Corporate finance of Research vs Development

Jiyoon Lee[a*], Jiyoung Park[b]

[a]Department of Finance, The George Washington University, Washington DC, USA

[b]Graduate School of Business, Yonsei University, Seoul, South Korea

April 18, 2016

Abstract

We compartmentalize R&D into R (research) and D (development), and investigate their association with important corporate financing decisions. We show that R is more positively associated with cash holdings than D, and that only R is sensitive to cash flows. These results are consistent with higher uncertainty and information asymmetry of R imposing more severe financial constraints relative to D. Supporting the financial constraint explanation, higher cash flows sensitivity of R is prominent among financially constrained firms. Consistent with D bearing product market risk, D is associated with higher cash holdings when product market competition is severe, but we do not find the same result for R. Lastly, we find negative association between leverage and R but not D.

Keywords: R&D, cash holdings, investment-cash flow sensitivity, capital structure, product market competition

JEL classification: G30, G32

*Corresponding author. Address: The George Washington University, Department of Finance, Funger Hall #507, 2201 G Street NW, Washington DC 20052, United States; Tel.: +1 202 994 2377; fax: +1 202 994 5014. E-mail address: leejiyoon@gwu.edu

1. Introduction

Research and development are two distinct activities that are important drivers of industrial innovation. They differ in purposes, degree of complexity, time horizon, levels and types of risk. For example, according to the Organization for Economic Cooperation and Development (OECD)(2005), the main purpose of research is to acquire new knowledge, whereas that of development is to introduce new or improved products or processes. Essentially, research is more theoretical in nature, while development is applied and usually attains physical outputs. In addition, research is considered a more complex activity with a greater importance of discontinuous jumps, whereas development has more incremental nature (Leifer and Triscari(1987), Karlsson et al.(2004), Chiesa and Frattini(2007)). Moreover, the time horizon of research is much longer than development. Research and development also differ in types of risk. Research bears higher technical uncertainty and business risk. Meanwhile, development faces higher market risk such as industry rivals entering the market earlier (Van Ark and Hulten(2007)).

Despite these differences, research (hereafter, R) and development (hereafter, D) have mostly been considered as a homogeneous activity in the finance literature.[1] For example, some studies show that firms hold more cash to finance R&D activities (Dittmar et al.(2003), Bates et al.(2009), Opler et al.(1999), Brown and Petersen(2011)), and that investment-cash flow sensitivity is higher for R&D compared to physical investment (Kamien and Schwartz(1978), Brown and Petersen (2009)). Other studies show the negative effects of R&D on financial leverage (Baxamusa et al.(2015), Halov and Heider(2011), Faulkender and Petersen(2005)). These studies generally attribute their findings to R&D's nature of uncertainty and/or information asymmetry increasing financial constraints.

Although these findings are consistent with R&D's common nature of informational asymmetry and uncertainty, R and D likely affect corporate financing differently due to their differences in the levels and types of information asymmetry and uncertainty. For example, the

[1]The only exception to the best of our knowledge is Czarnitzki et al.(2011). This paper uses Belgian part of the OECD's R&D survey and show that research investment is more sensitive to a firm's operating liquidity.

complex nature of R likely worsens information asymmetry relative to D. In addition, the longer horizon and discontinuous nature of R would increase uncertainty. On the other hand, D, but not R, would be influenced by product market competition because D bears market risk. The goal of this paper is to fill the gap in the finance literature by examining financing implications of R and D separately.

The reason for few studies separately analyzing R and D may be due to the lack of appropriate data. For example, U.S. firms do not distinguish between R and D in their financial statements, and rarely disclose information on R and D separately in their annual filings. To overcome this problem, we use Korean public firms' accounting data. Unlike U.S., Korean accounting standards on R&D requires firms to report R and D separately. Although R and D had been recorded separately even before 1998, the 1998 revision on R&D accounting standards made the categorization and recognition of R and D substantially similar to those of the International Financial Reporting Standards (IFRS): Expenditure on R shall be recognized as an expense when it is incurred. Examples of R activities include projects that are aimed at obtaining new knowledge. The expenditure incurred in D activities, on the other hand, can be recognized as intangible assets because the D phase of a project is further advanced than the R phase. To do so, a firm should be able to demonstrate six conditions, which are essentially the same as those of IFRS:

(a) the technical feasibility of completing the intangible asset so that it will be available for use or sale

(b) its intention to complete the intangible asset and use or sell it

(c) its ability to use or sell the intangible asset

(d) the existence of a market for the output of the intangible asset or the intangible asset itself or, if it is to be used internally, the usefulness of the intangible asset.

(e) the availability of adequate technical, financial and other resources to complete the development and to use or sell the intangible asset.

(f) its ability to measure reliably the expenditure attributable to the intangible asset during

its development.

Examples of D activities include the design, construction and testing of pre-production or pre-use prototypes and models. If a firm cannot distinguish between R and D, it should treat the expenditure as an R expense.

Using Korean public firms' accounting data, we compare between the capitalized D and the rest R&D. Such categorization is suitable to this study because our goal is to examine differences between R and D based on their distinct features such as the levels and types of uncertainty and information asymmetry. The conditions required to be met to capitalize D ensure that D has less uncertainty and information asymmetry problems than R and that firms cannot arbitrarily categorize R expenditure as D. Taking advantage of the data, we investigate the association between R (D) and cash holdings, investment-cash flow sensitivity, and capital structure. To ensure that previous findings on U.S. firms' aggregate R&D hold in our data, we start each analysis by aggregating R&D and then conduct separate investigation of R vs D.[2]

The results of the aggregate R&D and cash holdings analysis are not conclusive. We first create an indicator variable, *R&Ddummy*, which is equal to one if a firm reports positive R&D expenditure during a particular year and zero otherwise. We then examine the association between cash holdings and *R&Ddummy*. The regression result indicates that firms that make R&D expenditures hold cash more than firms that do not make R&D expenditures by approximately 0.7% of firm assets, which is consistent with previous findings. However, we do not find statistically significant result when we replace *R&Ddummy* with the level of R&D scaled by assets (*R&D*).[3]

Next, we repeat the same analysis separating R vs D. We first create indicator variables *Rdummy* (*Ddummy*), which is equal to one if a firm makes R (D) expenditure during a particular year and zero otherwise. Although *Rdummy* and *Ddummy* are both positively associated

[2]In most regressions in this paper, independent variables are lagged by one year following previous studies. We repeat all these regression tests using contemporaneous independent variables and the results do not change qualitatively. The results are presented in the Appendix.

[3]We scale the variables with assets rather than PPE because Korean PPE data is incomplete and scaling by PPE creates severe outliers.

with cash holdings, only *Rdummy* is statistically significant. In particular, firms that make R investment hold significantly more cash holdings (by 0.6% of firm assets), whereas firms that make D investment do not differ significantly on the level of cash holdings. The result holds when we repeat the test using the level of R and D scaled by assets (R and D, respectively) instead of indicator variables. Specifically, a one-standard-deviation increase in R is associated with an increase in cash holdings of approximately 0.3% of firm assets, which accounts for approximately 4.1% of the sample average value of cash holdings. However, D does not have significant association with cash holdings. These results are consistent with more severe information asymmetry and uncertainty of R worsening financial constraints, and thus cause firms to hold more cash.

Next, we find investment-cash flow sensitivity of aggregate R&D to be positive, which is consistent with previous studies' findings. For example, one-standard-deviation increase in cash flows is associated with an increase in $R\&D$ of approximately 0.1% of firm assets. It accounts for approximately 3.1% of the sample average value of $R\&D$. This result suggests that R&D is costly to support using external capital, and thus sensitive to internal cash flows.

When we separate R vs D, investment-cash flow sensitivity of R is positive and statistically significant. In particular, the estimate indicates that a one-standard-deviation increase in cash flows is associated with an increase in R of approximately 0.1% of firm assets. This effect is approximately 5.6% of the sample average value of R. However, the association between cash flows and D is not significant. This result indicate that R investment, but not D investment, is influenced by internal cash flows on average and that the positive investment-cash flow sensitivity of R&D in our sample is attributable to R investment and not to D investment.

Both cash holdings and investment-cash flows sensitivity analyses confirm that firms depend more on internal capital to finance R than D. These results are consistent with higher costs of external financing for R due to severe informational asymmetry and uncertainty. However, one concern regarding investment-cash flow sensitivity analyses is that cash flows could be a proxy for R investment opportunities. In this case, the high investment-cash flow sensitivity

of R is not attributable to financial constraints caused by the nature of R. To address this possibility, we repeat the investment-cash flow sensitivity analysis of R separating between financially constrained firms and unconstrained firms. If the positive association between R and cash flows is driven by investment opportunities, both financially constrained firms and unconstrained firms will show positive association between R and cash flows. On the contrary, if the positive association between R and cash flows is attributable to financial constraints, we will find a stronger result among financially constrained firms. To measure financial constraint, we use the four alternative proxies of financial constraint as in Almeida et al.(2004): Payout ratio, asset size, the existence of bond ratings and the existence of commercial paper ratings.

Our results indicate that financial constraints are the driving forces behind the positive sensitivity of R investment to cash flows. Specifically, we find that investment-cash flows sensitivity of R is more significant among the constrained group of firms in all specifications. Although investment-cash flows sensitivity of R is positive for all firms, the sensitivity is lower for firms that are categorized as financially unconstrained firms. The estimates suggest that for each dollar of additional cash flow, a firm that never had bond ratings during the sample period will spend around 32 cents for R, while a firm that had bond ratings spend approximately 14 cents. The result of regression analyses using other financial constraints measures are qualitatively the same.

We next explore the product market competition implications of D. The idea is based on D's unique feature of bearing product market risk (Van Ark and Hulten (2007)). For example, it is important to implement the result of D investment in a timely manner to deter competitors' entering the market earlier. To the extent that cash holdings help quickly implement the outcomes of D and deter competitors' entrance to the market, product market competition would cause a positive relationship between D and cash holdings.

We find empirical supports for this logic. First, we find that the positive association between cash holdings and aggregate R&D is stronger for firms that belong to the high product market competition group. When we use Herfindahl-Hirschman index (hereafter, HHI) to separate firms

that belong to more/less competitive industries, we find that R&D is positively associated with cash holdings in more competitive industries. The result indicates that a one-standard-deviation increase in $R\&D$ is associated with an increase in cash holdings of approximately 0.5% of firm assets. This effect is approximately 6.6% of the sample average value of cash holdings. However, $R\&D$ of firms in less competitive industries is not significantly associated with cash holdings.

When we separate R vs D and repeat the analysis, the results are consistent with D bearing product market risk. The result indicate that higher level of D is associated with higher cash holdings in more competitive industries. In particular, a one-standard-deviation increase in D is associated with an increase in cash holdings of approximately 0.7% of firm assets in competitive industries relative to less competitive industries. This effect is economically significant as it accounts for approximately 9% of the sample average value of cash holdings. On the contrary, we do not find any effect of product market competition on the association between cash holdings and R. It appears that product market competition does not affect the relationship between cash holdings and R investment.

Lastly, we analyze the relationship between R&D and capital structure. Previous studies generally predict a negative association between leverage and R&D. First, R&D creates intangible assets which cannot be used as collateral (Bester (1985), Frank and Goyal (2009)). Second, R&D is subject to risk-shifting problems. For example, a firm can concentrate its R&D on projects with a low probability of extremely high returns without bondholders' detecting because most firms do not disclose detailed information about R&D. (Long and Malitz(1985), Himmelberg and Petersen(1994)). In addition, R&D's long investment horizon would make firms to avoid debt issuance.

Our empirical evidence provides support for this logic. First, we find a negative association between leverage and aggregate R&D. Specifically, a one-standard-deviation increase in $R\&D$ is associated with a decrease in market leverage of approximately 1.3 percentage points. It is approximately 5.5% of the standard deviation and 3.1% of the sample average value of market leverage.

More importantly, this relationship holds among firms that make R investment. Specifically, a one-standard-deviation increase in R is associated with a decrease in leverage of approximately 1.7 percentage points, which is approximately 4.1% of the sample average value of market leverage. On the other hand, the association between D and leverage is statistically insignificant, although it is also negative. This result is expected as R is riskier, and thus, more susceptible to risk-shifting problems. Moreover, R is more subject to information asymmetry and provides for little collateral value. In addition, R's nature of longer term horizon also makes it harder to ensure timely payback of debt. Therefore, R is associated with less debt and more equity. On the contrary, D suffers less information asymmetry and uncertainty relative to R. Therefore, D does not have a significantly negative association with market leverage. The results continue hold when we use book leverage rather than market leverage. This result mitigates the concern that R&D investment increases market value of a firm, which mechanically results in lower market leverage.

Our work is related and contributes to the strand of finance literature on the association between corporate R&D investment and cash holdings. Dittmar et al.(2003) use R&D expenditure as a proxy for asymmetric information and find positive association between R&D and cash holdings. Opler et al.(1999) also provide evidence of higher cash holdings of R&D firms. Bates et al.(2009) show that R&D intensive firms hold more cash because it is costly to finance R&D investment using external capital. Brown and Petersen (2011) show that firms most likely to face financing frictions rely extensively on cash holdings to smooth R&D. Brown and Peterson (2009) find that investment-cash flow sensitivity is stronger for R&D investment compared to physical investment.

Our study is also related to the literature on the association between corporate R&D investment and capital structure. For example, Long and Malitz (1985) provide empirical evidence that financial leverage is negatively correlated with R&D expenditures. Frank and Goyal (2009) find significantly negative correlation between R&D expenditure and leverage. They explain lower leverage of R&D firms through a collateral channel: R&D firms have less incentive to issue

debt because firms making large discretionary expenditures have more intangible assets and less tangible assets. Bester (1985) also emphasizes the lack of R&D's collateral value. According to Himmelberg and Petersen(1994), equity is considered the natural financial instrument for high-tech investment because risk-shifting is more accentuated as firms become more leveraged.

Although the studies mentioned above provide ample evidence on the relationship between R&D and important corporate financial policy variables, our study contributes to the literature by revealing the differences between R and D. Our results indicate that we should consider R and D separately in evaluating corporate policies.

The paper proceeds as follows. In Section 2, we introduce the baseline empirical strategy and describe the data. We show the results of regression analyses on cash holdings in Section 3. In Section 4, we report the results of the investment-cash flow sensitivity analyses. In section 5, we conduct product market competition and cash holdings test. Section 6 presents results of regression analyses on capital structure decision. We conclude in Section 7.

2. Data and summary statistics

In this section, we describe the data used in this study as well as the summary statistics.

2.1. Data and variables

Firm-level accounting information is obtained from a database provided by Korea Investors Service (KIS), which is deemed to be one of the most complete and representative corporate databases. We follow the standard procedure of excluding financial institutions from the sample. The sample period is 2000-2014. Our final sample comprise 14815 firm-years.

Our main variable of interest is *R&Ddummy*, *Rdummy*, *Ddummy* along with *R&D*, *R*, and *D*. *R&Ddummy* is equal to one if a firm reports positive R&D expenditure in a particular year and zero otherwise. *Rdummy* (*Ddummy*) is defined to be equal to one if a firm reports any R (D) expenditure in a particular year and zero otherwise. *R&D* is R&D expenditure over total assets. *R* (*D*) is defined as R (D) expenditure over total assets.

The definitions of other variables are as follows. *Cash* represents the ratio of cash and cash equivalents to total assets and *CashFlow* is the ratio of EBITDA over total assets (EBITDA/total assets). *Capex* is capital expenditure scaled by total assets (Capex/total assets). *NWC* is the current assets minus current liabilities scaled by total assets ((Current assets-current liabilities)∗10 billion Korean Won/total assets).[4] *Size* is the natural logarithm of a firm's total assets. *Tobin'sQ* is calculated by subtracting the book value of equity from the sum of total asset and the market value of equity divided by total asset (Total assets - book value of equity + market value of equity)/total assets). *Market Leverage* is total debt over market value of a firm's total assets (Total debt/(total assets - book value of equity + market value of equity)). Finally, *Book Leverage* is the level of total debt divided by total assets (Total debt/total assets). All variables are winsorized at 1% in both tails of the distribution.

2.2. Summary statistics

Table I presents summary statistics of our sample firms. The mean value of *R&Ddummy* indicates that approximately 70% of our sample firms perform either R or D. On the other hand, the mean value of *R+Ddummy* indicates that approximately 27.4% of our sample firms engage in both R and D. Firms that report R and D are 61% and 37%, respectively. On average, firms spend 2.3% of total assets in R&D. Among this, 1.1% is spent on R and 1.2% is spent on D. Our firms hold on average 7.7% of total assets in the form of cash and cash equivalents. *Cash Flow*, on average, amounts to 8.7% of assets. In addition, the mean of *Market Leverage* is 0.421 and *Book Leverage* is 0.397.[5] The average of *Tobin'sQ* is 1.131.

TABLE 1 ABOUT HERE

[4]We multiply conventional net working capital by 10 billion Korean Won because the denominator is substantially larger than the numerator.

[5]Korean firms' market leverage is higher than book leverage on average.

3. Cash holdings

This section presents the results of cash holdings analyses. We first examine the association between cash holdings and aggregate R&D to ensure that the results of previous studies that analyze U.S. R&D and cash holdings hold in our sample. We then investigate the relationship between cash holdings and R vs D, separately.

3.1. Cash holdings and R&D

We first conduct a regression test of cash holdings on *R&Ddummy* controlling for the variables previously known to be associated with cash holdings, then replace *R&Ddummy* with *R&D*, the level of R&D expenditure over assets. In all cash holdings regressions we control for industry fixed effects and year fixed effects. Standard errors are clustered at an industry level.

The results are presented in Table II. The variable of interest in column (1) is *R&Ddummy*. The coefficient on *R&Ddummy* is positive and statistically significant, indicating that firms that make R&D expenditures hold cash more than firms that do not make R&D expenditures by approximately 0.7% of firm assets. In column (2), we replace *R&Ddummy* with *R&D*. However, the coefficients on *R&D* is not statistically significant.

3.2. Cash holdings and R vs D

Next, we separate R vs D and repeat the cash holdings analysis. In column (3) of Table II, the main variables of interest are *Rdummy* and *Ddummy*. The coefficient on *Rdummy* is positive and statistically significant, whereas that of *Ddummy* is not significant. The coefficient of *Rdummy* (0.006) indicates that firms that make R expenditure hold cash more than firms that do not by 0.6% of firm assets. The magnitude of the coefficient is similar to that of the *R&Ddummy* regression, suggesting that the result we find in *R&Ddummy* regression is attributable mostly to R.

In column (4), we replace *Rdummy* and *Ddummy* with *R* and *D*, respectively. The result is consistent with that of column (3). The coefficient on *R* is positive and statistically signif-

icant whereas the coefficient on D is insignificant. Given that the standard deviation of R is 0.022, a one-standard-deviation increase in R is associated with an increase in cash holdings of approximately 0.3% of firm assets. It is approximately 4.1% of the sample average value of cash holdings. These results are consistent with more severe information asymmetry and uncertainty of R investment worsening financial constraints and thus making firms hold more cash.

TABLE II ABOUT HERE

4. Investment-cash flow sensitivity

This section presents the results of investment-cash flow sensitivity analyses. As in the previous section, we first report the results of aggregate R&D analyses to ensure that previous studies' findings on investment-cash flow sensitivity of R&D hold in our sample. We then report the investment-cash flow sensitivity of R vs D separately. In all investment-cash flow sensitivity analyses, we use the sample of firms that report positive R&D expenditure and control for both year fixed effects and firm fixed effects.

4.1. Investment-cash flow sensitivity of R&D

We first examine the investment-cash flow sensitivity of aggregate R&D. The result is presented in column (1) of Table III. The coefficient on *CashFlow* is positive and statistically significant, suggesting positive investment-cash flow sensitivity of R&D. For example, the coefficient of 0.008 means that a one-standard-deviation increase in cash flows is associated with an increase in $R\&D$ of approximately 0.1% of firm assets, which accounts for approximately 3.1% of the sample average value of $R\&D$.

4.2. Investment-cash flow sensitivity of R vs D

In this section, we analyze investment-cash flow sensitivity of R and D separately. The results are presented in column (2) and (3), respectively. In column (2), the coefficient on *CashFlow* is positive and statistically significant. The coefficient of 0.007 indicates that a one-standard-deviation increase in cash flows is associated with an increase in R of approximately 0.1% of firm assets. This effect is economically significant as it is approximately 5.6% of the sample average value of R. On the other hand, the coefficient on *CashFlow* is statistically insignificant in column (3). This result indicates that the positive investment-cash flow sensitivity of R&D that we find is attributable to R investment and not to D investment. Again, this interpretation is consistent with information asymmetry and uncertainty of R worsening financial constraints, and thus R investment being significantly influenced by internal cash flows relative to D investment.

TABLE III ABOUT HERE

4.3. Financial constraints and Investment-cash flow sensitivity of R

One concern regarding the high investment-cash flow sensitivity of R is that cash flows may be positively correlated with R investment opportunities. Then the positive investment-cash flow sensitivity of R cannot be interpreted as R worsening financial constraints. To address this possibility, we repeat the investment-cash flow sensitivity analysis of R separating between financially constrained firms and unconstrained firms. If the positive association between R and cash flows is driven by investment opportunities, both financially constrained firms and unconstrained firms will show positive association between R and cash flows. On the contrary, if the positive association between R and cash flows is attributable to financial constraints, we will find stronger result among financially constrained firms. Similar to Almeida et al. (2004), we use four alternative measures to partition our sample into financially constrained and unconstrained group[6]:

[6]We also try Kaplan and Zingales (1997) index to categorize firms. As in Almeida et al. (2004), the results are inconsistent with other four measures of financial constraints.

(1) Payout ratio: We rank firms based on their average payout ratio during the sample period and assign to the financially constrained (unconstrained) group those firms in the bottom (top) half or tercile of payout distribution. We also use the raw payout ratio in the analysis. As in Almeida et al.(2004), we compute the payout ratio as the ratio of total distributions (dividends plus stock repurchases) to operating income. The intuition is that financially constrained firms have significantly lower payout ratios as suggested in Fazzari et al.(1988).

(2) Size: We rank firms based on their average asset size over the sample period, and assign to the financially constrained (unconstrained) group those firms in the bottom (top) half or tercile of the size distribution. We also use the raw size in the analysis. According to Almeida et al. (2004), small firms are generally young and less well known, and thus would be more vulnerable to market imperfections.

(3) Bond ratings: We categorize sample firms that never had their public debt rated during our sample period as financially constrained. Financially unconstrained firms are those whose bonds have been rated during the sample period.

(4) Commercial paper ratings: We categorize sample firms that never had their commercial paper ratings into the financially constrained group. Firms that issued commercial papers receiving ratings at some point during the sample period are considered unconstrained.

The results are presented in Table IV. Column (1) reports the result using raw payout ratio. The negative coefficient indicates that low payout firms' investment-cash flow sensitivity of R is higher. Because low payout firms are more financially constrained, it suggests that financially constrained firms' R is more sensitive to cash flows. Column (2) and (3) reports results when categorizing firms into two and three groups, respectively, based on payout ratio. In column (2) and (3), *PayoutBottom* is equal to one if a firm belongs to the bottom half (third) according to payout ratio and zero if it belongs to the top half (third). In both cases, the coefficient on $CashFlow \times PayoutBottom$ is positive and significant, again indicating that financially constrained firms have higher investment-cash flow sensitivity of R. For example, the estimates in column (3) suggest that for each dollar of additional cash flow, an unconstrained

firm will spend around 17 cents for R expenditure, while constrained firms spend approximately 38 cents. We attain similar results when we use a firm's size to categorize firms in column (4)-(6). Overall, the constrained firms display significantly higher sensitivities of R to cash flow compared to the set of unconstrained firms.

Column (7) reports estimates of bond ratings analysis. *NoBondRating* is an indicator variable that is equal to one if a firm never had its public debt rated during the sample period and zero otherwise. The coefficient estimates on the *CashFlow* indicate that a firm that had bond ratings spend approximately 14 cents on R for each dollar of additional cash flow after controlling for other firm characteristics. The coefficient estimates on the *CashFlow* $\times$ *NoBondRating* indicates that for each dollar of additional cash flow, a firm that never had bond ratings spends on R approximately 18 cents more than financially unconstrained group of firms, or spends around 32 cents for each dollar of additional cash flow. The result of commercial paper ratings analysis is reported in column (8). *NoCPRating* is an indicator variable that is equal to one if a firm never had its commercial paper rating and zero otherwise. The estimates in column (8) is the same as those of column (7) because the correlation between *NoBondRating* and *NoCPRating* equals one. All of the results in Table IV are consistent with the prediction that financial constraints are the driving forces behind the positive sensitivity of R investment to cash flow.

TABLE IV ABOUT HERE

5. Product market competition

In this section, we explore the product market competition implications of R and D. Because D bears product market risk such as competitors' entering the product market earlier, firms with D investment would hold more cash to the extent that cash holdings help quickly implement the outcomes of D and deter competitors' entrance to the market. Therefore, the relationship between cash holdings and D will be positive when product market competition is severe. To

test this logic, we examine whether the association between D and cash holdings is influenced by product market competition. As a measure of product market competition, we calculate HHI for each industry. To mitigate measurement error of HHI, we categorize our sample firms into two and three groups based on the median and terciles of HHI. In each analysis, we compare between the lowest HHI group with the highest HHI group. We create an indicator variable *HHIbottom* which is equal to one if a firm belongs to the lowest HHI group, and zero if it belongs to the highest HHI group.

5.1. Product market competition and R&D

We first examine whether the relationship between cash holdings and aggregate R&D differ under different levels of competition. The results are presented in column (1) and (2) of Table V. In column (1), we report the result where firms are categorized into two groups based on the median value of HHI. To examine the differential effects of R&D and cash holdings for the above-median HHI group and the below-median HHI group, we interact an indicator variable *HHIbottom* with our original variable of interest (i.e., $R\&D$). Because higher HHI indicates less competition, the positive coefficient on the variable of interest indicates that R&D is more positively associated with cash holdings in competitive industries. Given that the standard deviation of $R\&D$ is 0.045, the coefficient of interest in column (1), 0.113, indicates that a one-standard-deviation increase in R&D is associated with an increase in cash holdings of approximately 0.5% of firm assets. This effect is economically significant as it is approximately 6.6% of the sample average value of cash holdings. However, for firms in less competitive industries, R&D is not significantly associated with cash holdings.

In column (2), we separate firms into three groups based on HHI and compare the top and the bottom HHI groups. The coefficient of interest is again positive. However, for firms in less competitive industries, R&D is negatively associated with cash holdings. All in all, these results indicates that the positive relationship between cash holdings and R&D is more pronounced among firms in competitive product market environments.

5.2. Product market competition and R vs D

Next, we separate R vs D and repeat the regression analysis. The results are provided in column (3) and (4). The coefficient on $HHIbottom \times R$ is not significant in both columns, indicating that the relationship between R and cash holdings is not affected by product market competition. However, the coefficient on $HHIbottom \times D$ is positive and statistically significant in both columns. This result indicates that the relationship between D and cash holdings are positive for firms in competitive industries. In particular, a one-standard-deviation increase in D is associated with an increase in cash holdings of approximately 0.7% of firm assets in competitive industries relative to less competitive industries. This effect is economically significant as it accounts for approximately 9% of the sample average value of cash holdings. One thing to notice is that the coefficient on D is negative. It indicates that a one-standard-deviation increase in D is associated with a decrease in cash holdings of about 0.5% of firm assets in less competitive industries. The results in Table V indicate that D is the component of R&D that drives the positive association between competition and cash holdings. It is consistent with D bearing product market risk.

TABLE V ABOUT HERE

6. Capital structure

In this section, we study the association between financial leverage and R vs D. Previous studies generally predict a negative association between leverage and R&D. We first examine whether our sample firms show negative association between leverage and R&D, and then repeat the analyses separating R vs D.

6.1. Capital structure and R&D

The results of the market leverage and aggregate R&D analysis is presented in column (1) and (2) of Table VI. We use the full sample in column (1) and restrict the sample firms

to have positive R&D expenditure in column (2). In both cases, the coefficient on $R\&D$ is negative and statistically significant. For example, the coefficient of -0.289 on $R\&D$ in column (1) indicates that a one-standard-deviation increase in R&D is associated with a decrease in leverage of approximately 1.3 percentage points. This effect is approximately 5.5% of the standard deviation and 3.1% of the sample average value of market leverage. This result is consistent with previous studies finding the negative effect of R&D on leverage.

6.2. Capital structure and R vs D

Column (3) and (4) report results of leverage regression on R and D. Consistent with the R&D regressions, we use the full sample in column (3) and restricted sample in column (4). In both cases, the coefficient on R is negative and statistically significant, whereas that of D is not significant although negative. Given that the standard deviation of the R is 0.022, the coefficient of interest, -0.79, indicates that a one-standard-deviation increase in R is associated with a decrease in market leverage of approximately 1.7 percentage points. This effect is approximately 4.1% of the sample average value of market leverage. However, D does not have a significantly negative association with market leverage. This result is expected as R is riskier, and thus, more susceptible to risk-shifting problems. Moreover, R is more subject to information asymmetry and provides for little collateral value. In addition, R's nature of longer term horizon also makes it harder to ensure timely payback of debt. Therefore, R is associated with less debt and more equity. On the contrary, D suffers less information asymmetry and uncertainty relative to R, and thus D's negative association with leverage is statistically not significant.

6.3. Book leverage

One concern is that the negative association between market leverage and R could be attributable to the high market value of R. Because R investment has a potential for substantial success in the future, the market value of research could be higher than that of development,

and thus may mechanically leads to lower market leverage. To mitigate this concern, we use book leverage as our main variable and repeat the analysis.

The results are presented in panel B. In column (1) and (2), we regress book leverage on aggregate R&D using full sample and restricted sample, respectively. In both cases, the coefficient on R&D is not statistically significant, consistent with the concern that higher market value of R&D mechanically leading to lower market leverage. In column (3) and (4), we separate R vs D and repeat the regression analysis. The results indicate that R is negatively associated with book leverage, whereas D is positively associated (column (3)) or not significantly associated (column (4)) with book leverage. This result ensures that the negative association between R and leverage is unlikely to be attributable to higher market value of R. It appears that despite the intangible nature of D, its features of marketability and profitability allow D to be less subject to risk-shifting or collateral concerns of debt issuance.

Table VI About Here

7. Conclusion

This study provides strong empirical evidence that research and development have differential relationship with major corporate financing variables. Using Korean accounting data which compartmentalize research and development, we show that the previous findings on the associations between aggregate R&D and cash holdings, investment-cash flow sensitivity, and capital structure are mostly driven by research investment. Specifically, we show that research is more positively associated with cash holdings relative to development, and that only research is sensitive to cash flows. Meanwhile, consistent with development bearing product market risk, development investment is associated with higher cash holdings when product market competition is severe, but the same relationship does not hold for research. Lastly, we find negative association between leverage and research but not development. These results are consistent with higher uncertainty and information asymmetry of research imposing more severe financial

constraints than development.

These are important findings because research and development are generally considered as a homogeneous activity in the finance literature. In addition, research and development are reported aggregately in financial statements and even in corporate filings in most cases. The results of this study suggest that separate reporting of research and development would be useful in evaluating corporate financing decisions such as cash holdings and capital structure.

REFERENCES

Almeida, Heitor, Campello Murillo, and Weisbach Michael S., 2004, The Cash Flow Sensitivity of Cash, *Journal of Finance* 59, 1777-1804.

Bates, Thomas, Kahle Kathleen, and Stulz Rene, 2009, Why Do U.S. Firms Hold So Much More Cash than They Used To?, *The Journal of Finance* 64, 1985-2021.

Baxamusa, Mufaddal, Mohanty Sunil, and Rao Ramesh P., 2015, Information Asymmetry about Investment Risk and Financing Choice, *Journal of Business Finance & Accounting* 42, 947-964.

Bester, Helmut, 1985, Screening vs. Rationing in Credit Markets with Imperfect Information, *The American Economic Review* 75, 850-855.

Brown, James R. and Petersen Bruce C., 2009, Why has the investment-cash flow sensitivity declined so sharply? Rising R&D and equity market developments, *Journal of Banking & Finance* 33, 971-984.

Brown, James R. and Petersen Bruce C., 2011, Cash holdings and R&D smoothing, *Journal of Corporate Finance* 17, 694-709.

Chiesa, Vittorio and Frattini Federico, 2007, Exploring the differences in performance measurement between research and development: evidence from a multiple case study, *R&D Management* 37, 283-301.

Czarnitzki, Dirk, Hottenrott Hanna, and Thorwarth Susanne, 2011, Industrial research versus development investment: the implications of financial constraints, *Cambridge Journal of Economics* 35, 527-544.

Dittmar, Amy, Mahrt-Smith Jan, and Servaes Henri, 2003, International Corporate Governance and Corporate Cash Holdings, *The Journal of Financial and Quantitative Analysis* 38, 111-133.

Faulkender, Michael and Petersen Mitchell A., 2005, Does the Source of Capital Affect Capital Structure?, *The Review of Financial Studies* 19, 45-79.

Fazzari, Steven M., Hubbard R. Glenn, Petersen Bruce C., Blinder Alan S., and Poterba James M., 1988, Financing Constraints and Corporate Investment, *Brookings Papers on Economic Activity* 1988, 141-206.

Frank, Murray Z. and Goyal Vidhan K., 2009, Capital Structure Decisions: Which Factors Are Reliably Important?, *Financial Management* 38, 1-37.

Halov, Nikolay and Heider Florian, 2011, Capital structure, risk and asymmetric information, *Quarterly Journal of Finance* 1, 767-809.

Himmelberg, Charles P. and Petersen Bruce C., 1994, R&D and Internal Finance: A Panel Study of Small Firms in High-Tech Industries, *The Review of Economics and Statistics* 76, 38-51.

Kamien, Morton I. and Schwartz Nancy L., 1978, Self-Financing of an R and D Project, *The American Economic Review* 68, 252-261.

Kaplan, Steven N. and Zingales Luigi, 1997, Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?, *The Quarterly Journal of Economics* 112, 169-215.

Karlsson, Martin, Trygg Lars, and Elfstrom Bengt-Olof, 2004, Measuring R&D productivity: complementing the picture focusing on research activities, *Technovation* 24, 179-186.

Leifer, Richard and Triscari Thomas, 1987, Research versus Development Differences and Similarities, *IEEE Transactions on Engineering Management* 34, 71-78.

Long, Michael S. and Malitz Ileen B., 1985, Investment Patterns and Financial Leverage, In *Corporate Capital Structures in the United States*, 325-352, University of Chicago Press.

OECD, 2005, *Research and Development Expenditure in Industry*, Organizations for Economic Co-operation and Development.

Opler, Tim, Pinkowitz Lee, Stulz Rene and Williamson Rohan, 1999, The determinants and implications of corporate cash holdings, *Journal of Financial Economics* 52, 3-46.

Van Ark, Bart and Hulten Charles, 2007, Innovation, intangibles and economic growth: Towards a comprehensive accounting of the knowledge economy, *Yearbook on Productivity 2007*, 127-146.

Table I
Summary Statistics

This table provides summary statistics on the sample firms. The sample consists of non-financial public firms of Korea during 2000 and 2014. All variables are defined in Appendix. All variables are winsorized at 1% in both tails of the distribution.

	Count	Mean	SD	p25	p50	p75
$R\&Ddummy$	14815	0.702	0.458	0.000	1.000	1.000
$Rdummy$	14815	0.606	0.489	0.000	1.000	1.000
$Ddummy$	14815	0.370	0.483	0.000	0.000	1.000
$(R+D)dummy$	14815	0.274	0.446	0.000	0.000	1.000
$R\&D$	14815	0.023	0.045	0.000	0.004	0.026
R	14815	0.011	0.022	0.000	0.001	0.012
D	14815	0.012	0.034	0.000	0.000	0.005
$CashFlow$	14815	0.087	0.088	0.036	0.077	0.130
$Cash$	14815	0.077	0.090	0.017	0.048	0.101
$MarketLeverage$	14815	0.421	0.233	0.224	0.410	0.606
$BookLeverage$	14815	0.397	0.190	0.242	0.397	0.543
$Payout$	14815	0.245	0.402	0.051	0.156	0.315
$NoBondRating$	14815	0.610	0.488	0.000	1.000	1.000
$NoCPRating$	14815	0.610	0.488	0.000	1.000	1.000
$Asset$(in billions of Korean won)	14815	623.972	2049.941	58.140	111.627	280.914
$Tobin'sQ$	14815	1.131	0.666	0.748	0.935	1.266
$Capex$	13320	0.056	0.082	0.011	0.032	0.074
NWC	14815	0.036	0.074	0.000	0.011	0.046

Table II
R vs D and Cash Holdings

This table presents the results of R vs D and cash holdings analysis. Column (1)and (2) report results of cash holdings regression on aggregate R&D variables and column (3) and (4) report regression results separating R vs D. All other variables are defined in Appendix. Industry-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. Standard errors are clustered at an industry level. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dep. variable		Cash		
$R\&Ddummy_{t-1}$	0.007***			
	(0.001)			
$R\&D_{t-1}$		0.020		
		(0.055)		
$Rdummy_{t-1}$			0.006**	
			(0.002)	
$Ddummy_{t-1}$			0.001	
			(0.003)	
R_{t-1}				0.142***
				(0.024)
D_{t-1}				-0.037
				(0.087)
$Size_{t-1}$	-0.005**	-0.005**	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
$BookLeverage_{t-1}$	-0.052***	-0.051***	-0.051***	-0.051***
	(0.009)	(0.009)	(0.010)	(0.009)
$CashFlow_{t-1}$	0.079***	0.077***	0.079***	0.074***
	(0.009)	(0.010)	(0.009)	(0.011)
$Capex_{t-1}$	-0.061***	-0.061***	-0.062***	-0.059***
	(0.009)	(0.006)	(0.008)	(0.005)
$Tobin'sQ_{t-1}$	0.006*	0.007	0.006	0.007
	(0.003)	(0.004)	(0.004)	(0.004)
NWC_{t-1}	0.166***	0.167***	0.166***	0.165***
	(0.024)	(0.021)	(0.024)	(0.021)
Ind FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	13307	13307	13307	13307
R^2	0.152	0.151	0.152	0.152

Table III
Investment-Cash Flow Sensitivity of R vs D

This table presents the results of investment-cash flow sensitivity of R and D analysis. All columns report the result using positive R&D expenditure. In column (1), the dependent variable is $R\&D$. In column (2) and (3), the dependent variable is R and D, respectively. All other variables are defined in Appendix. firm-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
	R&D	R	D
$CashFlow_t$	0.008*	0.007***	0.001
	(0.004)	(0.002)	(0.004)
$Tobin'sQ_{t-1}$	0.002***	-0.000	0.003***
	(0.001)	(0.000)	(0.001)
$BookLeverage_{t-1}$	-0.006**	-0.005***	-0.000
	(0.002)	(0.001)	(0.002)
$Cash_{t-1}$	-0.022***	-0.002	-0.018***
	(0.003)	(0.002)	(0.003)
$Size_{t-1}$	-0.012***	-0.004***	-0.008***
	(0.001)	(0.000)	(0.001)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	10393	10393	10393
R^2	0.770	0.761	0.697

Table IV
Investment-Cash Flow Sensitivity of R and Financial Constraints

This table presents the results of investment-cash flow sensitivity of R and financial constraints analysis. In all columns, the dependent variable is *R*. Similar to Almeida et al (2004), we use four alternative measures to partition our sample: Payout ratio, asset size, the existence of bond ratings and the existence of commercial paper ratings. All other variables are defined in Appendix. firm-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. variable : R	Full	Median	Tercile	Full	Median	Tercile	Full	Full
$CashFlow \times Payout$	-0.010*							
	(0.006)							
$CashFlow \times PayoutBottom$		0.014***	0.021***					
		(0.005)	(0.006)					
$CashFlow \times Size$				-0.009***				
				(0.002)				
$CashFlow \times SizeBottom$					0.026***	0.044***		
					(0.005)	(0.006)		
$CashFlow \times NoBondRating$							0.018***	
							(0.005)	
$CashFlow \times NoCPRating$								0.018***
								(0.005)
$CashFlow_t$	0.029***	0.021***	0.017***	0.261***	0.014***	0.011***	0.014***	0.014***
	(0.003)	(0.003)	(0.004)	(0.041)	(0.003)	(0.004)	(0.004)	(0.004)
$Tobin'sQ_{t-1}$	-0.001**	-0.001**	-0.001***	-0.001**	-0.001**	-0.001	-0.001**	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$BookLeverage_{t-1}$	-0.007***	-0.007***	-0.006***	-0.007***	-0.007***	-0.006***	-0.007***	-0.007***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
$Cash_{t-1}$	-0.002	-0.002	-0.002	-0.002	-0.002	0.004	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Size_{t-1}$	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***	-0.002***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	7887	7887	5027	7887	7887	4979	7887	7887
R^2	0.802	0.802	0.803	0.803	0.803	0.823	0.802	0.802

Table V
Product Market Competition and Cash Holdings

This table reports the results of analysis on whether the relationship between cash holdings and R and D differ under different levels of competition. Firms are categorized into more/less competitive product market group based on the HHI of the industry they belong to. Column (1)-(2) reports aggregate R&D analysis and (3)-(4)reports R vs D analysis. All other variables are defined in Appendix. Industry-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. Standard errors are clustered at an industry level. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dep. variable : Cash	Median	Tercile	Median	Tercile
$R\&D_{t-1} \times HHIbottom$	0.113***	0.117***		
	(0.016)	(0.026)		
$R_{t-1} \times HHIbottom$			-0.069	0.006
			(0.129)	(0.115)
$D_{t-1} \times HHIbottom$			0.211***	0.175***
			(0.059)	(0.053)
$R\&D_{t-1}$	-0.047	-0.104***		
	(0.037)	(0.033)		
R_{t-1}			0.158*	0.069
			(0.089)	(0.106)
D_{t-1}			-0.154*	-0.194**
			(0.078)	(0.082)
$HHIbottom$	-0.011*	-0.011	-0.010*	-0.011
	(0.006)	(0.008)	(0.006)	(0.008)
$Size_{t-1}$	-0.006*	-0.005*	-0.006*	-0.006*
	(0.003)	(0.003)	(0.003)	(0.003)
$BookLeverage_{t-1}$	-0.053***	-0.051***	-0.052***	-0.050***
	(0.009)	(0.011)	(0.009)	(0.011)
$CashFlow_{t-1}$	0.069***	0.073***	0.068***	0.071***
	(0.011)	(0.009)	(0.012)	(0.010)
$Capex_{t-1}$	-0.065***	-0.061***	-0.064***	-0.059***
	(0.008)	(0.013)	(0.007)	(0.012)
$Tobin'sQ_{t-1}$	0.010**	0.012***	0.010**	0.012***
	(0.004)	(0.004)	(0.004)	(0.004)
NWC_{t-1}	0.181***	0.202***	0.180***	0.201***
	(0.020)	(0.017)	(0.020)	(0.017)
Ind FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	13307	8679	13307	8679
R^2	0.134	0.144	0.135	0.145

Table VI
Leverage and R vs D

This table presents the results of R vs D and leverage analysis. Column (1)and (2) of Panel A report results of market leverage regression on aggregate R&D variables and column (3) and (4) reports regression results separating R vs D. Column (1)and (2) of Panel B report results of book leverage regression on aggregate R&D variables and column (3) and (4) reports regression results separating R vs D. All other variables are defined in Appendix. In each panel, column (1) and (3) use the full sample, whereas (2) and (4) use restricted sample of firms with positive R&D expenditure. Industry-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. Standard errors are clustered at an industry level. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A : Market Leverage				
	(1)	(2)	(3)	(4)
	Full	R&D>0	Full	R&D>0
$R\&D_{t-1}$	-0.289***	-0.338***		
	(0.026)	(0.054)		
R_{t-1}			-0.790***	-0.941***
			(0.083)	(0.065)
D_{t-1}			-0.077	-0.108
			(0.066)	(0.087)
$Tobin'sQ_{t-1}$	-0.104***	-0.111***	-0.103***	-0.110***
	(0.006)	(0.006)	(0.006)	(0.007)
$CashFlow_{t-1}$	-0.323***	-0.319***	-0.315***	-0.306***
	(0.067)	(0.051)	(0.064)	(0.046)
$Cash_{t-1}$	-0.264***	-0.239***	-0.256***	-0.225***
	(0.065)	(0.050)	(0.064)	(0.050)
$Size_{t-1}$	0.027***	0.025***	0.027***	0.025***
	(0.003)	(0.002)	(0.003)	(0.002)
Ind FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	14811	10458	14811	10458
R^2	0.353	0.376	0.355	0.381

Panel B : Book Leverage				
	(1)	(2)	(3)	(4)
	Full	R&D>0	Full	R&D>0
$R\&D_{t-1}$	-0.005	-0.086		
	(0.046)	(0.080)		
R_{t-1}			-0.480***	-0.689***
			(0.101)	(0.107)
D_{t-1}			0.225**	0.174
			(0.078)	(0.099)
$Tobin'sQ_{t-1}$	0.013	-0.001	0.014	-0.000
	(0.011)	(0.009)	(0.011)	(0.008)
$CashFlow_{t-1}$	-0.246***	-0.261***	-0.239***	-0.248***
	(0.076)	(0.065)	(0.073)	(0.062)
$Cash_{t-1}$	-0.255***	-0.248***	-0.247***	-0.234***
	(0.083)	(0.074)	(0.083)	(0.075)
$Size_{t-1}$	0.027***	0.027***	0.028***	0.027***
	(0.004)	(0.003)	(0.004)	(0.002)
Ind FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	14811	10458	14811	10458
R^2	0.130	0.150	0.133	0.158

Appendix: Variable Definitions

Panel A. Financial Variables	
R	Research expenditure/total assets.
D	Development expenditure/total assets.
R&D	R&D expenditure/total assets.
Size	Natural logarithm of total assets.
Tobin'sQ	(Total assets - book value of equity + market value of equity)/total assets.
Cash flow	(Earnings before interest and taxes + depreciation)/total assets.
Cash	Cash and cash equivalents/total assets.
NWC	10 billions $*$ (Current asset - current liabilities)/total assets.
Capex	Capital expenditure/total assets.
Market leverage	Total debt/(Total assets - book value of equity + market value of equity).
Book leverage	Total debt/total assets.
Panel B. Indicator Variables	
R&Ddummy	An indicator variable that is equal to one if a firm reports positive R&D expenditure in a particular year and zero otherwise.
Rdummy	An indicator variable that is equal to one if a firm reports positive research expenditure in a particular year and zero otherwise.
Ddummy	An indicator variable that is equal to one if a firm reports positive development expenditure in a particular year and zero otherwise.
NoBondRating	An indicator variable that is equal to one if a firm never had a bond rating during the sample period and zero otherwise.
NoCPRating	An indicator variable that is equal to one if a firm never had a commercial paper rating during the sample period and zero otherwise.
PayoutBottom	An indicator variable that is equal to one if a firm belongs to a bottom group based on a payout ratio and zero if a firm belongs to a top group.

SizeBottom	An indicator variable that is equal to one if a firm belongs to a bottom group based on its asset size and zero if a firm belongs to a top group.
HHIbottom	An indicator variable that is equal to one if a firm belongs to an industry of bottom HHI group and zero if a firm belongs to an industry of top HHI group.

Appendix Table I : R vs D and Cash Holdings

This table presents the results of R vs D and cash holdings analysis. Column (1)and (2) report results of cash holdings regression on aggregate R&D variables and column (3) and (4) report regression results separating R vs D. All other variables are defined in Appendix. Industry-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dep. variable		Cash		
$R\&Ddummy_t$	0.007***			
	(0.001)			
$R\&D_t$		0.035		
		(0.039)		
$Rdummy_t$			0.007**	
			(0.002)	
$Ddummy_t$			-0.000	
			(0.003)	
R_t				0.171***
				(0.020)
D_t				-0.037
				(0.065)
$Size_{t-1}$	-0.005**	-0.005**	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
$BookLeverage_{t-1}$	-0.052***	-0.051***	-0.051***	-0.050***
	(0.009)	(0.009)	(0.009)	(0.009)
$CashFlow_{t-1}$	0.079***	0.078***	0.078***	0.074***
	(0.009)	(0.010)	(0.009)	(0.011)
$Capex_{t-1}$	-0.061***	-0.062***	-0.061***	-0.059***
	(0.009)	(0.007)	(0.008)	(0.006)
$Tobin'sQ_{t-1}$	0.006*	0.007	0.006*	0.007*
	(0.003)	(0.004)	(0.004)	(0.004)
NWC_{t-1}	0.166***	0.166***	0.166***	0.165***
	(0.024)	(0.022)	(0.023)	(0.022)
Ind FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	13307	13307	13307	13307
R^2	0.152	0.151	0.152	0.152

Appendix Table II : Investment-Cash Flow Sensitivity of D and Financial Constraints

This table presents the results of investment-cash flow sensitivity of D and financial constraints analysis. In all columns, the dependent variable is *D*. Similar to Almeida et al (2004), we use four alternative measures to partition our sample: Payout ratio, asset size, the existence of bond ratings and the existence of commercial paper ratings. All other variables are defined in Appendix. firm-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. variable : D	Full	Median	Tercile	Full	Median	Tercile	Full	Full
$CashFlow \times Payout$	0.018							
	(0.019)							
$CashFlow \times Payoutbottom$		0.000	0.017					
		(0.013)	(0.017)					
$CashFlow \times Size$				-0.012**				
				(0.005)				
$CashFlow \times Sizebottom$					0.027**	0.050***		
					(0.013)	(0.016)		
$CashFlow \times NoBondRating$							0.037***	
							(0.014)	
$CashFlow \times NoCPRating$								0.037***
								(0.014)
$CashFlow_t$	-0.014*	-0.010	-0.011	0.289**	-0.026**	-0.031**	-0.036***	-0.036***
	(0.008)	(0.009)	(0.011)	(0.117)	(0.011)	(0.013)	(0.012)	(0.012)
$Tobin'sQ_{t-1}$	0.003***	0.003***	0.005***	0.003***	0.003***	0.004***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$BookLeverage_{t-1}$	-0.002	-0.002	-0.004	-0.002	-0.002	0.000	-0.002	-0.002
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)
$Cash_{t-1}$	-0.027***	-0.026***	-0.028***	-0.027***	-0.027***	-0.028***	-0.027***	-0.027***
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)
$Size_{t-1}$	-0.018***	-0.018***	-0.019***	-0.017***	-0.018***	-0.020***	-0.018***	-0.018***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4736	4736	3007	4736	4736	2952	4736	4736
R^2	0.734	0.734	0.731	0.734	0.734	0.742	0.734	0.734

Appendix Table III : Product Market Competition and Cash Holdings

This table reports the results of analysis on whether the relationship between cash holdings and R and D differ under different levels of competition. Firms are categorized into more/less competitive product market group based on the HHI of the industry they belong to. Column (1)-(2) reports aggregate R&D analysis and (3)-(4)reports R vs D analysis. All other variables are defined in Appendix. Industry-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. Standard errors are clustered at an industry level. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dep. variable : Cash	Median	Tercile	Median	Tercile
$R\&D_t \times HHIbottom$	0.098***	0.098**		
	(0.018)	(0.034)		
$R_t \times HHIbottom$			-0.027	0.068
			(0.129)	(0.111)
$D_t \times HHIbottom$			0.172***	0.124**
			(0.052)	(0.053)
$R\&D_t$	-0.025	-0.073**		
	(0.024)	(0.030)		
R_t			0.161*	0.071
			(0.088)	(0.099)
D_t			-0.131**	-0.154**
			(0.057)	(0.072)
$HHIbottom$	-0.010*	-0.011	-0.010*	-0.011
	(0.006)	(0.007)	(0.005)	(0.007)
$Size_{t-1}$	-0.006*	-0.005*	-0.006*	-0.006*
	(0.003)	(0.003)	(0.003)	(0.003)
$BookLeverage_{t-1}$	-0.052***	-0.050***	-0.051***	-0.050***
	(0.009)	(0.011)	(0.009)	(0.011)
$CashFlow_{t-1}$	0.071***	0.074***	0.068***	0.071***
	(0.011)	(0.009)	(0.011)	(0.010)
$Capex_{t-1}$	-0.066***	-0.063***	-0.064***	-0.061***
	(0.009)	(0.014)	(0.008)	(0.014)
$Tobin'sQ_{t-1}$	0.010**	0.012***	0.010**	0.012***
	(0.004)	(0.004)	(0.004)	(0.004)
NWC_{t-1}	0.180***	0.200***	0.180***	0.199***
	(0.021)	(0.018)	(0.020)	(0.018)
Ind FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	13307	8679	13307	8679
R^2	0.134	0.144	0.135	0.145

Appendix Table IV : Leverage and R vs D

This table presents the results of R vs D and leverage analysis. Column (1)and (2) of Panel A report results of market leverage regression on aggregate R&D variables and column (3) and (4) reports regression results separating R vs D. Column (1)and (2) of Panel B report results of book leverage regression on aggregate R&D variables and column (3) and (4) reports regression results separating R vs D. All other variables are defined in Appendix. In each panel, column (1) and (3) use the full sample, whereas (2) and (4) use restricted sample of firms with positive R&D expenditure. Industry-fixed effects and year-fixed effects are included in all regressions. All variables are winsorized at 1% in both tails of the distribution. In each column, we report estimated coefficients from OLS regression and their standard error. ***, ** , and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A : Market Leverage				
	(1)	(2)	(3)	(4)
	Full	R&D>0	Full	R&D>0
$R\&D_t$	-0.365***	-0.419***		
	(0.021)	(0.035)		
R_t			-0.931***	-1.096***
			(0.100)	(0.063)
D_t			-0.104*	-0.134
			(0.055)	(0.083)
$Tobin'sQ_{t-1}$	-0.102***	-0.109***	-0.102***	-0.109***
	(0.006)	(0.006)	(0.006)	(0.006)
$CashFlow_{t-1}$	-0.330***	-0.328***	-0.320***	-0.311***
	(0.068)	(0.051)	(0.064)	(0.044)
$Cash_{t-1}$	-0.270***	-0.248***	-0.262***	-0.237***
	(0.064)	(0.047)	(0.063)	(0.047)
$Size_{t-1}$	0.026***	0.025***	0.026***	0.025***
	(0.003)	(0.002)	(0.003)	(0.002)
Ind FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	14811	10458	14811	10458
R^2	0.354	0.378	0.357	0.384

Panel B : Book Leverage				
	(1)	(2)	(3)	(4)
	Full	R&D>0	Full	R&D>0
$R\&D_t$	-0.060	-0.156*		
	(0.044)	(0.076)		
R_t			-0.506***	-0.744***
			(0.107)	(0.095)
D_t			0.165*	0.111
			(0.087)	(0.111)
$Tobin'sQ_{t-1}$	0.014	0.001	0.014	0.001
	(0.012)	(0.009)	(0.011)	(0.009)
$CashFlow_{t-1}$	-0.247***	-0.264***	-0.239***	-0.249***
	(0.076)	(0.065)	(0.073)	(0.060)
$Cash_{t-1}$	-0.255***	-0.250***	-0.249***	-0.241***
	(0.081)	(0.070)	(0.082)	(0.071)
$Size_{t-1}$	0.027***	0.027***	0.027***	0.027***
	(0.004)	(0.003)	(0.004)	(0.002)
Ind FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	14811	10458	14811	10458
R^2	0.130	0.151	0.133	0.158