

Finally, daily stock return data and financial variables used as characteristic factors of the study were collected from the FnGuide. The number of samples by year for which research data were collected in this way is shown in Table 2.

Table 2: Number of samples

Year	Patent application	Patent acquisition						
		Country		Number of Disclosure		Patent Holder		Total
	Total	Korea	Non-Korea	One	Two or more	Single	Joint	
2009	7	25	6	26	5	29	2	31
2010	13	24	7	30	1	28	3	31
2011	18	38	6	39	5	40	4	44
2012	16	24	8	29	3	29	3	32
2013	10	23	8	22	9	30	1	31
2014	6	26	9	33	2	32	3	35
2015	3	15	6	18	3	20	1	21
2016	1	23	8	25	6	31	-	31
2017	-	1	-	1	-	1	-	1
Sum	74	199	58	223	34	240	17	257

3.2. RESEARCH METHOD

3.2.1. Event study

Among Fama's three types of efficient markets, event study is particularly used to test the semi-strong form hypothesis, that is, how quickly market prices adjust to new information being published (). The summary of the methodology of research on the announcement effect of patent applications and patent acquisitions by Korean companies is shown in Table 3. Most studies used only the market model to calculate the excess return, but Lee et al. (2007) and Kim and Nam (2019) used both the market-adjusted return model and the industry index market model based on it. Excluding the study by Kim and Jeong (1995), it is confirmed that the estimation window is set to at least 200 days and the event window to a maximum of 61 days.

This study analyzed the effect of patent acquisition information on the stock prices of individual companies through the event study. The event window is a total of 15 days from D-7 to D+7 by selecting the patent acquisition announcement date as the event date, and the estimation window is a total of 163 days from D-170 to D-8.

Table 3 Summary of prior research methodology

Division / Researcher	Research model		CAR	Estimation window	Event window
	Market-adjusted return model	Market model			
Kim and Jeong (1995)		○	-30 ~ +1 [32]	-90 ~ -31 [60]	-30 ~ +10 [41]
Kim et al. (2004)		○	-1 ~ +1 [3]	-230 ~ -31 [200]	-30 ~ +10 [41]
Cho (2005)	○		0 ~ +3 [4]	-300 ~ -10 [290]	-10 ~ +10 [21]
Lee et al. (2007)	○	○	-1 ~ +1 [3]	-220 ~ -21 [200]	-10 ~ +10 [21]
Kwon and Yoo (2011)	○		-1 ~ +1 [3]	-	-30 ~ +30 [61]

Na and Kwak (2011)	○		-2 ~ +2 [5]	-	-10 ~ +10 [21]
Kim et al. (2016)		○	0 ~ +1 [2]	-250 ~ -50 [201]	-25 ~ +25 [51]
Kim and Nam (2019)	○	○	0 ~ +1 [2]	-250 ~ -50 [201]	-25 ~ +25 [51]
This study		○	-2 ~ +2 [5]	-170 ~ -8 [163]	-7 ~ +7 [15]
[ ] : number of day					

$$ARi,t = Ri,t - \hat{\alpha}_i - \hat{\beta}iRm,t \quad (1)$$

Based on the market model of Equation (1), the alpha and beta of the normal return period were estimated from D-170 to D-8. Through this, the AR of the event window was estimated, and the AAR of a specific day was estimated by dividing it by the number of samples. Excluding the seven days prior to the event from the estimation window is to exclude the impact of the patent acquisition disclosure from individual stock price estimates (Mackinlay 1997). Then the stock market's response to a specific event is highly likely to be observed the day before and on the day of the event if the event date is accurate and there is no information leakage (Jung 2006). The $CAAR_{(t1,\ t2)}$ is estimated by summing up $AAR_{i,t}$ for two specific points in time. To verify the statistical significance of AAR_t and $CAAR_{(t1,\ t2)}$ derived in this study, the test statistic is estimated as shown in Equation (2) [23][24].

$$t_{AAR} = \frac{AAR_t}{\sigma(AAR_t)}, t_{CAAR(t_1,t2)} = \frac{CAAR_{(t_1,t_2)}}{\sqrt{n}\sigma\left(CAAR_{(t_1,t_2)}\right)} \quad (2)$$

3.2.2. Difference analysis

This study aimed to check the difference in market response according to patent acquisition information. The difference test to break down the difference between the CAARs was analyzed through the following equation (3). Based on the contents described in the disclosure information, it was divided into groups A and B based on the country of patent acquisition, the number of patent publications, and the number of patent holders.

$$t = \frac{CAAR(t_1,t_2)^A - CAA\ \ (t_1,t_2)^B}{\sqrt{V_{av}\left(CAAR(t_1,t2)\right)^A + \mathrm{Var}\left(CAAR(t_1,t_2)\right)^B}} \quad (3)$$

3.2.3. Multiple regression analysis

In this study, a cross-sectional regression analysis was performed using Equation (4) to identify the factors that affect stock price response according to patent acquisition disclosure.

$$CAR(-2,+2) = b_0 + b_1Cty + b_2NoP + b_3CoP + b_4Size + b_5RnD + b_6Lev + b_7Beta + b_8OPS + b_9SGR + \varepsilon_i \quad (4)$$

CAR (-2, +2): Cumulative abnormal return during 2 days before and after the event date

Cty: Country of patent acquisition (Korea = 1, other countries = 0)

NoP: Number of patent disclosure per day (1 case = 1, 2 or more cases = 0)

CoP: Number of patent holders (single = 1, joint = 0)

Size: Company size (= ln(total assets))

RnD: R&D cost (= R&D cost / total assets)

Lev: Leverage Ratio (= Total Debt / Total Assets)

Beta: Risk for individual companies

OPS: Operating Profit-to-Sales ratio (= Operating Profit / Sales)

SGR: Sales growth ratio

The dependent variables are the CARs (-2, +2) of companies that have disclosed patent acquisition, and the independent variables are R&D expenses, company size, leverage ratio, beta, operating profit-to-sales ratio and sales growth ratio. The values of the variables used in the cross-sectional analysis refer to the values of the previous year of patent acquisition disclosure.

4. EMPIRICAL ANALYSIS

4.1. Patent application

Table 4 and Figure 1 show the AAR, CAAR, and each t-value for 7 days before and after the patent application date as a result of conducting an event study for the entire sample and period set above.

During the 7 days before and after the announcement date, there were 9 trading days where AAR is positive, and among them, 4 days (D = -6, -4, +5, +6) were statistically significant. On D-6, AAR is 0.696%, which is significant at the 10% level, and on D-4, AAR is 0.791%, which is significant at the 5% level. There is a positive share price response before the official announcement. Conversely, on D-0, AAR is -0.981%, which is significant at the 1% level, indicating a negative stock price reaction. This means that the stock price overreacting on the event day falls to a certain extent. In contrast, CAAR shows positive values from -7 days to +7 days, and in particular, CAAR from D-4 to D-1 is all significant at the 5% level.

This empirically shows that patent application disclosure is a favorable factor that, on average, raises a company's stock price. Therefore, the patent application announcement shows a result consistent with a study in which information on patent application disclosure is already reflected in stock prices by market prediction or insider trading before it is officially announced (Kim and Jeong 1995).

Table 4: AAR and CAAR before and after the application date

Day	AAR		CAAR	
	%	t-value	%	t-value
-7	0.126	0.351	0.126	0.351
-6	0.696	1.942*	0.822	1.621
-5	-0.083	-0.233	0.738	1.189
-4	0.791	2.205**	1.529	2.132**
-3	0.339	0.946	1.868	2.330**
-2	0.274	0.764	2.142	2.439**
-1	-0.276	-0.769	1.866	1.968**
0	-0.981	-2.736***	0.886	0.873
1	-0.168	-0.469	0.717	0.667
2	0.093	0.258	0.810	0.714
3	-0.115	-0.320	0.695	0.585
4	-0.526	-1.467	0.169	0.136
5	0.706	1.968**	0.875	0.677
6	0.719	2.005**	1.594	1.188
7	0.336	0.938	1.930	1.390
*** p<0.01, ** p<0.05, * p<0.1				

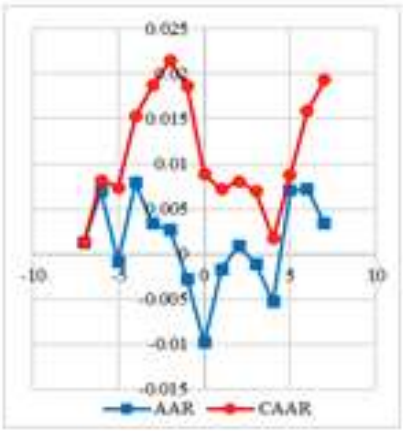

Fig. 1: Changes in AAR and CAAR before and after the application date

4.2. Patent acquisition

This study examined the stock price response of a company when it was revealed at the time of gaining a patent, which is the result of a company's R&D activities. For this purpose, the AAR and CAAR of the entire sample obtained by the market model based on 257 samples and each t-value are shown in Table 5 and Figure 2.

Table 5: AAR and CAAR before and after the acquisition date

Day	AAR		CAAR	
	%	t-value	%	t-value

-7	0.190	0.940	0.190	0.940
-6	-0.027	-0.132	0.163	0.572
-5	-0.055	-0.273	0.108	0.309
-4	0.137	0.677	0.245	0.606
-3	0.008	0.042	0.253	0.561
-2	0.098	0.487	0.351	0.711
-1	0.090	0.444	0.441	0.826
0	0.546	2.708***	0.987	1.730*
+1	-0.009	-0.042	0.979	1.617
+2	-0.105	-0.522	0.873	1.369
+3	0.321	1.592	1.195	1.786*
+4	-0.359	-1.781*	0.835	1.196
+5	-0.162	-0.803	0.673	0.926
+6	0.095	0.472	0.768	1.018
+7	-0.278	-1.380	0.490	0.627
*** p<0.01, ** p<0.05, * p<0.1				

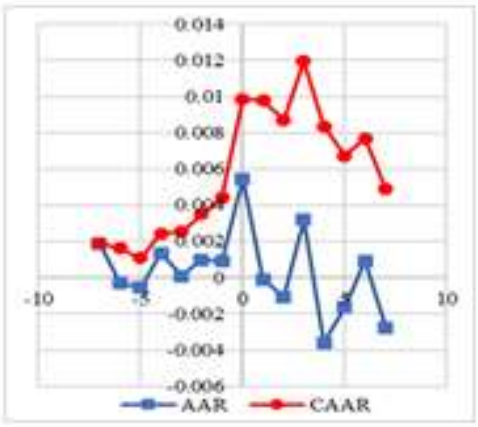

Fig. 2: Changes in AAR and CAAR before and after acquisition date

Companies that have disclosed that they have acquired a patent show a positive AAR of 0.546% on D-0, which is significant at the 1% level. This means that investors participating in the KOSPI market positively accept the information. Instead, on D-4, an AAR of -0.359% appears significant at the 10% level. Moreover, CAAR continues to show a positive value during the event window, indicating a positive stock price response. In particular, on D-0 and D+3, the CAARs are 0.987% and 1.195%, respectively, being statistically significant at the 10% level.

These results mean that even though patent acquisition disclosure is self-disclosure, ex-ante stock price reactions before the announcement are not observed in the short term, and are in line with the research results of Lee and Kim (2016). Namely, it empirically shows that Korea's securities market is a semi-strong form efficient market defined by Fama's (1970) efficient market theory.

4.2.1. Country: Korea vs. Non-Korea

Table 6 shows the result of the analysis after identifying the country where the patent was obtained through the patent name or other important matters about investment judgment, and dividing it into 'Korea' and 'Non-Korea'.

Table 6: Announcement effect by country

Panel A. Korea					Panel B. Non-Korea				
Day	AAR		CAAR		Day	AAR		CAAR	
	%	t-value	%	t-value		%	t-value	%	t-value
-7	0.282	1.259	0.282	1.259	+7	-0.126	-0.353	-0.126	-0.353
-6	0.091	0.406	0.373	1.177	+6	-0.429	-1.201	-0.556	-1.099
-5	0.054	0.240	0.426	1.100	-5	-0.429	-1.199	-0.985	-1.590
-4	-0.015	-0.065	0.412	0.920	-4	0.656	1.834*	-0.329	-0.460
-3	-0.101	-0.452	0.311	0.621	-3	0.385	1.076	0.056	0.070
-2	0.201	0.899	0.512	0.934	-2	-0.255	-0.713	-0.199	-0.228
-1	0.225	1.007	0.737	1.245	-1	-0.376	-1.052	-0.575	-0.608
0	0.572	2.556**	1.309	2.068**	0	0.458	1.281	-0.117	-0.116
+1	-0.081	-0.362	1.228	1.829*	+1	0.240	0.671	0.122	0.114
+2	0.014	0.060	1.242	1.755**	+2	-0.513	-1.434	-0.390	-0.345
+3	0.427	1.906*	1.668	2.248**	+3	-0.041	-0.115	-0.431	-0.364
+4	-0.333	-1.486	1.336	1.723*	+4	-0.450	-1.260	-0.882	-0.712
+5	-0.177	-0.791	1.159	1.436	+5	-0.110	-0.309	-0.992	-0.770
+6	0.303	1.352	1.461	1.745*	+6	-0.617	-1.725*	-1.609	-1.203
+7	-0.254	-1.133	1.208	1.394	+7	-0.363	-1.016	-1.972	-1.424
*** p<0.01, ** p<0.05, * p<0.1									

When exploring the AAR for 15 days before and after the event date when a patent was acquired in Korea, the AAR for 9 trading days shows a positive value. Particularly, on D-0, the AAR of 0.572% is significant at the 5% level, indicating a positive stock price response. Then, on D+3, the AAR of 0.427% is significant at the 10% level. CAAR also shows a positive value during the event window, and especially, it is statistically significant within the 10% level from D-0 to D+4.

Otherwise, the AAR shows a negative value on 11 trading days when the patent right was attained in a foreign country. On D-4, AAR is 0.656%, showing a positive stock price reaction, but on D+6, AAR is -0.617%, showing a negative stock price reaction. All of these are significant at the 10% level, respectively. On D-0, the AAR is 0.458% (t-value = 1.281), which is not significant at the commonly used significance level, but indicates a positive AAR. Unlike accomplishing patent rights in Korea, CAAR shows a negative value during the event window, although most of them are insignificant.

4.2.2. Number of publications: 1 vs. 2 or more

Table 7 shows the result of the analysis when the groups were classified according to whether the number of companies that disclosed that they developed patent rights per day was one, two, or more.

Table 7: Announcement effect by the number of acquisitions

Panel A. One					Panel B. Two or more				
Day	AAR		CAAR		Day	AAR		CAAR	
	%	t-value	%	t-value		%	t-value	%	t-value
+7	0.169	0.800	0.169	0.800	+7	0.322	0.708	0.322	0.708
+6	-0.088	-0.417	0.081	0.270	+6	0.379	0.832	0.701	1.089
-5	-0.112	-0.527	-0.031	-0.083	+5	0.315	0.692	1.016	1.289
-4	0.140	0.661	0.109	0.259	-4	0.114	0.251	1.131	1.242

-3	0.131	0.621	0.241	0.509	-3	-0.798	-1.753*	0.333	0.327
-2	-0.024	-0.115	0.216	0.417	-2	0.903	1.983**	1.236	1.108
-1	0.024	0.113	0.240	0.429	-1	0.521	1.144	1.756	1.458
0	0.630	2.977***	0.871	1.454	0	0.005	-0.011	1.751	1.360
+1	0.088	0.418	0.959	1.510	+1	-0.644	-1.415	1.107	0.811
+2	-0.139	-0.674	0.820	1.225	+2	0.116	0.255	1.223	0.849
+3	0.387	1.829*	1.207	1.719*	+3	-0.113	-0.249	1.110	0.735
+4	-0.324	-1.532	0.883	1.204	+4	-0.588	-1.291	0.522	0.331
+5	-0.299	-1.411	0.584	0.766	+5	0.734	1.613	1.256	0.765
+6	0.099	0.469	0.684	0.863	+6	0.068	0.149	1.324	0.777
+7	-0.126	-0.596	0.558	0.680	+7	-1.276	-2.803***	0.048	0.027
*** p<0.01, ** p<0.05, * p<0.1									

When a company announces that it has acquired one patent right per day, the AAR increases rapidly to 0.630% on D-0, and at this time, the t-value is 2.977, which is statistically significant at the 1% level. The AAR increases to 0.387% on D+3, and at this time, the t-value is 1.829, which is statistically significant at the 10% level. In addition, CAAR shows positive values most of the time during the event window, and especially, CAAR is 1.207% on D+3, which is statistically significant at the 10% level.

On the other hand, when a company announces that it has achieved two or more patent rights per day, on D-3, AAR is -0.798% (t-value = -1.753), which is significant at the 10% level, but on D-2, AAR is 0.903% (t-value = 1.983), it is significant at the 5% level. On D+7, AAR sharply decreases to -1.276%, and at this time, the t-value is -2.803, which is statistically significant at the 1% level. As well, CAAR shows positive values during the event window, but it is insignificant.

4.2.3. Patent holder: Single vs. joint

Table 8 shows the result of the analysis when whether a specific technology, which is the subject of patent right acquisition, was classified as independently developed and acquired by a company or jointly developed and acquired with other companies or research institutes.

When a company independently acquires patent rights, the AAR on D-0 is 0.444% (t-value = 2.220), which is significant at the 5% level, indicating a positive stock price response. On D+3, the AAR increased to 0.358%, and at this time, the t-value is 1.787, which is statistically significant at the 10% level. CAAR also shows positive values during the entire event period, and in particular, CAAR is 1.268% on D+3, which is statistically significant at the 10% level.

Likewise, when companies jointly gain patent rights, the ARR on D-0 is 1.989% (t-value = 2.400), which is significant at the 5% level, indicating a positive stock price response. However, on D+2 and D+4, AAR is -1.791% and -1.520%, respectively, which are significant at the 5% and 10% levels, indicating a negative stock price reaction. CAAR shows an insignificant positive value continuously from D-4 to D+3.

Table 8: Announcement effect by the number of patent holder

Panel A. Single					Panel B. Joint				
Day	AAR		CAAR		Day	AAR		CAAR	
	%	t-value	%	t-value		%	t-value	%	t-value
-7	0.219	1.097	0.219	1.097	-7	-0.233	-0.281	-0.233	-0.281
-6	-0.053	-0.265	0.166	0.588	-6	0.348	0.420	0.115	0.098
-5	-0.023	-0.114	0.144	0.415	+5	-0.512	-0.618	-0.397	-0.277
-4	0.050	0.249	0.194	0.484	-4	1.361	1.643	0.964	0.582
-3	0.046	0.229	0.239	0.535	-3	-0.518	-0.624	0.447	0.241
-2	0.081	0.405	0.320	0.654	-2	0.341	0.411	0.788	0.388

-1	0.094	0.470	0.414	0.783	-1	0.027	0.033	0.814	0.371
0	0.444	2.220**	0.859	1.518	0	1.989	2.400**	2.804	1.196
+1	0.037	0.187	0.896	1.493	+1	-0.658	-0.794	2.146	0.863
+2	0.014	0.071	0.910	1.439	+2	-1.791	-2.161**	0.355	0.135
+3	0.358	1.787*	1.268	1.911*	+3	-0.193	-0.233	0.162	0.059
+4	-0.277	-1.385	0.991	1.430	+4	-1.520	-1.834*	-1.358	-0.473
+5	-0.161	-0.804	0.830	1.151	+5	-0.179	-0.216	-1.537	-0.514
+6	0.107	0.536	0.937	1.252	+6	-0.075	-0.091	-1.613	-0.520
+7	-0.230	-1.152	0.707	0.912	+7	-0.953	-1.150	-2.566	-0.799
*** p<0.01, ** p<0.05, * p<0.1									

4.2.4. Difference analysis

Table 9 shows the results of the t-test of the difference analysis for independent samples with CAAR as the test variable to check how CAAR changes according to the collective characteristics of companies that voluntarily disclosed the acquisition of patent rights.

Table 9: Difference analysis of CAAR by group

Period	Country		Number of disclosures		Patent holder		Difference	t-value	
	Korea	Non-Korea	One	Two or more	Single	Joint			
CAAR (-7, +7)	0.0091	-0.0060					0.0151	6.575	***
			0.0051	0.0099			-0.0048	-3.257	***
					0.0061	0.0006	0.0055	1.396	
CAAR (-6, +6)	0.0094	-0.0053					0.0147	6.899	***
			0.0053	0.0111			-0.0058	-3.967	***
					0.0063	0.0028	0.0034	0.874	
CAAR (-5, +5)	0.0094	-0.0043					0.0137	7.108	***
			0.0055	0.0113			-0.0058	-3.286	***
					0.0064	0.0047	0.0017	0.411	
CAAR (-4, +4)	0.0097	-0.0031					0.0128	5.886	***
			0.0062	0.0113			-0.0051	-2.468	**
					0.0068	0.0079	-0.0011	-0.266	
CAAR (-3, +3)	0.0100	-0.0022					0.0122	5.333	***
			0.0065	0.0122			-0.0057	-2.546	**
					0.0070	0.0107	-0.0037	-0.960	
CAAR (-2, +2)	0.0101	-0.0023					0.0124	7.893	***
			0.0062	0.0141			-0.0079	-3.308	**
					0.0068	0.0138	-0.0070	-1.660	
CAAR (-1, +1)	0.0109	-0.0019					0.0128	13.651	***
			0.0069	0.0154			-0.0085	-2.145	

					0.0072	0.0192	-0.0120	-2.682	
*** p<0.01, ** p<0.05, * p<0.1									

First, as a result of classifying into 'Korea' and 'Non-Korea' depending on the country in which the patent was acquired, there is a statistically significant difference at the 1% level from CAAR (-7, +7) to CAAR (-1, +1). Investors show a more positive response when a company acquires a patent right in Korea than when a company acquires a patent right abroad.

Second, as a result of classifying it into 'one' and 'two or more' according to the number of patents announced by a company per day, most of them have a significant difference at the 1% or 5% level, except for CAAR (-1, +1). A more positive response is shown when two or more disclosures are released per day, rather than one disclosure per day. Therefore, the more patents a company acquires, the higher its firm value.

Third, as a result of classifying patent rights into 'independent' and 'joint' according to whether the patent was independently developed or jointly acquired with other companies or research institutes, there is no statistically significant difference from CAAR (-7, +7) to CAAR (-1, +1). There is no difference in information regardless of whether patent rights are achieved independently or jointly with other companies or research institutes.

4.2.5. Multiple regression analysis

To identify the factors affecting the announcement effect of the patent acquisition of the company as a result of the company's R&D activities, a cross-sectional regression analysis was conducted with the CAR as the dependent variable and the company's characteristic variable as the independent variable.

Table 10: Regression analysis results

Var.	Model 1: CAR (-1, +1)			Model 2: CAR (-2, +2)			Model 3: CAR (-3, +3)		
	Coef.	t-value		Coef.	t-value		Coef.	t-value	
Cons	-0.117	-0.92		-0.229	-1.35		-0.247	-1.22	
Cty	0.011	1.32		0.021	1.95	*	0.022	1.67	*
NoP	0.018	1.86	*	0.012	0.93		-0.028	-1.76	*
CoP	-0.007	-0.58		0.007	0.41		0.020	1.01	
Size	0.003	0.83		0.008	1.30		0.007	1.00	
RnD	-0.000	-0.91		-0.003	-2.60	***	-0.004	-2.74	***
Beta	0.023	2.74	***	0.024	2.13	**	0.031	2.26	**
Lev	-0.033	-1.54		-0.067	-2.30	**	-0.050	-1.43	
OPS	-0.021	-0.81		-0.076	-2.19	**	-0.067	-1.62	
SGR	0.002	0.92		0.004	1.12		0.006	1.23	
R^2	0.0481			0.0675			0.0701		
Adj. R^2	0.0134			0.0335			0.0362		
F(p-value)	1.39(0.1948)			1.99(0.0414)			2.07(0.0329)		
*** p<0.01, ** p<0.05, * p<0.1									

As a result of the empirical analysis, Model 2 and Model 3 are suitable since the F-values representing the goodness of fit of the model are 2.07 and 1.99, respectively. The adj-R^2 values representing the explanatory power of the model are 0.0362 and 0.0335, respectively. The signs of each variable in the two models (model 2 and model 3) all appeared in the same direction, and the variable Cty is significant at the 10% level, indicating that gaining a patent in Korea has a more positive effect than obtaining a patent abroad. Besides, beta shows a significantly positive value at the 5% level, and the larger the beta, the greater the positive stock price response to patent acquisition. However, R&D shows a significantly negative value at the 1% level, indicating that companies with relatively low R&D expenses showed higher performance in obtaining patents. Participants in the stock market positively evaluate companies that have gained patents with low R&D investment.

Additionally, in Model 2, the coefficient values of Lev and OPS are -0.067 and -0.076, respectively, which are significant at the 5% level. Namely, the lower the leverage ratio and the lower the operating profit-to-sales ratio, the higher the performance of patent acquisition.

The number of patent holders and the other characteristics of the company such as company size and sales growth ratio are not statistically significant at the traditional level.

5. CONCLUSION

5.1. Summary

This study examined the change in firm value according to the patent acquisition announcement by using the event study. From February 2009 to January 2017, when it was changed to voluntary disclosure due to rational improvement of occasional disclosure items and expansion of voluntary disclosure, there are a total of 257 data that companies disclosed about their 'acquisition of patent rights' through the KIND. Besides, as a result of checking the patent application date with the released contents, 74 cases were confirmed, and the results of the empirical analysis are summarized as follows.

First, based on the patent application date, AAR shows a meaningfully positive response on D-6 and on D-4, and then AAR shows a significantly negative response on D-0. CAAR shows a significantly positive response from D-4 to D-1. In other words, a patent application is good news that raises a company's stock price on average, and at the same time, the information about a patent application is already reflected in the stock price by market prediction or insider trading before it is officially announced.

Second, based on the patent acquisition date, both AAR and CAAR show a significantly positive response on D-0. This means that investors participating in the stock market positively accept the information that a company has attained patent rights. Namely, Korea's securities market is a semi-strong form of efficient market defined by efficient market theory. With the above results, it was divided into two groups by subdividing by country of patent acquisition, number of patent holders, and number of published cases per day. In terms of country classification, when a patent was acquired in Korea, not only did AAR appear to have a significantly positive response on D-0 and D+3, but also CAAR showed a substantially positive response from D-0 to D+4. When a patent was obtained in a foreign country, positive AAR appeared on D-4, but negative AAR appeared on D+2. Concerning the number of disclosures per day, when a company announces that it has acquired one patent per day, positive AAR occurred on D-0 and on D+3. When a company announces that it has acquired two or more patent rights in a day, negative AAR appears on D-3 and D+7, but positive AAR appears on D-2. Regarding the number of patent holders, regardless of whether the companies acquired patent rights independently or jointly, positive AARs appeared on D-0.

Finally, a regression analysis was conducted to examine the factors that patent acquisition announcement affects firm value. Given that the country of patent acquisition is significant, obtaining a patent in Korea has a more positive effect than obtaining a patent abroad. R&D expense, leverage ratio, and operating profit-to-sales ratio hurt firm value, while beta had a positive effect on it. Therefore, the lower the R&D expense, the lower the leverage ratio, and the lower the operating profit-to-sales ratio, the higher the firm value, whereas the higher the beta, the higher the firm value.

5.2. Implication and limitation

The implications of this study are as follows. First, despite the change in the acquisition of patent rights from ad-hoc disclosure to voluntary disclosure, investors still perceive companies' acquisition of patent rights as useful information and eventually it leads to firm value. Second, there is a difference in the reaction time of investors in the KOSPI market depending on patent application and patent acquisition. Patent application information is already reflected in stock prices through market forecasts or insider trading before it is officially announced, while patent acquisition information is reflected in stock prices at the time of public announcement. In sum, the acquisition of patent rights is a fundamental event that increases firm value, and companies should strive to accomplish patents by effectively in R&D expenses.

Meanwhile, the limitations of this study are as follows. First, the research period was set from 2009 to 2019 before COVID-19, but this study was inevitably set to January 2017 because data after February 2017 could not be collected. Thus, a wide range of analyses could not be performed by dividing the data before and after COVID-19. Second, a significantly positive AAR appeared on D+5 and D+6, but it was not clarified whether these results were due to the patent application or other events. Lastly, this study examined only companies listed on the KOSPI market, but it would be more meaningful if other results were derived by expanding the analysis to companies listed on the KOSDAQ and KONEX markets as a follow-up study.

6. ACKNOWLEDGMENTS

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2020S1A5B5A17090841).

7. REFERENCES

Brown, S. J. & Warner, J. B. (1985). Using daily stock returns: the case of event studies. *Journal of Financial Economics*, 14(1), 3-31. DOI: https://doi.org/10/1016/0304-405X(85)90042-X

Chan, S. H., Martin, J. D. & Kensinger, J. W. (1990). Corporate research and development expenditures and share value. *Journal of Financial Economics*, 26(2), 255-276. DOI: https://doi.org/10.1016/0304-405X(90)90005-K

Chaney, P. K. & Devinney, T. M. (1992). New product innovation and stock price performance. *Journal of Business Finance & Accounting*, 19(5), 677-695. DOI: https://doi.org/10.1111/j.1468-5957.1992.tb00651.x

Cho, Y. D. (2005). A study on the information effect of public patent announcement. *Accounting Information Review*, 23(4), 133-156.

Choi, C. S. (2021). A Study on the Asymmetric Volatility of the U.S. and Japanese REITs Returns. *International Journal of Smart Business and Technology*, 9(2), 87-94, DOI:10.21742/IJSBT.2021.9.2.07

Cockburn, I. & Griliches, Z. (1987). Industry effects and appropriability measures in the stock market's valuation of R&D and patents. *National Bureau of Economic Research*, Working Paper, 2465, 1-44. DOI: https://doi10.3386/w2465

Ehie, I. C. & Olibe, K. (2010). The effect of R&D investment on firm value: An examination of US manufacturing and service industries. *International Journal of Production Economics*, 128(1), 127-135. DOI: https://doi.org/j.ijpe.2010.06.005

Fama, E. F. (1970). Efficient capital markets: a review of theory and empirical work. *Journal of Finance*, 25(2), 383-417. DOI: https://doi.org/10.2307/2325486

Jo, J., Jeong, J. & Bae, K. (2014). A study on the firm value and intangible assets of technology innovation companies. *Global Business Administration Review*, 11(2), 33-59.

Jung, H. C. (2006). Small sample size problems and the power of the test in the event study methodology. *Korean Journal of Financial Studies*, 35(3), 107-140.

Kamiyama, S., Sheehan, J. & Martinex, C. (2006). Valuation and exploitation of intellectual property. Institutes of Public Goods and Policies, Working Paper, DOI: https://doi.org/10.1787/18151965

Kim, M. J. & Jeong, H. C. (1995). 특허출원의 공시와 주식가치. *The Korean Journal of Financial Management*, 12(2), 121-142.

Kim, P., Koo, N. & Nam, Y. (2016). The valuation effects of patent announcements. *Journal of Business Research*, 31(3), 219-241.

Kim, P. & Nam, Y. M. (2019). Patents by KOSDAQ listed firms. *Korean Journal of Business Administration*, 32(2), 195-218. DOI: https://doi.org/10.18032/kaaba.2019.32.2.195

Kim, S., Byun, H. & Jin, M. (2004). Stock price effect at announcement of patent registrations. 경상논집, 32(1), 21-35.

Kogan, L., Papanikolaou, D., Seru, A. & Stoffman, N. (2017). Technological innovation, resource allocation, and growth. *The Quarterly Journal of Economics*, 132(2), 665-712. DOI: https://doi.org/10.1093/qje/qjw040

Kwon, Y. & Yoo, W. (2011). A study on the influence on enterprise value of public announcement of obtaining a patent for KOSDAQ listed venture business. *Korean Business Education Review*, 26(2), 51-72.

Lee, J. G., Jung, Y. K. & Jeon, S. I. (2007). Patent disclosures and stock market reactions. *Korean Business Education Review*, 47(1), 285-305.

Lee, J. W. & Kim, J. Y. (2016). Real-time information effect of patent listing disclosure. *Management Information Systems Review*, 35(3), 195-212. DOI: https://earticle.net/Article.A286861

Lim, S. (2021). A study on the determinants of firm's patent activity and strategies. *Innovation studies*, 16(3), 305-331. DOI: https://doi.org/10.46251/INNOS.2021.8.16.3.305

Mackinlay, A. C. (1997). Event studies in economics and finance. *Journal of Economic Literature*, 35(1), 13-39. DOI: https://jstor.org/stable/2729691

Na, Y. & Kwack, J. M. (2011). An empirical analysis on the value relevance to the patent acquisition disclosure - based on KOSPI and KOSDAQ markets. *Accounting Information Review*, 29(1), 97-132.

Pakes, A. (1985). On patent, R&D and the stock market rate of return. *Journal of Political Economy*, 93(2), 390-409. DOI: https://doi.org/10.1086/261305

Sung, O. & Jo, K. (2009). A study about the effects of intellectual property investment and management on the value of intangible assets of firms. *Journal of Korea Technology Innovation Society*, 12(2), 291-311.