



## ORIGINAL ARTICLE

# Analysis on Time-Lag Effect of Research and Development Investment in the Pharmaceutical Industry in Korea

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Received: July 7, 2015  
Revised: July 14, 2015  
Accepted: July 15, 2015

**KEYWORDS:**

enterprise value,  
pharmaceutical industry,  
research and  
development  
investment,  
time-lag effect

**Abstract**

**Objectives:** The aim of this study is to analyze the influence of the research and development (R&D) investment of pharmaceutical companies on enterprise value.

**Methods:** The period of the empirical analysis is from 2000 to 2012, considering the period after the influence of the financial crisis. Financial statements and comments in general and internal transactions were extracted from TS-2000 of the Korea Listed Company Association, and data related to stock price were extracted from KISVALUE-III of National Information and Credit Evaluation Information Service Co., Ltd. STATA 12.0 was used as the statistical package for panel analysis.

**Results:** In the pharmaceutical firms, the influence of the R&D intensity with regard to Tobin's  $q$  was found to be positive. However, only the R&D expenditure intensities of previous years 2 and 5 ( $t-2$  and  $t-5$ , respectively) were statistically significant ( $p < 0.1$ ), whereas those of previous years 1, 3, and 4 years ( $t-1$ ,  $t-3$ , and  $t-4$ , respectively) were not statistically significant.

**Conclusion:** R&D investment not only affects the enterprise value but is also evaluated as an investment activity that raises the long-term enterprise value. The research findings will serve as valuable data to understand the enterprise value of the Korea pharmaceutical industry and to strengthen reform measures. Not only should new drug development be made, but also investment and support should be provided according to the specific factors suitable to improve the competitiveness of each company, such as generic, incrementally modified drugs, and biosimilar products.

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## 1. Introduction

Pharmaceutical companies tend to develop new drugs to treat new diseases through research and development (R&D) investment to create a next-generation profit source, or develop relatively cost-effective drugs to maximize enterprise value. R&D investment has been relatively insufficient despite constant industry growth, whereas the percentage of selling, general, and administrative expenses including sales promotion costs has been high. Going forward, the government's reform policies will kick into high gear in the pharmaceutical industry. These have established in the domestic market relatively high generic medicine costs compared with those of advanced countries and unfair competition such as negative rebates. It can be said that a bond of sympathy has developed between the pharmaceutical industry and the government around the need to support R&D investment to promote the industry as a future growth engine.

Studies that have empirically analyzed R&D investment in the pharmaceutical industry largely clarify factors that have positive relevance for R&D investment. Grabowski and Vernon [1] determined that, among pharmaceutical companies, there is a positive relevance between a firm's internal cash flow and R&D costs. Vernon [2] studied firms exposed to the U.S. pharmaceutical pricing policy and revealed that there is a positive relevance between the former term's internal cash flow and the current term's expected returns as R&D determinants. Lee and Lee [3] used explanatory variables such as R&D intensity and accounting profit rate (BIS) ratio, targeting 63 pharmaceutical companies using data from 2001 to 2006, and analyzed their effects on corporate performance in a time-lag model. They reported that R&D cost intensity a year ago had a positive influence on the current term's ratio of ordinary profit, whereas R&D expenditures of previous years 2 and 3 had a negative influence on that ratio. This was presumably due to the research investment characteristics for new drug developments (long-term investment), and structural characteristics of R&D activities that focus on incrementally modified drugs and generic medicine.

A firm's R&D activities are gradually taking up a significant part of its investment activities related to the enhancement of enterprise value [4]. Thus, analysis of R&D activities and enterprise value is an ongoing research topic. There are many studies that analyze the relevance between R&D expenditures and the present or future enterprise value, which can be summarized mainly into three perspectives. First, there is the perspective of a decrease in enterprise value. It argues that R&D investment has relatively higher risk than real investment due to a higher probability of failure, and thus, if investors make investments with a short-term

requirement in the stock market, R&D investment leads to a decline in stock prices. Moreover, even if an R&D investment turns out to be successful, it takes quite a long time for the outcome to come to fruition, and only investments that satisfy certain capitalization requirements are processed as assets. Other research costs (in Korea), or the total R&D costs (in the United States), are processed as expenses, which may reduce the profits for the term. Studies that analyzed the cases of actual R&D processed as assets or costs [5] presented an empirical analysis result showing that the processed research costs may negatively affect enterprise value. Some point out that market response to R&D investment may vary according to periods. In the United States, it was reported that the influence of R&D investment on enterprise value in the 1980s was insignificant or negative [6]. Second, it is the perspective of an increase in enterprise value. Although an R&D investment may have a negative effect on short-term accounting profits or stock price increases, in the long-term such investment enables new technologies, increases productivity, and reduces costs. At the same time, increased sales from new and improved products enhance profitability. However, R&D projects have a high uncertainty and do not lead directly to profits. Nevertheless, these can increase future expected cash flow by securing core corporate competences and enhancing competitiveness, and thus, they positively affect enterprise value [7]. As a result, firms making R&D investments can be considered firms that make strategic investments for the long term to increase enterprise value. Therefore, the dominant argument is that R&D investment positively affects enterprise value, such as a stock price response showing a positive excess earning rate due to disclosure or increase of an R&D investment, or an increase in the long-term enterprise value [7–10].

If the outcome of R&D activities influences enterprise value, the degree of its effect on enterprise value may vary according to the degree or characteristics of the factors that influence R&D activities. Empirical studies suggest that the relationship between R&D investment and enterprise value may be influenced by corporate and financial characteristics or financial environment. Doukas and Switzer [11] presented evidence that firms with higher industrial concentration show greater stock price response when R&D investment is disclosed. Chauvin and Hirschey [12] and Connolly and Hirschey [9] argued that the greater the business scale, the greater the effect of R&D investment. Hall and Oriani [13] suggested that lower ownership concentration showed more positive market response to R&D investment in France, Germany, and Italy. Franzen and Radhakrishnan [14] pointed out that the information effect of R&D activities may be reflected differently on the market value of profitable firms versus unprofitable firms, and stated that

disclosure of R&D investment contents may be important for the effect of the R&D investment. Hillier et al [15] comprehensively analyzed the corporate characteristic variables that had been considered in previous studies. The result showed that business scale, growth, and market share had a positive influence on enterprise value. By contrast, free cash flow, external capital dependence, labor intensity, and capital intensity were proven to have a negative effect on enterprise value. In particular, more free cash flow may lead to a higher probability of implementing investment projects with net present value (NPV) of 0 or below (i.e.,  $NPV < 0$ ) in the view of Jensen [16], which is negative for the enterprise value creation. Moreover, R&D investment projects originally have high information asymmetry, and thus, higher external capital dependence leading to a negative effect on enterprise value. These results, however, cannot be generalized for all firms in terms of the degree of enterprise value effect from R&D expenditures, but they do provide evidence that multiple variables have influence on the effect.

It analyzes the influence of the R&D investment of pharmaceutical companies on enterprise value and evaluates the influential factors identified through analysis and examines positive promotion plans.

## 2. Materials and methods

### 2.1. Data sources

The period of the empirical analysis is from 2000 to 2012, considering the period after the influence of the financial crisis. The targeted firms for analysis are those listed on the stock exchange, and they are all of firm level. Financial statements and comments in general and internal transactions were extracted from TS-2000 of the Korea Listed Company Association, and data related to stock price are extracted from KISVALUE-III of National Information and Credit Evaluation Information Service Co., Ltd. STATA 12.0 was used for panel analysis. While analyzing data on R&D investment, there were issues of omitted records, inconsistency, and failure of reflected changes in the TS-2000 and KISVALUE-III databases despite the fact that accuracy of R&D cost-related data was extremely important. Thus, this study collected data from the Data Analysis, Retrieval, and Transfer system of the Financial Supervisory Service.

Ultimately, 640 firm-year data of 81 firms were included in the sample. Unbalanced panel data with different data-inclusion periods of variables listed in Table 1 could be obtained according to the availability of data. Considering the characteristics of R&D in the pharmaceutical industry, we expanded the lagged variable to 6 years including the current term. The data used in this study are panel data with characteristics of both cross-sectional and time series data, and therefore,

**Table 1.** Annual distribution of sample firms.

Year	No. of firms	Percentage	Cumulative
2000	14	2.19	2.19
2001	19	2.97	5.16
2002	30	4.69	9.84
2003	34	5.31	15.16
2004	36	5.63	20.78
2005	43	6.72	27.50
2006	46	7.19	34.69
2007	52	8.13	42.81
2008	61	9.53	52.34
2009	68	10.63	62.97
2010	76	11.88	74.84
2011	80	12.50	87.34
2012	81	12.66	100.00

require the application of an appropriate analysis method. That is, in linear regression models for panel data, the estimation scheme varies depending on whether there is the error term within the fixed effect or random effect model.

The data for this study are not randomly extracted from the population of the listed market and can be the population itself with the exclusion of certain data, and therefore, they can be estimated using the fixed effect model. It was intuitively decided that the characteristics of panel entities must be taken into account considering that the sample is the listed market. Thus, the  $F$  test was used to conduct the goodness-of-fit test for the fixed effect model. The result showed that the  $p$  value is smaller than 0.01 in the entire model, indicating that there are fixed entity characteristics. In other words, the fixed effect model was more suitable than OLS. Moreover, the null hypothesis that the corporate characteristics variable of the individual effect does not exist was rejected when the Hausman test was conducted. Therefore, the result coincided with the knowledge that the fixed effect model is a better fit than the random effect model.

### 2.2. Definition and measurement of variables

*Tobin's  $q$* : The majority of studies use Tobin's  $q$  to proxy for firm value. Consistent with Cummins et al [17], we define Tobin's  $q$  as the market value divided by the book value of assets.

*R&D intensity*: This was measured based on research costs and ordinary development costs on income measurement. R&D intensity was used as a dependent variable to eliminate errors due to relative difference according to sales of each firm [18].

*Growth*: This study also assumed that firms with high growth will be more active in R&D investment, and used the rate of sales increase as the proxy variable for growth.

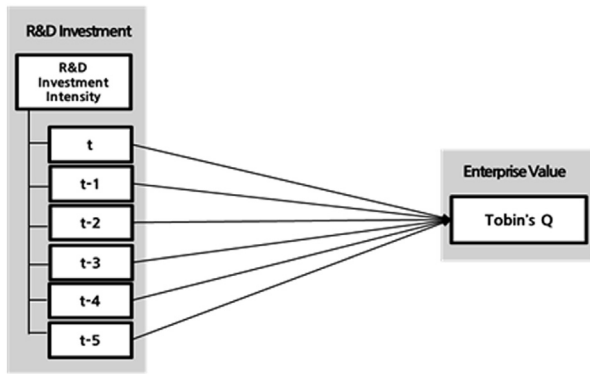


Figure 1. Research model.

*Liquidity:* Firms tend to prefer internal financing to external financing due to information asymmetry. This study used current ratio as the proxy variable for liquidity.

*Leverage:* Making strategic decisions such as R&D investment may be restricted by financial resources available in the company, and thus, it is necessary to examine the capacity of external financing of the company [19]. This study used debt ratio.

*Major shareholders:* One major shareholder refers to the shareholder with the most shares owned by himself or herself as well as his or her family, relatives, and affiliate persons. The major shareholder information announced in the distribution of shareholding size in the business report in the relevant settlement term was used to determine the shareholding ratio of major shareholders.

*Foreign ownership:* In the view of the efficient monitoring hypothesis, institutional and foreign investors are important agents and external control mechanisms that monitor the business activities of

the management as outside shareholders, and they influence corporate innovation in the long-term investment view [20]. Therefore, this study used the data of the shareholding ratio of foreigners of end-of-the-term ordinary shares.

*Business scale:* If the scale is huge, there are relatively more resources, thereby increasing the capacity to endure investments with long payback periods such as R&D [21]. Therefore, business scale was controlled in this study

*Firm age:* The longer the term after the firm was established and listed, the higher the possibility that investment decisions will be long term. In this study, the years listed (years passed after the firm was listed) was controlled instead of years established.

### 2.3. Research model

We applied the research model (Fig. 1) for the empirical analysis as follows:

$$Q_{it} = \alpha + \beta_1 RD_{it} + \beta_2 RD_{it-1} + \beta_3 RD_{it-2} + \beta_4 RD_{it-3} + \beta_5 RD_{it-4} + \beta_6 RD_{it-5} + \beta_7 SG_{it} + \beta_8 LIQ_{it} + \beta_9 LEV_{it} + \beta_{10} OWN_{it} + \beta_{11} FOR_{it} + \beta_{12} YEAR_{it} + \mu_i + \varepsilon_{it}$$

where  $\mu_i$  is an individual-specific effect that is not observable and that is not changeable with lapse of time and  $\varepsilon_{it}$  is an ordinary error term. Details of the other variables are provided in the “Results” section.

### 3. Results

Table 2 shows the descriptive statistics of key variables of all firms used in the empirical analysis. The characteristics of probability distribution and the outliers

Table 2. Descriptive statistics.

Variable	Observed	Mean	Standard deviation	Minimum	Maximum
<i>q</i>	640.00	4.89	13.34	-1.53	112.36
<i>RD</i>	640.00	6.95	9.92	0.14	99.07
<i>RD<sub>t-1</sub></i>	589.00	6.31	8.65	0.14	86.69
<i>RD<sub>t-2</sub></i>	534.00	5.72	7.50	0.14	63.90
<i>RD<sub>t-3</sub></i>	477.00	5.42	7.02	0.14	63.90
<i>RD<sub>t-4</sub></i>	422.00	5.05	6.47	0.19	63.90
<i>RD<sub>t-5</sub></i>	370.00	4.60	5.48	0.12	41.30
<i>SG</i>	640.00	10.51	25.76	-48.72	501.81
<i>LIQ</i>	640.00	362.91	289.60	35.20	2,269.89
<i>LEV</i>	640.00	61.14	77.65	0.00	1,549.72
<i>OWN</i>	640.00	37.18	14.67	2.31	79.50
<i>FOR</i>	640.00	5.91	10.84	0.00	57.79
<i>SIZE</i>	640.00	7.98	0.43	6.98	9.24
<i>YEAR</i>	640.00	1.01	0.44	0.00	1.71

FOR = shareholding ratio of foreigners; LEV = stability; LIQ = liquidity; OWN = shareholding ratio of major shareholders; RD = R&D investment; SG = growth; SIZE = firm size; YEAR = firm age.

of key variables are as follows. The dependent variable of Tobin's  $q$  ( $q$ ) appeared to be approximately 4.89%, and the maximum and minimum values show that there are considerable gaps among firms.

The average of the variables related to R&D investment was highest for the  $RD$  with 6.95, whereas that for  $RD_{t-1}$  was 6.31,  $RD_{t-2}$  was 5.72,  $RD_{t-3}$  was 5.42,  $RD_{t-4}$  was 5.05, and  $RD_{t-5}$  was 4.60. It can be inferred that R&D investment increases every year. However, the average of variables related to control variables was the highest for liquidity (LIQ) with 362.91, and maximum and minimum values show that there are considerable gaps among firms. Growth (SG), stability (LEV), shareholding ratio of major shareholders (OWN), shareholding ratio of foreigners (FOR), firm size (SIZE), and firm age (YEAR), which, in this study, were considered as control variables and factors that may influence enterprise value, turned out not to have a great standard deviation compared with the average, and therefore, appeared not to have a significant problem in normal distribution.

Table 3 presents the Pearson correlation coefficient to verify the multicollinearity status and correlation among explanatory variables. According to the analysis of the correlation between R&D intensity and the controlled variables, most of the R&D intensity lagged variables showed positive correlation; in particular, the R&D intensity of the current and previous terms showed very high positive correlation. The results are presented in Table 4.

In the pharmaceutical firms, the influence of the R&D intensity with regard to Tobin's  $q$  was found to be positive. However, only the R&D expenditure intensities of previous years 2 and 5 ( $t-2$  and  $t-5$ , respectively) were statistically significant ( $p < 0.1$ ), whereas those of the previous years 1, 3, and 4 ( $t-1$ ,  $t-3$ , and  $t-4$ , respectively) were not statistically significant. In terms of the regression coefficient of other controlled variables, it can be said that the enterprise value was higher when the current ratio (LIQ) was higher—or the enterprise value was higher when the business scale (SIZE) was smaller. It can be inferred that when listed for more years (YEAR), the enterprise value is rated higher.

### 4. Discussion

This study verified whether R&D investment influences enterprise value through the time-lag effect. TS-2000 and KISVALUE-III was used for the data analysis in this study. This study analyzed the influence of R&D investment on enterprise value at pharmaceutical companies. According to Eberhart et al [22], an increase in R&D investment significantly increases business performance. Jain and Kini [23] stated that there is a significant positive relationship

Table 3. Pearson correlation coefficients.

	$q$	$RD$	$RD_{t-1}$	$RD_{t-2}$	$RD_{t-3}$	$RD_{t-4}$	$RD_{t-5}$	SG	LIQ	LEV	OWN	FOR	SIZE	YEAR
$q$	1													
$RD$	-0.0374	1												
$RD_{t-1}$	-0.0493	0.9207	1											
$RD_{t-2}$	-0.0668	0.7970	0.8990	1										
$RD_{t-3}$	-0.0727	0.7130	0.7756	0.8873	1									
$RD_{t-4}$	-0.0723	0.6949	0.7381	0.7992	0.9089	1								
$RD_{t-5}$	-0.0735	0.7199	0.7470	0.7770	0.8200	0.8977	1							
SG	0.002	0.0257	0.1571	0.1687	0.1076	0.0651	0.0538	1						
LIQ	0.1286	0.2627	0.2523	0.1841	0.1974	0.1566	0.0994	0.005	1					
LEV	-0.0940	-0.0415	-0.0498	-0.0721	-0.0602	-0.0577	-0.0382	-0.021	-0.3338	1				
OWN	0.0641	-0.1586	-0.1868	-0.2195	-0.2189	-0.2017	-0.1740	-0.041	0.0387	-0.0542	1			
FOR	-0.1353	-0.0144	-0.0186	-0.0324	-0.0566	-0.0629	-0.0567	-0.0275	-0.0345	-0.1010	-0.007	1		
SIZE	-0.3355	0.0272	0.0452	0.0658	0.0437	0.0307	0.0455	-0.0637	-0.3566	0.1240	-0.2322	0.4229	1	
YEAR	-0.1387	-0.2260	-0.2265	-0.2227	-0.2323	-0.2458	-0.2552	-0.1227	-0.2928	0.1800	-0.2589	0.2497	0.5411	1

FOR = shareholding ratio of foreigners; LEV = stability; LIQ = liquidity; OWN = shareholding ratio of major shareholders; RD = R&D investment; SG = growth; SIZE = firm size; YEAR = firm age.

**Table 4.** Results.

	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
RD	-0.0721	0.0736											0.0748	0.177
$RD_{t-1}$			-0.0756	0.0819									0.0279	0.184
$RD_{t-2}$					-0.0516	0.0930							0.335 <sup>‡</sup>	0.192
$RD_{t-3}$							0.0444	0.107					0.191	0.160
$RD_{t-4}$									0.0787	0.126			0.188	0.171
$RD_{t-5}$											0.418 <sup>†</sup>	0.188	0.334 <sup>‡</sup>	0.203
SG	-0.00627	0.0122	-0.00544	0.0211	0.00654	0.0222	0.00503	0.0233	$9.24 \times 10^3$	0.0248	-0.00686	0.0264	-0.00135	0.0266
LIQ	0.00180	0.00162	0.00142	0.00180	0.00127	0.00200	0.00077	0.00218	0.00126	0.00242	0.00434	0.00263	0.0055 <sup>†</sup>	0.00278
LEV	0.00340	0.00463	0.00379	0.00478	0.00855	0.0164	0.0112	0.0180	-0.00472	0.0199	-0.00873	0.0210	0.00296	0.0213
OWN	0.0261	0.0506	0.0404	0.0580	0.0317	0.0628	0.0203	0.0701	-0.0362	0.0778	-0.0727	0.0829	-0.0563	0.0827
FOR	-0.00638	0.0461	-0.00347	0.0463	-0.0068	0.0488	-0.00344	0.0512	-0.0168	0.0539	-0.0270	0.0549	-0.0190	0.0548
SIZE	-10.92*	2.829	-13.39*	3.107	-15.01*	3.435	-15.30*	3.829	-13.07*	4.181	-11.71 <sup>†</sup>	4.692	-14.63*	4.817
YEAR	14.37*	2.073	20.73*	2.881	25.11*	3.706	24.97*	4.713	24.10*	5.840	20.82*	7.129	7.129	7.150
Constant	76.32*	21.54	88.33*	23.10	95.72*	25.11	97.66*	27.50	83.10*	29.80	75.02 <sup>†</sup>	33.07	93.81*	34.03
Adjusted $R^2$	0.0612		0.0615		0.0727		0.115		0.153		0.165		0.151	
Observed	640		589		534		477		422		370		370	
ID	81		81		76		72		68		62		62	

FOR = shareholding ratio of foreigners; LEV = stability; LIQ = liquidity; OWN = shareholding ratio of major shareholders; RD = R&D investment; SE = standard error; SG = growth; SIZE = firm size; YEAR = firm age. \* $p < 0.01$ , <sup>†</sup> $p < 0.05$ , <sup>‡</sup> $p < 0.1$ .

between investment in equipment and machinery and business performance. Compared with the findings of previous studies, this study focused on pharmaceutical companies publicly listed between 2000 and 2012, and found that R&D investment increased enterprise value. This analysis identified conditions for R&D investment that translate into corporate performance, and revealed that R&D investment has a positive impact on enterprise value, which is a comprehensive value index for any company. It can be inferred that R&D investment not only affects the enterprise value but is also evaluated as an investment activity that raises the long-term enterprise value. In addition, even if this influence is led by firms with a high R&D investment ratio and the influence on the enterprise value is offset by firms that do not invest in R&D at all, it can be understood that R&D investment increases the enterprise.

The results of this research are assumed to reflect the characteristics (long-term investment) of new drug development in the Korean pharmaceutical industry with poor sales, structural characteristics of generic drugs, and modified drug-centered R&D activities. However, as it is anticipated that there will be a significant systematic difference, it appears that this situation would not be applied in the future. The reason is that for systematic changes, such as the implementation of the positive list system of pharmaceuticals where it is determined whether the insurance payment would be made according to the economic evaluation of the pharmaceuticals, the enhancement of the patent right according to free trade agreements including the United States–Korea Free Trade Agreement, etc. would be a significant threat.

It is believed that, in the future, R&D-centered pharmaceutical firms focusing on the development of modified new drugs and new molecular entities that are competitive in the global market would achieve better financial performance than they currently do. The future growth of the Korean pharmaceutical industry would be possible only with the combination of the management of firms based on the strategic R&D investment, strategic thoughts of chief executive officers, strategic partnerships with other firms, and systematic support (tax system, medicine price system, etc.) by the government. Thus, R&D investment is a significant activity that would positively contribute to profit creation in the future: to secure competitive advantage in the health medical field in the future, it would be necessary to take a strategic approach to current R&D investment.

#### 4.1. Practical implications

There is a need for strategies to develop a portfolio of products that would improve the competitiveness of the relevant company rather than a consistent strategy of new drug development. Recently, many companies

considered new drug development as the only way to secure competitiveness in the tough conditions prevailing in the pharmaceutical industry. However, developing new drugs carries great risk, requiring high investment and time. Therefore, not only should new drug development be made, but also investment and support should be provided according to the specific factors suitable to improve the competitiveness of each company, such as generic, incrementally modified drugs, and biosimilar products. Further, it is necessary to support the generic industry, to improve access to drugs. Using generic drugs to reduce medical costs is a global trend, and considering the case of Israel's pharmaceutical company Teva as well as India's policy of developing the generic industry, fostering the generic industry should be viewed negatively. Therefore, there is a need for strategies that are suitable to improve the competitiveness and characteristics of each company.

#### Conflicts of interest

All contributing authors declare no conflicts of interest.

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