세무와회계저널 ISSN 1738－3323
제19권 제3호 2018년 6월 pp.45～72
한국세무학회

Do Cash Holdings of a Firm Investing in Research and Development Cause Sudden Stock Price Movement?*

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〈Abstract〉

In this study, I examine the influence of cash holdings on sudden stock price movements in relation with research and development (R&D) investments. Higher cash holdings weaken monitoring from investors and enables managers to hide bad news from overinvestment. Because R&D investment is inherently uncertain, managers would want to particularly hide bad news regarding R&D investment. When the negative news is eventually known to investors, stock price would crash.

In this study, I test my conjectures using data from firms listed on the Korean Stock Exchange from 1985 to 2014. I find a positive relation between stock price crash risk and cash holdings using the R&D firm sample, but not in the results using non－R&D sample. Robustness tests show that endogeneity is not the driver of these results. However, stock price upward jump is not related to cash holdings because positive news is rarely hidden from market participants.

Prior studies on cash holdings do not directly investigate the effect of cash holdings on a firm's opacity and valuation through investment and financing. This study contributes to the literature by addressing this aspect. Furthermore, unlike prior studies that suggest manager related attributes such as agency problems or managerial overconfidence as causes of stock price crash, this study suggests uncertainty of investment and/or financing activities as a potential reason for stock price crash.

〈Key words〉 cash holdings, stock price crash, stock price upward jump, research and development

* This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF－A2016－0152).

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논문접수일 2017년 12월 25일 1차수정일 2018년 2월 27일 게재확정일 2018년 3월 25일

Ⅰ. Introduction

Despite recent increases in firms' cash holdings, the economic consequences of cash holdings are not fully understood. In particular, the effect of cash holdings on information asymmetry has not been fully understood. In this study, I will investigate the effect of cash holdings on information asymmetry and valuation effect in the context of highly uncertain investment, i.e., research and development (R&D) investment.

Cash and cash equivalents can be valued without significant uncertainty. However, the price impact of cash holdings on firm value is not easy to measure because cash holdings could affect firm value through financing, investing and operating activities in several different ways. On one hand, as an internal financing source, cash holdings could improve firm value by facilitating investment activities (Faulkender and Wang 2006). On the other hand, as an monitoring－free asset, cash and cash equivalents could aggravate information asymmetry, which could increase value－destroying overinvestment (Jensen 1986 ; Harford 1999).

Among several aspects that cash holdings affect, this study focuses on information asymmetry. The influence of financing decisions on information asymmetry is a traditional research topic in accounting research (Botosan 1997 ; Botosan and Plumlee 2002 ; Watts 2003). Prior studies on information asymmetry generally focus on external financing. However, studies on cash holdings point out that cash holdings are important for firms' financial status because cash holdings provide internal financing source without friction.[1] This study expands the scope of prior studies on information asymmetry by examining the influence of cash holdings.

I propose that cash holdings would aggravate information asymmetry. Cash holdings provide a monitoring－free funding source ; hence, in firms with large cash holdings, managers may overinvest in risky projects without being monitored by investors (Harford 1999). When these investment projects become unsuccessful, negative news related to the projects is generated, whereas the failure of internally financed investment projects is less likely to be known to investors in a timely fashion.[2] Therefore, managers are likely to hide the negative news generated

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1) To the best of my knowledge, Keynes's (1936) study is the first research to focus on the usefulness of cash holdings as an internal financing source. After Keynes (1936), cash holdings have been studied in the context of financing activities (Opler et al. 1999 ; Alcharya et al. 2007 ; Campello et al. 2010). Bates et al. (2009) argue that precautionary motive is the main driver of cash holdings, which means that cash holdings cannot be separated from financing activities.

2) Managers should continue to provide capital providers with the outcome of their investment. For example, in the case of real estate investments, if a mortgage is used, the lender will want to be informed about

from risky investments, especially when the investment projects are innately opaque. However, accumulated negative news cannot be hidden forever. Investors would eventually discover the hidden negative news and the stock price would crash (Jin and Myers 2006 ; Hutton et al. 2009).

Even if the risky investments are likely to be successful, investors cannot adequately monitor the use of cash holdings and, therefore, are unlikely to see through the success of investments. Positive news about investments would accumulate and cause stock prices to jump upward when the news becomes public. Alternatively, positive news could already have been reflected in the stock prices because managers have an incentive to inform the public of the positive news ; in this case, it is unlikely that the stock prices would jump upward.

Among several risky investments, this study focuses on R&D investments, for the following reasons. First, R&D investments have the greatest uncertainty among various types of investments. Unlike investments in real assets or mergers and acquisitions (M&A), the results of R&D investments cannot be easily observed by outsiders because R&D creates mainly intangible assets. Information about R&D investments is easily hidden from investors compared with other types of investments. Second, because R&D investment utilizes assets with large adjustment costs,[3] managers cannot easily stop and eliminate R&D activities.[4] In addition, R&D investments create largely intangible assets that have firm－specific characteristics[5] and that do not contribute to capital－raising through collateralized borrowing because they have low collateral value. Therefore, R&D investments rely on cash holdings as an important funding source (Himmelberg and Petersen 1994 ; Brown and Petersen 2011). Because of the reasons above, R&D investment provides a powerful setting that is most suitable for this study.

The empirical analyses of this study find that the stock prices of R&D firms crash more often as cash holdings increase. However, non－R&D firms' crashes are not influenced by their cash holdings. These results support the argument that an increase in cash holdings encourages managers to hide bad news from R&D investments and result in a stock price crash. Further, the

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the status of the property, and profitability information related to the property. If a firm issues shares to raise investment funds, investors will want to be provided with detailed information about the investment project as they will participate in the capital increase in anticipation of the share price rally.

3) Hall (2002) points out that the largest portion of R&D expenditure is salaries and wages for highly educated employees. Prior studies generally accept that these types of expenditures have high adjustment costs(Banker et al. 2013).

4) Although a large portion of R&D expense is discretionary, eliminating all R&D activities and related assets is not a convenient option.

5) The "asset" here is an economic asset, not an asset that meets the definition of accounting standards.

accumulation of positive news is not affected by cash holdings. In sum, cash holdings aggravate information asymmetry of negative news from R&D activities. The relation between cash holdings and crash is not driven by managers' private information about future financing needs, changes in cash flows, or capital expenditure. Results are qualitatively unaffected by these factors.

In the first additional analysis, the relation between cash holdings and stock crash exists only in low－profitability firms, which supports my conjecture that overinvestment is the cause of the correlation between cash holdings and stock price crash. In the second additional test, the positive association between cash holdings and stock price crash is found in the subsample that does not pay dividends. Because dividend payout decreases the possibility of overinvestment by reducing excess resources, this result also supports that overinvestment is the cause of the main finding. Finally, a positive association between cash holdings and stock price crash has been observed only in companies that do not have a commercial paper rating. In firms with commercial paper ratings, cash holdings decrease stock crashes. These results support that the accumulation of negative information is indeed the driver of stock crashes.

This study examines the effect of cash holdings on the opacity and valuation of firms from the perspective of investment. In the literature on cash holdings, to the best of my knowledge, no study directly addresses the combined effect of investment and financing on a firm's opacity and valuation. Assuming a perfect capital market, traditional valuation theory distinguishes financing from investment and argues that firm value is determined by investment (Feltham and Ohlson 1995). However, in actual capital markets, no economic entity can separate investment and/or operation from financing due to market friction limiting timely external financing (Denis 2011). Since Keynes (1936), it is well known that cash holdings help economic entities to overcome financial constraint, which facilitates financing for investment (Opler et al. 1999 ; Bates et al. 2009). This study contributes to the literature by adding empirical results to the connection between investment and financing through cash holdings and firm valuation.

In addition, this study contributes to stock price crash literature by expanding the scope of research. Previous studies designate agency problems and managerial overconfidence as potential causes of stock price crash (Kim et al. 2011a, 2011b ; Lee 2018). However, no study has investigated the inherent uncertainty of investment and/or financial characteristics as a cause of stock price crash. This study contributes to the literature by filling the void in the prior studies.

The remaining paper proceeds as follows. Chapter 2 reviews the relevant studies and develops hypotheses. Chapter 3 presents the results of empirical analysis and Chapter 4 explains the sample and descriptive statistics. Chapter 5 describes the results of regression analysis. Finally, Chapter

6 concludes.

Ⅱ. Background and Hypothesis Development

1. Cash Holdings

Traditional finance theory assumes that firms can easily raise capital from perfect capital markets. However, in real capital markets, firms may not finance their investment project from external capital markets due to market friction (Almeida et al. 2011). Cash holdings are invaluable for firms because they alleviate underinvestment by providing capital in time (Kim et al. 1998 ; Graham and Harvey 2001 ; Campello et al. 2010). Recent studies report an increasing trend of cash holdings (Bates et al. 2009 ; Harford et al. 2014), which implies that managers prefer cash holdings as a source of funding.

Despite the positive role of cash holdings, they also have a downside. Because managers utilize cash holdings without the consent of investors, market monitoring may be weak for investment projects that rely solely on cash holdings (Jensen 1986). Consequently, large cash holdings encourage managers to overinvest in risky projects that can destroy firm value (Blanchard et al. 1994 ; Garcia Lara et al. 2016 ; Harford 1999).

2. Research and Development Investment

R&D investment is the key to corporate innovation. Through R&D investment, firms can become specialized in their own products and generate sustainable operating cash flows (Opler et al. 1993, 1994). As information technologies continue to develop, the importance of intangible assets has increased even more. This explains increasing R&D investments in recent decades (Srivastava 2014).

Despite its benefits, R&D investment entails great uncertainty with respect to the outcomes compared with other forms of investment (Kothari et al. 2002). It is difficult for outsiders to monitor or evaluate R&D investments as they generally comprise intangible assets. This lack of corporeal substance complicates the evaluation process for outsiders. Furthermore, outsiders do not receive a sufficient amount of useful information on R&D investments from the companies' financial statements due to current accounting standards that require most R&D investments to be

expensed as incurred (Lev and Sougiannis 1996). As mentioned above, R&D investment often focuses on specializing a firm's product (Titman and Wessels 1988 ; Opler and Titman 1993) ; that is, R&D investment usually creates knowledge that has little value to others (Kothari et al. 2002). Therefore, R&D activities cannot facilitate collateralized borrowing. To continuously invest in R&D activities, it is necessary for firms to maintain sufficient financial slack, i.e., cash holdings (Brown and Petersen 2011).

3. Stock Price Crash and Upward Jump

Jin and Myers (2006) argue that stock price crashes occur when news about a firm is hidden and cumulated more than critical points. The accumulated news is disclosed at once to revise investors' prior expectations about the firm's future cash flows. According to previous studies, the probability of a crash increases with the opacity of financial reporting (Hutton et al. 2009), decreases with the conservativeness of accounting information, and decreases with the comparability of financial reports (Kim and Zhang 2016). Managers' equity incentives also increase crash risk because managers are more likely to hide negative news (Kim et al. 2011b, 2011a). However, none of these studies analyze the impact of cash holdings and few have considered the impact of investment activity.[6)]

4. Hypothesis Development

Financing R&D investments is difficult (Hall 2002). Because cash holdings provide friction-free capital, cash holdings are invaluable in smoothing R&D investments (Brown and Petersen 2011). Through stable R&D investments, firms can create firm-specific cash flows by specializing their products (Opler and Titman 1993 ; Opler and Titman 1994).

However, as cash assets provide a funding source free from monitoring, cash holdings could exacerbate information asymmetry because managers would rarely be required to explain investments financed by cash holdings. The lack of monitoring could cause agency problems such as overinvestment in risky projects (Jensen 1986 ; Harford 1999). The possibility of overinvestment is especially higher for R&D investments than for other forms of investment because R&D activities are not easy to monitor (Aboody and Lev 2000 ; Chan et al. 2001). Therefore, R&D firms with large cash holdings are likely to generate negative news from overinvestments.

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6) Kim et al. (2016) focuses on investment activity, but investment activity itself is not the main theme.

Because of the weak monitoring of cash－rich firms, managers are unlikely to release bad news to public markets. They are likely to hide the bad news until they can turn around unprofitable investment projects. However, negative news cannot be hidden forever. Eventually, the accumulated bad news would be known to market participants. As the accumulated negative news is reflected in the stock price at once, the stock price would crash.

In contrast, if a firm does not invest in R&D, future cash flows would be relatively easy to predict using public information and market－ or firm－level forecasts. Thus, it would be less likely for negative news to accumulate for non－R&D firms. In sum, for non－R&D firms, a stock price crash is unlikely to be related to cash holdings.

Based on the conjecture above, I set the first hypothesis：

H1：The association between cash holdings and stock price crash is positive for R&D firms.

Because cash holdings are useful in smoothing R&D investments, R&D firms with large cash holdings are more likely to be successful in R&D activities. Compared with other forms of investment, the outcome of R&D investments are less likely to be accurately predicted by outside investors. Therefore, news about the success of R&D investments is less likely to be reflected in the stock price before managers publicly disclose the information and the stock price would jump upward when news about the success of R&D investments is announced and reflected in stock prices at once.

Based on the conjecture above, I suggest the second hypothesis：

H2：The association between cash holdings and stock price upward jump is positive for R&D firms.

Alternatively, it is also possible that stock price upward jump is not related to cash holdings in either both R&D firms or non－R&D firms because managers have an incentive to disclose positive news quickly (Watts 2003). If this is the case, then positive news from R&D investments would not be hidden from investors. Consequently, cash holdings and stock price upward jump would have no significant relation.

Ⅲ. Research Design

"Cash holdings" is the best indicator of a firm's financial slack because this is the firm's easiest funding source. Furthermore, users of financial statements can easily interpret cash holdings without uncertainty.[7] Debt is also an important aspect of corporate financing. This study includes the debt ratio in the regression model to control and investigate the influence of debt financing capacity on the relation between cash holdings and crash risk.

We use all measures of firm-specific crash risk used in Chen et al. (2001) and other prior studies such as Kim et al. (2011a, 2011b). These measures are estimated based on firm-specific weekly returns. To eliminate the effect of market events or industry-specific news, market return and industry return are included as control variables in the firm-specific return model. The following is the expanded market model regression to estimate firm-specific return in this study :

$$r_{j,\tau} = \alpha_j + \beta_{1,j} r_{m,\tau-2} + \beta_{2,j} r_{m,\tau-1} + \beta_{3,j} r_{m,\tau} + \beta_{4,j} r_{m,\tau+1} + \beta_{5,j} r_{m,\tau+2} + \beta_{6,j} r_{i,\tau-2} + \beta_{7,j} r_{i,\tau-1} + \beta_{8,j} r_{i,\tau} + \beta_{9,j} r_{i,\tau+1} + \beta_{10,j} r_{i,\tau+2} + \epsilon_{j,\tau} \quad (1)$$

$r_{j,\tau}$ is the return on stock j in week τ, $r_{m,\tau}$ is the market return in week τ, and $r_{i,\tau}$ is the return on the two-digit SIC industry return in week τ. Additionally, I include lead and lag terms for the market and industry index to control for time lag in reflecting information.[8] The firm-specific weekly return for stock j in week τ is the natural log of the residuals of Equation (1) plus one. Because Equation (1) controls for industry effects and macro-economic effects, the residuals of Equation (1) indicate firm-specific returns that are free from time or industry effects.

A crash (upward jump) week is a week in which the firm experiences firm-specific weekly returns that drop (rise) more than 3.2 standard deviations below (above) the average firm-

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7) There are credit lines that can provide liquidity at a level similar to cash equivalents. However, unlike cash equivalents, credit lines are constrained by the company's cash flow, so they cannot provide liquidity when it is most needed (Sufi 2009). In addition, a credit line is private information that is not disclosed in Korean financial statements, so access to this information is limited. Because use of the credit line is determined by prior consultation between the bank and the enterprise, the liquidity supply through the credit line is indirectly reflected in the use of debt. Therefore, we do not examine the credit line in this study, which is one of its limitations.

8) Although a firm's stock price moves earlier than the market index or industry index, a correlation between the firms stock price and market or industry index indicates that the stock price of the firm has been affected by market or industry common information, so both the lead term and the lag term of industry index and market index are required.

specific weekly returns during the fiscal year. The value 3.2 is chosen to generate a frequency of 0.1 percent in the normal distribution. The crash (upward jump) measure *CRASH* (*JUMP*) is equal to one for a firm－year observation that experiences at least one crash (upward jump) week over the fiscal year and zero otherwise.

To test the relation between cash holdings and stock price crash, I use the following regression model：

$$\begin{aligned} CRASH_t \text{ or } JUMP_t = {} & \beta_0 + \beta_1 CASH_{t-1} + \beta_2 OCF_t + \beta_3 LEV_{t-1} + \beta_4 DTO_{t-1} + \beta_5 NCSKEW_{t-1} \\ & + \beta_6 SIGMA_{t-1} + \beta_7 RET_{t-1} + \beta_8 MB_{t-1} + \beta_9 ROA_{t-1} + \beta_{10} ABACC_{t-1} \\ & + \beta_{11} TANG_{t-1} + \beta_{12} SIZE_{t-1} + YearDummy + \gamma \end{aligned} \quad (2)$$

where the dependent variables, $CRASH_t$ and $JUMP_t$, are dummy variables indicating a firm's stock price crash or upward jump, respectively. The key independent variable in Equation (2) is $CASH_{t-1}$, which is cash and cash equivalents deflated by total assets. In addition to cash holdings, operating cash flows (OCF_t) are also included in the model because these are a primary source of investment that precedes cash holdings. Following prior studies, the model includes several variables related to stock price (*DTO*, *NCSKEW*, *SIGMA*, *RET*, and *MB*), financial risk (*LEV*), profitability (*ROA*), size (*SIZE*), and the opacity of accounting (*ABACC* and *TANG*). The model also has a year dummy variable to control unknown year fixed effects. Definitions of variables are presented in Table 1.

〈Table 1〉 Variable Definitions

CRASH	One for a firm－year observation that has at least one firm－specific weekly stock return lower than 3.2 standard deviations.
JUMP	One for a firm－year observation that has at least one firm－specific weekly stock return higher than 3.2 standard deviation.
NCSKEW	The negative skewness of firm－specific weekly stock returns
ε	Firm－specific weekly stock return, defined as the natural log of residual return in Equation (1) plus one, where (j, τ) is the return on stock j in week τ,r_(m, τ) is the market return in week t, and r_(i, τ) is the return on the two－digit SIC industry return in week τ. Additionally, we include lead and lag terms for the market and industry index to allow for nonsynchronous trading. The firm－specific weekly return for stock j in week τ is calculated by the natural log of residual return in Equation (1) plus one.

〈Table 1〉 Variable Definitions (continued)

CASH	Beginning cash and cash equivalents divided by beginning total assets
LEV	Beginning balance of interest－bearing debts deflated by beginning total assets
SLEV	Beginning balance of interest－bearing current debts deflated by beginning total assets
LLEV	Beginning balance of interest－bearing long－term debts deflated by beginning total assets
OCF	Cash flow from operation deflated by beginning total assets
CAPEX	Capital expenditure deflated by beginning total assets
DTO	Average of monthly share turnover
SIGMA	Standard deviation of firm－specific weekly stock return for the fiscal period
RET	Average firm－specific weekly stock return
MB	Market value of equity－to－book value of equity
ROA	Return on assets
ABACC	Absolute value of abnormal accruals
TANG	Ratio of tangible asset to total assets
R&D	R&D expenditure deflated by beginning total assets
R&D_DUMMY	One if R&D expenditures are not zero or missing, 0 otherwise.
SIZE	Natural log of total assets

DDeterminants of crashes or upward jumps could be associated differently in R&D firms and non－R&D firms. Thus, following Lin and Wang (2016), Equation (2) is estimated by dividing the sample into two groups according to whether the firm invests in R&D.[9)]

Ⅳ. Sample and Descriptive Statistics

1. Sample

The sample of this study is collected from firms listed on the Korean Stock Exchange. Market information efficiency plays a central role in the empirical tests of this study. If the market

9) Consistent with this conjecture, R&D firms and non－R&D firms have significant differences in the regression results.

efficiency is low, then the stock price cannot incorporate public information in a timely fashion and, thus, the influence of public information is classified as firm－specific returns. In addition, the noise in stock prices could be considered as a reaction to the information. Therefore, firms listed on the Korea Securities Dealers Automated Quotations (KOSDAQ), where market efficiency is low, are excluded from the analysis (Kwon et al. 2015). Observations with missing variables were deleted and variables used for empirical analysis were truncated at the high and low 1% levels. The final sample includes 8,223 firm－year observations from 1985 to 2014.

Table 2 shows the industry composition of the final sample. Most industries have both R&D firms and non－R&D firms, though the composition of the two groups varies. This shows that industry is not the sole determinant of R&D investments. Thus, the difference between the two groups is not the result of industry.[10)]

〈Table 2〉 Sample Composition by Industry

Industry number	Industry	# of observations (A)	# of R&D observations (B)	(B)/(A)
1	Fishery	66	19	29%
2	Grocery manufacturing	431	243	56%
3	Beverage manufacturing	19	9	47%
4	Textile product manufacturing	141	64	45%
5	Manufacture of apparel, clothing accessories and fur products	143	38	27%
6	Manufacture of leather, bags and footwear	48	19	40%
7	Manufacture of pulp, paper and paper products	315	123	39%
8	Manufacture of coke, briquette and petroleum products	77	6	8%
9	Chemical and chemical products manufacturing	1,000	570	57%
10	Manufacture of medical materials and pharmaceuticals	431	343	80%
11	Manufacture of rubber and plastic products	278	152	55%
12	Manufacture of non－metallic mineral products	361	218	60%
13	Manufacture of primary metals	636	312	49%

10) In addition, industry common effects are controlled in the calculation of firm－specific returns. Equation (1) includes the industry index to control for industry common effects.

〈Table 2〉 Sample Composition by Industry (continued)

Industry number	Industry	# of observations (A)	# of R&D observations (B)	(B)/(A)
14	Manufacture of metal processing products	128	73	57%
15	Manufacture of electronic components, computers, video, sound and communication equipment	524	371	71%
16	Medical, precision, optical equipment and watch manufacturing	32	26	81%
17	Electrical equipment manufacturing	274	128	47%
18	Other machinery and equipment manufacturing	375	259	69%
19	Automobile and trailer manufacturing	531	308	58%
20	Other transportation equipment manufacturing	72	49	68%
21	Furniture manufacturing	40	38	95%
22	Electricity, gas, steam and air conditioning supply business	121	92	76%
23	Total construction business	498	353	71%
24	Wholesale and commodity brokerage	478	160	33%
25	Retail	75	38	51%
26	Land transportation and pipeline transportation	164	–	0%
27	Water transportation	19	4	21%
28	Warehouse and transportation related service	25	5	20%
29	publishing business	20	11	55%
30	Computer programming, system integration and management	63	48	76%
31	Professional Services	815	430	53%
32	Construction technology, engineering and other scientific and technical services	14	8	57%
33	Business Support Services	9	2	22%
	Total	8,223	4,519	55%

2. Descriptive statistics

Table 3 lists the descriptive statistics of the sample. In the sample, 11.2% of observations report stock price crashes. The average of cash holdings – to – total assets ratio is 6.5% while that

of operating cash flows－to－total assets is 5.2%, which is higher than ROA, 2.9%. The average of interest－bearing debt is 27.7% of total assets, among which short－term debt is 16.3% and long－term debt is 11.3%. The average indicator variable for R&D expense is 0.55, which means that observations with R&D spending account for 55% of total observations.[11)]

〈Table 3〉 Descriptive Statistics

Variable	Average	Standard Deviation	10%	25%	50%	75%	90%
CRASH	0.112	0.315	0.000	0.000	0.000	0.000	1.000
JUMP	0.242	0.429	0.000	0.000	0.000	0.000	1.000
OCF	0.052	0.084	－0.040	0.006	0.050	0.098	0.149
CASH	0.065	0.063	0.006	0.018	0.046	0.090	0.150
LEV	0.277	0.176	0.026	0.133	0.276	0.407	0.515
SLEV	0.163	0.123	0.005	0.063	0.150	0.241	0.329
LLEV	0.113	0.108	0.000	0.014	0.088	0.183	0.266
DTO	－0.024	0.202	－0.211	－0.078	－0.018	0.019	0.135
NCSKEW	－0.192	0.829	－1.256	－0.720	－0.179	0.359	0.845
SIGMA	0.066	0.027	0.038	0.047	0.061	0.080	0.104
RET	0.169	0.536	－0.396	－0.187	0.069	0.404	0.861
MB	0.939	0.681	0.299	0.462	0.759	1.222	1.796
ROA	0.029	0.057	－0.023	0.009	0.028	0.057	0.092
ABACC	0.155	0.098	0.055	0.085	0.132	0.202	0.283
TANG	0.343	0.167	0.121	0.222	0.340	0.458	0.565
R&D	0.004	0.011	0.000	0.000	0.000	0.003	0.013
R&D_DUMMY	0.550	0.498	0.000	0.000	1.000	1.000	1.000

The definitions of variables are in Table 1.

11) Management may conceal R&D activities by reporting R&D expenses as items not related to R&D activities. Among 45% of non－R&D firm observations, some observations may be from R&D firms. However, this study assumes that the costs associated with R&D activities are accurately recorded. As an outsider, I cannot exactly know whether the manager hides R&D activities. This is a limitation of archival studies that depend on public data.

3. Differences between R&D firms and non-R&D firms

Table 4 shows a comparison of characteristics between R&D and non-R&D firms. In the R&D sample (RND=1), the stock price crashed less frequently than in the non-R&D sample (RND=0). In contrast, the likelihood of stock price upward jump is not significantly different between the two subsamples. This means that the influence of cash holdings could be different for positive news and negative news.

The difference of *CASH* is statistically insignificant at the conventional level. Operating cash flows (*OCF*) and total leverage (*LEV*) are not different between the two subsamples, either. When leverage is dissected, significant differences are found between R&D firms and non-R&D firms. Compared with R&D firms, non-R&D firms use more short-term but less long-term debt. The difference is statistically significant. However, the difference is small compared with the total debt level, indicating that the difference has little economic significance.

The market-to-book ratio (*MTB*) of R&D firms is 0.972, which is significantly higher than that of non-R&D firms (0.900). Return-on-assets (*ROA*) for R&D firms is 2.8%, which is higher than non-R&D firms by 0.3%. The average of R&D expenses is 0.78% of total assets, so R&D firms are more profitable before spending R&D expenses.

〈Table 4〉 Comparison between R&D firms and non-R&D firms

Variable	R&D firms (n=4,547)	Non-R&D firms (n=3,711)	Difference	t-Value
CRASH	0.123	0.103	0.019***	(-2.98)
JUMP	0.238	0.246	-0.007	(0.84)
CASH	0.066	0.064	0.002	(-1.66)
OCF	0.052	0.052	0.000	
MB	0.900	0.972	-0.072***	(-0.31)
ROA	0.031	0.028	0.003***	(-3.22)
LEV	0.276	0.277	-0.001	(3.16)
SLEV	0.168	0.160	0.008***	(-5.26)
LLEV	0.109	0.117	-0.008***	(6.80)

The definitions of variables are in Table 1. *, **, *** denote significance at 10%, 5%, 1% level in two-tailed tests.

In sum, although statistically significant differences are found in some variables, the economic differences are not significant. The fact that R&D firms have a public debt ratio that is significantly higher than that of non－R&D firms is due to the fact that R&D firms receive more attention from the public capital market and, therefore, have easier access to the public debt market (Lin and Wang 2016).

Ⅴ. Empirical Results

1. Main test

Table 5 shows the main test results. Columns (1) and (2) show the results of the R&D and non－R&D firm subsamples, respectively. In the R&D sample, *CASH* has a significantly positive relation with crash. However, the coefficient on *CASH* is not significant in the non－R&D sample. The result means that cash－rich R&D firms accumulate negative news and, thus, the stock price crashes for R&D firms. Columns (3) and (4) report the results for stock price upward jump for R&D and non－R&D subsamples, respectively. *CASH* has an insignificant coefficient for both subsamples, implying that good news is not accumulated. This could be because managers want to disclose positive news in a timely fashion. In sum, the results support H1 but not H2.

Operating cash flow (*OCF*) is negatively related to stock price crash, meaning that strong operating cash flows reduce crash risk of R&D firms. This result is reasonable because strong cash flows indicate financial stability. However, surprisingly, *OCF* is negatively related to *JUMP* in both subsamples, although conventional level of significance is only found in the non－R&D subsample. A potential explanation is that investors are overly optimistic about the future performance of firms with strong cash flows, but the cash flows later reverse, resulting in a stock price crash.

The coefficients of leverage are also interesting. In R&D firms, both upward jump and crash have no significant relation with leverage. However, in non－R&D firms, as leverage increases, stock price crashes less frequently but jumps upward more frequently. These results imply that leverage prevents negative news from accumulating but not positive news. Since debt holders are more sensitive to negative news than positive news, as leverage increases it becomes more difficult to hide negative news but not positive news.

<Table 5> Main Result

R&D firm Dependent Var.	(1) R&D CRASH	(2) Non-R&D CRASH	(3) R&D JUMP	(4) Non-R&D JUMP
$CASH_{t-1}$	0.756*	−0.056	−0.097	−0.201
	(1.71)	(−0.10)	(−0.27)	(−0.46)
OCF_t	−1.014***	−0.127	−0.441	−0.710**
	(−2.90)	(−0.39)	(−1.55)	(−2.24)
LEV_{t-1}	0.244	−0.370*	0.253	0.561***
	(1.38)	(−1.69)	(1.58)	(3.35)
MB_{t-1}	−0.003	0.158***	−0.004	−0.055
	(−0.06)	(2.60)	(−0.11)	(−1.03)
DTO_{t-1}	0.294**	0.349**	−0.340***	−0.176
	(2.28)	(2.29)	(−3.04)	(−1.41)
$NCSKEW_{t-1}$	0.009	0.032	−0.018	−0.076**
	(0.24)	(0.83)	(−0.63)	(−2.18)
$SIGMA_{t-1}$	−0.147	−0.257	1.094	1.392
	(−0.10)	(−0.17)	(1.02)	(1.21)
RET_{t-1}	−0.012	0.029	−0.157***	−0.150**
	(−0.15)	(0.38)	(−2.82)	(−1.96)
ROA_{t-1}	−0.663	−1.946***	−0.229	0.163
	(−1.27)	(−3.16)	(−0.51)	(0.33)
$ABACC_{t-1}$	−0.544**	−0.449	0.227	0.025
	(−2.03)	(−1.43)	(0.98)	(0.10)
$TANG_{t-1}$	0.122	0.057	0.022	−0.020
	(0.70)	(0.33)	(0.15)	(−0.13)
$SIZE_{t-1}$	−0.040*	−0.026	−0.153***	−0.145***
	(−1.83)	(−1.12)	(−8.59)	(−7.15)
Year Dummy	Included	Included	Included	Included
Pseudo R^2	0.0462	0.0647	0.0590	0.0534
# of Obs.	4519	3,704	4,519	3,704

The definitions of variables are in Table 1. The upper row shows coefficients of probit regressions, and the numbers in parentheses are z-values. *, **, *** denote significance at 10%, 5%, 1% level in two-tailed tests. Standard errors are clustered by firm.

Lastly, the differences in regression coefficients show that R&D firms and non－R&D firms are different in several aspects. This implies that separating the subsample is the right approach because R&D firms and non－R&D firms are different in several economic characteristics.

2. Robustness Test

Managers adjust the level of cash holdings considering future cash demand (Opler et al. 1999). Hence, large cash holdings could be the result of managers' pessimistic expectations for potential bad news for the firm. In this case, cash holdings and crash could be negatively related. To test this conjecture, two years of lagged differences in *CASH* ($DCASH_{t-1}$ and $DCASH_{t-2}$) are included in the model. If managers expect negative events, then they may have accumulated cash and cash equivalents for precautionary purposes. Thus, if this is the case, $DCASH_{t-1}$ and $DCASH_{t-2}$ would be positively related to crash. A significant portion of operating cash flow is caused by time－series correlation and is already reflected in stock prices. Therefore, the change in cash flow is the informative part of operating cash flows. To test this reasoning, the changes in cash flows are added as an additional variable. Finally, in order to examine the effect of investment on real assets, capital expenditure is added as a control variable to the effect of investment on real assets.

Table 6 shows the results of the effect of controlling the variables above. In column (1) of Table 6, both $DCASH_{t-1}$ and $DCASH_{t-2}$ are insignificant. The coefficient of *CASH* in column (1) is still significantly positive. This means that managers' motivation to accumulate cash assets does not affect the main results. The results in Table 6 are qualitatively consistent with Table 5, signaling that the main results are robust.

Table 6 documents several interesting points ; for example, $\triangle OCF_t$ has no qualitative effect on the relation between OCF_t and both dependent variables. $\triangle OCF_t$ is positively related to *CRASH* for R&D firms. The positive relation implies that the stock price over－reacts to positive cash flow shocks. *CAPEX* is significantly negative in column (2), indicating that non－R&D firms investing in real asset is less likely to experience a crash.

Robustness is tested using all the combinations of variables that can be created from the variables added in Table 6. No result is qualitatively different from the main results.

<Table 6> Robustness Tests

R&D firm Dependent Var.	(1) R&D CRASH	(2) Non−R&D CRASH	(3) R&D JUMP	(4) Non−R&D JUMP
$CASH_{t-1}$	1.226*	0.206	−0.300	−0.064
	(1.76)	(0.27)	(−0.57)	(−0.09)
$\triangle CASH_{t-1}$	−0.724	−0.647	0.959	−0.340
	(−0.57)	(−0.48)	(1.03)	(−0.31)
$\triangle CASH_{t-12}$	0.397	0.358	−0.363	0.017
	(0.62)	(0.54)	(−0.70)	(0.03)
OCF_t	−2.866***	−0.173	−1.186***	−1.213**
	(−5.14)	(−0.29)	(−2.66)	(−2.20)
$\triangle OCF_t$	1.458***	0.336	0.576	0.325
	(2.93)	(0.61)	(1.53)	(0.77)
$CAPEX_t$	0.094	−0.508*	−0.177	0.213
	(0.24)	(−1.71)	(−0.63)	(0.75)
LEV_{t-1}	0.199	−0.426	0.221	0.531**
	(0.90)	(−1.59)	(1.17)	(2.50)
MB_{t-1}	−0.013	0.197***	0.019	−0.104
	(−0.21)	(2.70)	(0.36)	(−1.50)
DTO_{t-1}	0.365**	0.249	−0.452***	−0.203
	(2.26)	(1.23)	(−2.95)	(−1.05)
$NCSKEW_{t-1}$	−0.014	0.004	−0.048	−0.080*
	(−0.33)	(0.09)	(−1.40)	(−1.91)
$SIGMA_{t-1}$	−2.038	−0.381	−0.258	1.778
	(−1.10)	(−0.19)	(−0.19)	(1.16)
RET_{t-1}	0.019	−0.090	−0.136**	−0.154*
	(0.20)	(−0.93)	(−2.01)	(−1.66)
ROA_{t-1}	−0.401	−1.946**	0.271	−0.010
	(−0.52)	(−2.51)	(0.47)	(−0.01)
$ABACC_{t-1}$	−0.323	−0.574	0.548*	−0.058
	(−0.93)	(−1.39)	(1.86)	(−0.18)
$TANG_{t-1}$	0.329	0.028	0.134	−0.027
	(1.49)	(0.13)	(0.72)	(−0.13)
$SIZE_{t-1}$	−0.037	−0.042	−0.156***	−0.146***
	(−1.51)	(−1.57)	(−7.17)	(−5.75)
Year Dummy	Included	Included	Included	Included
Pseudo R^2	0.0570	0.0746	0.0580	0.0618
# of Obs.	3,346	2,663	3,346	2,663

The definitions of variables are in Table 1. The upper row shows coefficients of probit regressions, and the numbers in parentheses are z−values. *, **, *** denote significance at 10%, 5%, 1% level in two−tailed tests. Standard errors are clustered by firm.

Harford et al. (2014) argue that firms reserve cash assets to prevent refinancing constraint.[12] The reserved cash assets cannot be spent for other purposes because a shortage of cash could trigger default. Thus, not all the cash assets can be utilized as a funding source, which undermines the argument of this study. This possibility is tested by dividing leverage into two categories − short − term debt and long − term debt − according to their maturity. Table 7 shows the results.

The results in Table 7 are consistent with the results in previous tables. Interestingly, short − term debt (*SLEV*) is positively related to both *CRASH* and *JUMP*, except in Column (2). Risky firms cannot access stable long − term debts easily, thus they rely more on short − term financing. Those firms are more likely to experience a stock price crash, especially when these firms invest in risky R&D projects. On the other hand, managers who are confident about future performance are less likely to commit to long − term borrowing contracts with unfavorable terms.

〈Table 7〉 Debt Maturity Effect

	(1)	(2)	(3)	(4)
R&D firm	R&D	Non−R&D	R&D	Non−R&D
Dependent Var.	CRASH	CRASH	JUMP	JUMP
$CASH_{t-1}$	0.814*	−0.034	−0.071	−0.202
	(1.83)	(−0.06)	(−0.20)	(−0.46)
OCF_t	−1.029***	−0.133	−0.450	−0.710**
	(−2.93)	(−0.41)	(−1.59)	(−2.24)
$SLEV_{t-1}$	0.487**	−0.245	0.362*	0.554***
	(2.21)	(−0.92)	(1.65)	(2.59)
$LLEV_{t-1}$	−0.112	−0.570*	0.092	0.571**
	(−0.41)	(−1.67)	(0.39)	(2.19)
Control Variables	Included	Included	Included	Included
Year Dummy	Included	Included	Included	Included
Pseudo R^2	0.0471	0.0649	0.0592	0.0534
# of Obs.	4,519	3,704	4,519	3,704

The definitions of variables are in Table 1. For brevity, coefficients of control variables are omitted. The upper row shows coefficients of probit regressions, and the numbers in parentheses are z − values. *, **, *** denote significance at 10%, 5%, 1% level in two − tailed tests. Standard errors are clustered by firm.

12) For brevity, the coefficients of control variables are omitted in the remaining tables. I find no special results from these variables.

They may use short－term financing temporarily and wait until positive expectations are realized. This drives the positive coefficients on *SLEV* in Columns (3) and (4). Long－term leverage (*LLEV*) has a negative coefficient in Column (2), but a positive coefficient in Column (4). Firms that increase their long－term financing are more stable, thus their stock prices are less likely to crash. In contrast, positive surprises are more likely to occur as long－term debt increases in non－R&D firms.

3. Additional Tests

The main argument of this study is that the positive association between cash holdings and crash is the result of accumulated negative news caused by overinvestment. This chapter provides evidence to support this conjecture. Especially, this chapter focuses on stock price crash.[13)]

(1) Growth Potential

Cash holdings facilitate excessive investment by providing capital sources free from monitoring (Jensen 1986 ; Blanchard et al. 1994 ; Harford 1999), especially when there are few profitable investment opportunities. If overinvestment drives the positive relation between crash and cash holdings, then the relation would be strong in firms with low growth potential.

Market－to－book ratio (M/B) is used as the proxy for growth potential. If the M/B is higher (lower) than the average industry－year M/B, then the observation is classified as a high (low) growth potential firm. The test results are reported in Table 8.[14)] As we have conjectured, *CASH* has a significantly positive coefficient only for R&D firms with low growth potential. These results support the conjecture that overinvestment drives the positive relationship between cash holdings and crash.

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13) In untabulated results, no significant difference is found regarding *JUMP*. Thus, I omit the results of *JUMP* model to avoid redundancy.

14) In Table 7, 8, and 9, total numbers of observations are slightly less than that of Table 4 because some observations are automatically omitted by the statistical analysis package to avoid error in estimation.

〈Table 8〉 Growth Potential Effect

Dep. Var=CRASH M/B R&D firm	(1) Low R&D	(2) Low Non−R&D	(3) High R&D	(4) High Non−R&D
$CASH_{t-1}$	1.171*	0.368	0.378	−0.274
	(1.81)	(0.42)	(0.66)	(−0.43)
OCF_t	−1.141**	0.599	−0.981**	−0.545
	(−2.37)	(1.14)	(−1.99)	(−1.41)
LEV_{t-1}	0.371	−0.639**	0.118	−0.050
	(1.39)	(−2.11)	(0.48)	(−0.16)
Control Variables	Included	Included	Included	Included
Year Dummy	Included	Included	Included	Included
Pseudo R^2	0.0598	0.1091	0.0600	0.0684
# of Obs.	2,114	1,822	2,348	1,882

The definitions of variables are in Table 1. The dependent variable is *CRASH*. For brevity, coefficients of control variables are omitted. The upper row shows coefficients of probit regressions, and the numbers in parentheses are z−values. *, **, *** denote significance at 10%, 5%, 1% level in two−tailed tests. Standard errors are clustered by firm.

(2) Dividend Payment Effect

Prior studies argue that dividend payouts mitigate managers' agency problems by reducing unnecessary financial resources distributed to equity holders. If the relationship between cash holdings and crash is due to overinvestment, then the correlation between the two would be weak for firms that pay dividends.

Table 9 shows the test results of the effect of dividend payout. *CASH* has positive coefficients in the no−payout R&D subsample, as in the main results. On the contrary, in dividend−paying firms, *CASH* has an insignificant coefficient in both R&D firms and non−R&D firms. These results support our conjecture that overinvestment connects crash and cash holdings in R&D firms.

〈Table 9〉 Dividends Payout Effect

Dep. Var=CRASH Dividend Payout R&D firm	(1) NO R&D	(2) NO Non-R&D	(3) YES R&D	(4) YES Non-R&D
$CASH_{t-1}$	1.348*	0.021	0.350	−0.128
	(1.77)	(0.03)	(0.67)	(−0.16)
OCF_t	−0.879*	−0.372	−1.149**	0.120
	(−1.68)	(−0.84)	(−2.41)	(0.25)
LEV_{t-1}	0.384	−0.056	0.089	−0.535
	(1.42)	(−0.19)	(0.37)	(−1.61)
Control Variables	Included	Included	Included	Included
Year Dummy	Included	Included	Included	Included
Pseudo R^2	0.0481	0.0780	0.0369	0.0678
# of Obs.	1,481	1,409	2,938	2,273

The definitions of variables are in Table 1. The dependent variable is *CRASH*. For brevity, coefficients of control variables are omitted. The upper row shows coefficients of probit regressions, and the numbers in parentheses are z-values. *, **, *** denote significance at 10%, 5%, 1% level in two-tailed tests. Standard errors are clustered by firm.

(3) Commercial Paper Rating

A firm that is well known in public capital markets would have little room to hide negative news due to its exposure to increased market scrutiny. Therefore, the relationship between cash holdings and crash would be weak in firms that are well known in capital markets.

I test this conjecture by dividing the sample by the existence of commercial paper (CP) rating. CP is a means of raising short-term capital from the public debt markets. Only firms that are the most outstanding in public debt markets can issue CP. Hence, the presence of a CP rating is a stronger measure of the degree of attention from public debt market participants rather than the existence of a corporate bond rating.

Table 10 shows the test results about the influence of the existence of CP rating.[15] In the subsample without a CP rating, a positive correlation between cash holdings and crash is still found in R&D firms. However, surprisingly, for firms with a CP rating, cash holdings are negatively correlated with CRASH. In sum, these results support the conjecture that hidden bad news causes stock price crashes in R&D firms with a large cash balance. In addition, in firms

15) Because of data limitation regarding CP rating, Table 10 contains observations after year 1996.

severely monitored by market participants, cash holdings could facilitate R&D investment, reducing the probability of a stock price crash.

〈Table 10〉 Capital Market Accessibility Effect

Dep. Var=CRASH CP rating R&D firm	(1) NO R&D	(2) NO Non-R&D	(3) YES R&D	(4) YES Non-R&D
$CASH_{t-1}$	0.957*	−0.115	−1.585*	−0.397
	(1.70)	(−0.14)	(−1.82)	(−0.24)
OCF_t	−0.744	−0.111	−2.475***	0.201
	(−1.54)	(−0.24)	(−3.55)	(0.18)
LEV_{t-1}	0.389*	−0.412	−0.213	0.783
	(1.72)	(−1.38)	(−0.59)	(1.27)
Control Variables	Included	Included	Included	Included
Year Dummy	Included	Included	Included	Included
Pseudo R^2	0.0331	0.0562	0.0932	0.0923
# of Obs.	2,461	2,143	1,214	542

The definitions of variables are in Table 1. The dependent variable is *CRASH*. For brevity, coefficients of control variables are omitted. The upper row shows coefficients of probit regressions, and the numbers in parentheses are z-values. *, **, *** denote significance at 10%, 5%, 1% level in two-tailed tests. Standard errors are clustered by firm.

Ⅵ. Conclusion

This study examines the relationship between cash holdings and sudden stock price movements in the context of R&D investment. Because R&D investment is an opaque form of investment, hiding news from investors is relatively easy for R&D firms. Cash holdings reduce a firm's dependence on capital markets, which weakens monitoring by the market. Weaker monitoring and sufficient internal capital are likely to encourage overinvestments in R&D firms, and thus, negative news is more likely to accumulate. Accumulated bad news is eventually known to investors, which causes a sudden drop of stock price.

The tests of this study find evidence supporting the conjecture above. The main results are robust to several additional tests. In additional analyses, the relation between cash holdings and crash is observed only in the firms having low growth potential, paying no cash dividends, or

limited to access to commercial paper markets.

In recent years, managers have preferred liquid asset structures (Bates et al. 2009 ; Strebulaev and Yang 2013 ; Harford et al. 2014). Large cash reserves are useful to protect a firm's investment activities from market friction. However, asset liquidity affects market monitoring, firms' transparency, and investment decisions. This study contributes to the literature by investigating the combined effect of these factors.

Traditional theory addresses firms' financing, investing, and operating activities separately (Feltham and Ohlson 1995). However, investing and financing cannot be separated in the real financial market (Almeida et al. 2011). The correlation between financing and investment activities has a real impact (Faulkender and Wang 2006). In addition, the relation also affects information asymmetry and firm valuation. This study contributes to the literature by providing empirical evidence supporting the effect of the interrelation between financing and investing.

This study has a caveat. Although this study, at least partly, addresses the agency perspective, it does not directly investigate the influence of corporate governance that is widely accepted as a direct solution to the agency problem. Additional tests of this study tried to alleviate this problem by indirectly addressing these problems ; however, the influence of corporate governance is generally unexplored. We leave this issue for future research.

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연구개발기업의 현금성자산은 급격한 주가변동을 유발하는가?*

임상균**

<요 약>

본 연구에서는 연구개발투자와 관련하여 현금성자산의 보유가 급격한 주가 변동에 미치는 영향을 살펴보았다. 현금성자산이 증가함에 따라 기업의 외부자본시장 의존이 감소하여 투자자들의 모니터링을 약화된다. 결과적으로 현금성자산은 과잉투자로부터 발생하는 부정적인 뉴스를 숨기려는 경영자의 행동을 강화할 것이다. 특히 연구개발투자는 본질적인 불투명성으로 인해 현금성자산으로 인한 부정적 뉴스의 축적 경향이 강하게 나타날 것이다. 그러나 숨겨진 부정적 정보는 결국 투자자들에게 알려질 것이며 주가의 급락으로 이어질 것이다. 따라서 연구개발기업의 현금성자산은 주가급락을 촉진하게 될 것으로 예상된다.

본 연구에서는 1985년부터 2014년까지 유가증권시장에 상장된 기업을 이용한 다중회귀분석에서 이상의 추론을 검증하였다. 연구개발기업 표본에서는 주가급락과 현금성자산이 양의 상관관계를 가지는 반면, 비연구개발기업에서는 이러한 관계가 나타나지 않았다. 본 연구의 강건성 분석은 이러한 결과가 내생성에 의해 발생된 것이 아님을 보여준다. 추가 테스트에서는 과잉투자가 주가급락과 현금성자산 보유 사이의 상관관계를 발생시키는 원인임을 보여주는 결과들을 발견하였다. 그러나 주가의 급등은 연구개발 투자여부와 무관하게 현금성자산의 보유와 관련이 없었다. 이것은 긍정적인 뉴스는 시장 참여자에게 적시에 제공되기 때문인 것으로 판단된다.

본 연구의 공헌점은 다음과 같다. 현금보유와 관련된 문헌에서 현금보유로 인한 투자와 자본조달 측면의 결합된 효과가 기업의 불투명성과 주가평가에 미치는 효과를 본 연구는 드물다. 본 연구는 바로 이러한 측면을 분석하고 있다 또한, 주가급락의 선행연구들은 주로 대리인 문제나 경영자의 과신에서 주가급락의 원인을 찾는다. 그러나 본 연구는 투자의 불확실성과 자본조달 특성을 주가급락의 원인 가운데 하나로 제시함으로써 주가급락 문헌에도 공헌점을 가진다.

<주제어> 현금성자산, 주가급락, 주가급등, 연구개발

* 이 논문은 2016년 대한민국 교육부와 한국연구재단의 지원을 받아 수행된 연구임 (NRF－A2016－0152).

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