Mispricing or Risk Premium?
An explanation of the R&D-to-market anomaly

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Abstract

Two contrasting explanations are offered in the literature for the R&D-to-market anomaly: limited investor attention to R&D spending that is expensed under generally accepted accounting principles or failure of conventional risk factors to completely capture the risk associated with R&D. Exploiting accounting treatments in Korea, in which R&D expenditures are capitalized under certain conditions, we show that both the expensed and capitalized portions of R&D are positively associated with returns. The positive R&D-return relationship weakens with the extent of progress toward completion of R&D projects, consistent with Berk, Green, and Naik's (2004) risk-based theoretical prediction. In addition, the decrease in returns following progress toward R&D completion is fully explained by conventional risk factors. The results suggest overall that the positive R&D-return relationship is attributable to compensation for bearing risk.

Keywords: R&D, risk premium, mispricing, R&D capitalization

JEL classification: G12,O32

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1. Introduction

A large portion of corporate investments fund research and development (R&D) in recent years. Corrado and Hulten (2010), for example, estimate that intangible capital makes up 33.9% of firms' total capital for the period running from 1995 through 2007. According to an article published by PwC, annual worldwide corporate R&D spending among the 1,000 largest firms exceeded $700 billion during 2017, setting a record high.[1] Such increases in corporate R&D have attracted a fair amount of attention from finance and accounting researchers, who consistently find that R&D investment is positively associated with stock returns.[2] However, there exist at least two distinct explanations for this anomaly. One explanation is based on limited investor attention to R&D that is attributed to accounting conservatism: R&D costs are expensed, as financial statements do not report internally generated intangible assets under generally accepted accounting principles (GAAP). Such conservative accounting treatments complicate investors' valuation of an R&D-intensive firm, which often results in mispricing of its equity.[3] The other explanation is based on R&D risk: Conventional risk factors fail to completely capture the riskiness of R&D.

The goal of this paper is to investigate whether the R&D-to-market anomaly is attributable to mispricing or risk premium. To do so, we exploit R&D accounting treatments in Korea, in which R&D expenditures are capitalized under certain conditions. If the positive relationship between R&D and stock returns is attributable to limited investor attention that arises mainly from conservative accounting treatment of R&D there should not exist a positive association between the capitalized components of R&D and stock returns. The risk-based explanation, on the other hand, predicts a positive relationship between capitalized components of R&D and stock returns to the extent that the capitalized portion of R&D is risky.

[1] https://www.pwc.com/us/en/press-releases/2017/corporate-rd-spending-hits-record-highs-for-the-top-1000.html

[2] See Chan, Lakonishok, and Sougiannis (2001), Chambers, Jennings, and Thompson (2002), Li (2011), Hou, Xue, and Zhang (2015), and Gu (2016).

[3] Limited investor attention can be also attributable to the complex and difficult-to-process nature of R&D. We address this in section 3.2.2.

Our empirical results support a risk-based explanation of the R&D-to-market anomaly. First, we find evidence that is inconsistent with the idea that accounting conservatism explains the positive R&D-return relationship. In particular, we find using Fama-MacBeth (1973) cross-sectional regressions that both the expensed and capitalized components of R&D are positively associated with stock returns. For example, a one-standard-deviation increase in CAP (EXP), which is defined as capitalized (expensed) components of R&D over the market value of equity, is associated with an increase in monthly stock returns of 17.9 (23.7) basis points after controlling for characteristics that are known to be associated with risk such as size, the book-to-market ratio, and momentum.

The results of the portfolio sorts are consistent with the Fama-MacBeth cross-sectional regression results. The returns on the portfolios increase monotonically with CAP (EXP) intensity and the returns on the high-minus-low CAP (EXP) portfolio is 0.69% (1.22%), with a t-statistic of 2.34 (6.03). More importantly, the alpha of the high-minus-low CAP (EXP) portfolio is 0.74% (0.98%), suggesting that risk that is captured by the Carhart's (1997) four factors, i.e. the Fama and French's (1993) three factors and momentum, cannot account for the return on high-minus-low CAP (EXP) portfolios. This result is inconsistent with the idea that accounting conservatism explains the R&D-to-market anomaly.

We next show that a theoretical prediction based on R&D risk is consistent with the data. In particular, we test one of the predictions of Berk, Green, and Naik (2004) (hereafter, BGN). In their model, there is a purely idiosyncratic risk associated with the resolution of technical uncertainty and the systematic component of risk associated with cash flows after development is complete. Firms decide whether to continue with R&D projects conditioning on the resolution of systematic as well as idiosyncratic uncertainty. This feature generates the prediction that resolving idiosyncratic uncertainty reduces the risk premium although there is no risk premium earned on idiosyncratic risk per se. As a result, the required risk premium decreases as an R&D project approaches completion.

To test the above-mentioned BGN prediction in the data, we take advantage of the capitalization criteria that apply to R&D accounting standards in Korea. The categorization and recognition of expensed and capitalized components of Korean accounting standards have been similar to those in International Financial Reporting Standards (IFRS): Research expenditures must be recognized as expenses when they are incurred. Expenditures incurred through development activities, on the other hand, can be recognized as intangible assets. To capitalize expenditures as intangible assets, a firm should be able to demonstrate that six conditions hold, which are essentially the same as those listed in the IFRS.[4] These conditions include the technical feasibility of completing an intangible asset, which ensures that capitalized components of R&D are associated with lower levels of technical uncertainty and further progress toward completion of associated R&D projects than expensed components of R&D. Therefore, according to BGN's prediction, for a given level of R&D, the larger the proportion of capitalized components, the lower the risk premium.

Our empirical results from the Fama-MacBeth cross-sectional regressions are consistent with BGN's prediction. Using the ratio of capitalized components of R&D to total R&D (hereafter, *CAP/R&D*) as a proxy for progress towards completion of R&D projects, we find that R&D progress weakens the positive R&D-return association. In particular, the coefficient on *CAP/R&D* is negative and statistically significant, suggesting that firms whose R&D expenditures consist only of capitalized components of R&D earn 24.9 basis points less per month than firms whose R&D expenditures consist only of expensed components.

An alternative explanation that is consistent with both the positive *CAP*-return relationship and the negative *CAP/R&D*-return relationship is that capitalized components of R&D suffer less severe mispricing than expensed components of R&D for reasons unrelated to differential accounting treatments. For example, investors may pay limited attention to R&D but pay relatively more attention to capitalized components of R&D because those components are less complex and easier to process than expensed components. According to this mispricing-based explanation, the negative *CAP/R&D*-return relationship should not be fully explained by risk

[4] Although Korea adopted IFRS in 2011 (K-IFRS), the change did not have a major effect on R&D accounting.

factors. Therefore, to address this alternative, we investigate whether conventional risk factors explain the negative *CAP/R&D*-return relationship.

We find through a portfolio analysis that the negative *CAP/R&D*-return relationship can be fully explained by the four factors. When we form portfolios based on *CAP/R&D*, portfolio returns decrease with *CAP/R&D* intensity, consistent with the results of the Fama-MacBeth cross-sectional regressions. The return on the high-minus-low *CAP/R&D* portfolio is -0.57% with a t-statistic of -2.31, and this spread is driven by the loadings on the book-to-market factor. On the other hand, the alpha of the high-minus-low *CAP/R&D* portfolio is statistically and economically insignificant. This result suggests that the negative *CAP/R&D*-return relationship can be fully explained by the conventional risk factors, and thus is inconsistent with the above-mentioned mispricing-based explanation.

We examine whether q^5 factors (Hou, Mo, Xue, and Zhang (2020)) can explain the R&D-to-market anomaly in Korean firms.[5] The results of the portfolio sorts based on *R&D*, *EXP*, and *CAP* remain similar to those of the Carhart's four-factors analysis. For example, the alpha of the high-minus-low *R&D* portfolios, high-minus-low *EXP* portfolios, and high-minus-low *CAP* portfolios are 0.96%, 1.15%, and 0.63%, respectively. These results suggest that q^5 factors cannot account for the positive relationship between stock returns and *R&D* (*EXP*, *CAP*) appreciably better than the Carhart four factors. However, the results of the *CAP/R&D*-return analysis differ from those of the four-factor analysis. When we consider the q^5 factors, the alpha of the high-minus-low *CAP/R&D* portfolio is negative and statistically significant: -0.54%, with a t-statistic of -2.25. This result suggests that q^5 factors cannot account for the negative *CAP/R&D*-return relationship. It appears that the book-to-market factor, which is the primary factor that accounts for the negative returns on high-minus-low *CAP/R&D* portfolios, plays an important role in explaining the risk premium associated with R&D progress towards completion.

This paper contributes to the literature on the R&D-to-market anomaly. Chan, Lakonishok,

[5]All results remain qualitatively the same when we use q-factors (Hou, Xue, and Zhang (2015)) instead of q^5 factor.

and Sougiannis (2001) find a positive association between the level of R&D expenditure and subsequent excess returns and suggest that investors are misled by conservative accounting for R&D expenditures. On the other hand, Chambers, Jennings, and Thompson (2002) show that the positive association between R&D and excess returns is more likely to be attributable to failure to adequately control for risk. Gu (2016) shows through a real options model that R&D-intensive firms are riskier, especially in competitive industries, and that firms in competitive industries earn higher expected returns than firms in concentrated industries, primarily among R&D-intensive firms. Li (2011) shows that R&D-intensive firms' risk increases with financial constraints and find empirical evidence that the positive R&D-return relationship exists only among financially constrained firms. Our paper contributes to discussions of the mechanism underlying the positive R&D-return relationship by providing empirical evidence that is inconsistent with mispricing owing to conservative accounting treatments, i.e. a positive *CAP*-return relationship, and consistent with the risk-based explanation, i.e., a negative *CAP/R&D*-return relationship. In addition, our finding that the negative *CAP/R&D*-return relationship can be fully explained by conventional risk factors helps to rule out the possibility that capitalized components of R&D suffer less severe mispricing because they are less complex and easier to process than expensed components of R&D.

This paper is related to studies that examine the information benefits of R&D capitalization (Oswald and Zarowin (2007), Healy, Myers, and Howe (2002), Mohd (2005)). Several studies find that the market's valuation of the capitalized and expensed components of R&D differs. Tsoligkas and Tsalavoutas (2011) find that the capitalized components of R&D are positively related to market values, suggesting that the market perceives capitalized components as successful projects with future economic benefits. Lee and Park (2019) analyze Korean firms and find that R&D capitalization provides information that helps explain corporate financing policies; they also find that investors use this information when evaluating these policies. Aboody and Lev (1998) find that changes in capitalized software development costs, in accordance with the Financial Accounting Standards Board's Statement No. 86, are positively associated with contemporaneous stock returns. To the best of our knowledge, this paper is the first in the asset pricing literature to take advantage of information provided by expensed and capitalized components of R&D to investigate the mechanism underlying the R&D-to-market anomaly. This paper thereby adds to the literature by providing evidence that R&D capitalization provides useful information regarding risk to investors, and also contributes to the debate among academics and practitioners over capitalization versus full expensing of R&D expenditures.

The remainder of this paper proceeds as follows. We describe R&D accounting treatments in Korea and illustrate the data and variables in section 2. We present empirical results in section 3. We conclude in section 4.

2. R&D accounting in Korea, data, and variables

In this section, we describe R&D accounting treatments in Korea, the data used in this study, and the summary statistics.

2.1. R&D accounting in Korea

Korean R&D accounting standards have required firms to report expensed components and capitalized components of R&D separately since 1987. However, asset recognition criteria for capitalization have changed over time. Prior to the 1999 revision of R&D accounting treatments, R&D expenditures were classified as either ordinary or extraordinary, depending on the characteristics of the activities. In particular, R&D expenditures that occurred in the ordinary course of business were expensed and those that occurred out of the ordinary course of business were capitalized. However, the 1999 revision on R&D accounting standards brought the categorization and recognition of expensed components and capitalized components of R&D into much closer alignment with those of IFRS: Research expenditures must be recognized as expenses when they are incurred. Expenditures incurred by development activities, on the other hand, can be recognized as intangible assets. To capitalize R&D expenditures, a firm should be able to demonstrate that six conditions hold:[6]

(a) The technical feasibility involved in completing an intangible asset so that it will be available for use or sale;

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

(c) the 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; and

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

2.2. Data and Summary statistics

Firm-level accounting information, including expensed components and capitalized components of R&D, and stock return data are obtained from the DataGuide database provided by FnData. DataGuide is one of the most representative databases that provides standardized accounting and financial information for Korean firms. The stock return data are collected for the July 2000 through June 2019 period and the accounting information is collected for the period running from 1999 through 2018. Following Fama and French (1992), we match the accounting data for all fiscal year-ends in calendar year t-1 with the returns from July of year t through June of t+1.

The main variables used in this paper are *R&D*, *CAP*, *EXP*, and *CAP/R&D*. *R&D* is defined as total R&D expenditures scaled by the market value of equity for the fiscal year ending in year t-1. *CAP* is defined as the capitalized components of R&D expenditures scaled by the market value of equity for the fiscal year ending in year t-1. *EXP* is defined as the expensed components

[6] For more details about R&D accounting treatment in Korea and descriptions of financial statements issued by Korean firms, refer to Lee and Park (2019).

of R&D scaled by the market value of equity for the fiscal year ending in year t-1. *CAP/R&D* is defined as the ratio of capitalized components of R&D to total R&D expenditures. Other variables used in this paper are defined as follows. *Size* is the natural logarithm of market capitalization at the end of June of year t. *BTM* is the ratio of book equity to market equity for the fiscal year ending in year t-1. *MOM* is prior six-month returns with a one-month gap between the holding period and the current month, and *REV* is prior one-month returns. *ROA* is net income for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending in year t-2. *CAPX* is capital expenditures for the fiscal year ending for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending for the fiscal year ending in year t-2. *ACCR* denotes accruals, which is the difference between net income and operating cash flow for the fiscal year ending for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending for the fiscal year ending in year t-2. All variables are winsorized at the top and bottom 1%.

We follow the standard procedure of excluding financial institutions from the sample. We restrict our sample to firms that report positive R&D and have all variables required for the analyses. This procedure results in 231,172 observations.[7] Panel A of Table I presents the average values of firm characteristics for the entire sample, firms reporting positive *EXP*, and firms reporting positive *CAP* in columns (1), (2), and (3), respectively. The number of observations with positive *EXP* is 220,796, accounting for approximately 95.5% of the sample. On the other hand, the number of observations with positive *CAP* is 83,193, accounting for approximately 36.0% of the sample. As such, a significantly larger proportion of firm-year observations report positive *EXP* than report positive *CAP*. The average values of *R&D*, *EXP*, and *CAP* are 0.048, 0.036, and 0.011, respectively. Positive-*CAP* firms appear to be larger in market capitalization and total assets, less profitable, and younger than positive-*EXP* firms. Positive-*CAP* firms have lower book-to-market ratios than positive-*EXP* firms, suggesting that positive-*CAP* firms are growth stocks. In addition, positive-*CAP* firms spend more on R&D and capital expenditures

[7] Without restricting our sample to report positive R&D, the number of observations is 343,202. This suggests that approximately 67% of Korean firms report positive R&D during the sample period.

than positive-*EXP* firms. For example, the average of *R&D* (*CAPX*) for positive-*CAP* firms is 0.067 (0.046), while that for positive-*EXP* firms is 0.049 (0.042).

In Panel B we report 20-year averages of cross-sectional Pearson correlation coefficients of *R&D*, *EXP*, and *CAP*. All the correlations are statistically significant at the 1% level. When we consider sample firms that report positive *EXP*, the correlation between the *EXP* and *CAP* is 0.160. When we restrict the sample to observations reporting positive *CAP*, the correlation coefficient between *EXP* and *CAP* increases to 0.255. To address the high correlation between *EXP* and *CAP* in the positive-*CAP* sample, we later control for *EXP* in the Fama-MacBeth cross–sectional regressions on *CAP*.

TABLE I ABOUT HERE

3. Empirical results

3.1. Mispricing or the risk premium?

In this section, we study the association between stock returns and the two components of R&D. We first investigate whether the R&D-to-market anomaly exists in Korea, and then separate expensed and capitalized components of R&D to examine their association with stock returns. To do so, we conduct Fama-MacBeth cross-sectional regressions analyses and portfolio sorts.

3.1.1. Fama-MacBeth analyses

We report the results of Fama-MacBeth cross-sectional regressions in Table II. All independent variables are standardized to zero mean and 1 standard deviation. We control for industry fixed effects to obtain the results reported in all columns. To obtain the results reported in even-numbered columns, we additionally control for firm characteristics that are known to be associated with stock returns, such as *Size*, *BTM*, *MOM*, *REV*, *ROA*, *CAPX*, and *ACCR*. The main variable of interest is *R&D* for columns (1) and (2). The coefficient on *R&D* is positive and statistically significant in both columns, consistent with the positive R&D-return relationship documented in prior studies. In particular, the coefficient estimate reported in column (2) indicates that a one-standard-deviation increase in *R&D* is associated with an increase in monthly returns of 27.9 basis points. As such, the results provided in columns (1) and (2) are similar to findings of prior studies on U.S. stocks. The variable of interest is *EXP* for columns (3) and (4). We use sample firms that report positive *EXP* for the analysis. The coefficient on *EXP* is positive and statistically significant in both columns, suggesting that expensed components of R&D are positively associated with returns. The coefficient estimate reported in column (4) indicates that a one-standard-deviation increase in *EXP* is associated with an increase in monthly returns of 23.7 basis points.

The variable of interest is *CAP* for columns (5)-(8). We use sample firms that report positive *CAP* for the analysis. The coefficient on *CAP* is positive and statistically significant, as seen in column (5). The coefficient estimate indicates that a one-standard-deviation increase in *CAP* is associated with an increase in monthly returns of 23.2 basis points. The coefficient estimate decreases to some degree when we control for firm characteristics, as shown in column (6). In particular, the coefficient estimate suggests that a one-standard-deviation increase in *CAP* is associated with an increase in monthly returns of 17.9 basis points. It is, however, still economically and statistically significant. These results suggest that capitalized components of R&D, which are not associated with conservative accounting treatments, are positively associated with stock returns. Therefore, the results are inconsistent with the explanation that limited investor attention that arises from conservative accounting treatments of R&D cause the R&D-to-market anomaly.

It is possible that the positive coefficients on *CAP* shown in columns (5) and (6) are attributable to the positive correlation between *CAP* and *EXP*, which was documented in Table I. To mitigate this concern, we additionally control for *EXP* in the regression. The results are presented in columns (7) and (8). The economic magnitudes and statistical significance of the coefficients on *CAP* remain similar to those shown in columns (5) and (6). As such, the positive and significant coefficients on *CAP* are less likely to be attributable to the positive correlation between *CAP* and *EXP*.

Turning to control variables, the coefficient on *MOM* is negative in all columns and generally significant at the 10% level. This result is consistent with prior studies that analyze Korean stocks, such as Kam and Shin (2011) (written in Korean). The coefficient on *Size* is negative and statistically significant at the 1% level in all columns. The coefficients on *ROA* and *BTM* are positive and significant at the 1% level in all columns. The coefficients on *ACCR* in all columns are negative and statistically significant at the 1% level and the coefficients on *CAPX* in columns (2) and (4) are negative and statistically significant. As such, the signs of the coefficient estimates are consistent with those reported in studies analyzing U.S. stocks, except for those on *MOM*.

TABLE II ABOUT HERE

3.1.2. Portfolio analysis

In this section, we report the results of the portfolio analyses. At the end of June of year t, we sort firms into three groups based on *R&D*, *EXP*, and *CAP*, using sample firms that report positive *R&D*, *EXP*, and *CAP*, respectively. We hold these portfolios over the next 12 months. We calculate the monthly portfolio returns as the equal-weighted average of stock returns. We calculate monthly risk-free rates using the one-year yield of monetary stabilization bonds.[8]

In Panels A, B, and C of Table III we report the averages of the main variables and the average number of firms in portfolios in which firms are split into three groups based on *R&D*, *EXP*, and *CAP*. In Panel A, the reported book-to-market ratio is lower for the high-*R&D* group than the low-*R&D* group but there is no monotonic trend. The market value of equity is higher for the high-*R&D* group than the low-*R&D* group but there is no monotonic trend. *EXP* and *CAP* increase monotonically with *R&D* intensity. On the other hand, *CAP/R&D* decreases

[8]Monthly risk-free rate r_f is calculated as $r_f = (1+r_{msb})^{\frac{1}{12}} - 1$, where r_{msb} is the one-year yield of monetary stabilization bonds.

monotonically with *R&D* intensity.

When we sort firms into three groups based on *EXP*, as shown in Panel B, the book-to-market ratio increase monotonically with *EXP* intensity. The market value of equity is higher for the high-*EXP* group than the low-*EXP* group but there is no monotonic trend. *R&D* and *CAP* increase monotonically with *EXP* intensity, and *CAP/R&D* decreases monotonically with *EXP* intensity. When we sort firms into three groups based on *CAP* intensity, as shown in Panel C, the book-to-market ratio decreases monotonically with *CAP* intensity. This result suggests that *CAP*-intensive firms are likely to be growth stocks. The market value of equity also decreases monotonically with *CAP* intensity. On the other hand, *R&D*, *EXP*, and *CAP/R&D* increase monotonically with *CAP* intensity.

TABLE III ABOUT HERE

Table IV reports the average monthly excess returns (returns in excess of the risk-free rate), alphas, and factor loadings of the portfolios. Mkt, SMB, HML, and MOM are the market factor, the size factor, the book-to-market factor, and the momentum factor, respectively. Portfolios are formed based on *R&D* intensity in Panel A. The excess returns and alphas on the portfolios increase monotonically with *R&D* intensity, consistent with the positive R&D-return relationship documented in Table II. High-*R&D* portfolios load heavily on the size factor, consistent with the idea that R&D-intensive firms are relatively larger firms. The return on the high-minus-low *R&D* portfolio is 1.05% with a t-statistic of 4.64. Most of these returns cannot be explained by the Carhart four factors, as the alpha of the high-minus-low *R&D* portfolio, 0.93%, accounts for approximately 88% of the portfolio returns. This result shows that the R&D-to-market anomaly that is well documented in the U.S. stock market holds in the Korean stock market as well.

Panel B reports the average monthly excess returns, alphas, and factor loadings of *EXP*-intensity portfolios. The portfolio returns increase monotonically with *EXP* intensity, consistent with the positive *EXP*-return relationship documented in Table II. The returns on the high-minus-low *EXP* portfolio is 1.22% with a t-statistic of 6.03. The loadings of the high-minus-low *EXP* portfolio on the size, book-to-market, and momentum factors are positive and statistically significant, while those on the market factor are negative and statistically significant. More importantly, most of the returns on the high-minus-low *EXP* portfolio cannot be explained by risk factors: The alphas of *EXP*-intensity portfolios increase monotonically with *EXP* intensity, and the alpha of the high-minus-low *EXP* portfolio is 0.98% with a t-statistics of 4.87. The results shown in this table suggest that *EXP* is positively related to stock returns even after adjusting for conventional risk factors, as is largely the case with *R&D*.

Panel C reports the average monthly excess returns, alphas, and factor loadings of *CAP*-intensity portfolios. The portfolios' returns increase monotonically with *CAP* intensity, consistent with the positive *CAP*-return relationship documented in Table II. The returns on the high-minus-low *CAP* portfolio is 0.69% with a t-statistic of 2.34. The loadings of the high-minus-low *CAP* portfolio on the size and momentum factors are positive and statistically significant. Unlike with the *EXP* portfolio, however, the loadings of the high-minus-low *CAP* portfolio on the book-to-market factor are negative and statistically significant and those on the market factor are insignificant. More importantly, the alphas of *CAP*-intensity portfolios increase monotonically with *CAP* intensity and the alpha of the high-minus-low *CAP* portfolios is 0.74%, with a t-statistic of 2.65. These results suggest that the conventional four risk factors cannot explain the returns on the high-minus-low *CAP* portfolio. As such, the results presented in Table II and IV suggest overall that the positive R&D-return relationship exists for both expensed and capitalized components of R&D, inconsistent with the explanation that conservative accounting treatments complicate investors' valuation of an R&D firm, which leads to mispricing of its equity.

<u>TABLE IV ABOUT HERE</u>

3.2. R&D risk premium and progress toward R&D completion

In this section, we report the results of empirical tests of BGN's risk-based theoretical prediction–that further progress toward R&D completion lowers the risk that R&D itself entails. To do so, we conduct both Fama-MacBeth cross-sectional analyses and portfolio sorts. We use *CAP/R&D* as a proxy for progress toward completion of R&D projects. This is because a key condition for R&D capitalization is resolution of technical feasibility involved in completing an intangible asset. This criterion ensures that technical uncertainty has been largely resolved for the capitalized portion of R&D. On the other hand, the remaining R&D expenditures, which are likely incurred during the earlier stages of R&D, are expensed. Therefore, expensed R&D is more likely to be subject to technical uncertainty. As such, the distinction between expensed and capitalized components of R&D in Korean R&D accounting treatments suits the description of the resolution of technical (idiosyncratic) uncertainty in BGN's framework.

3.2.1. Fama-MacBeth regressions

To investigate whether and how the resolution of technical uncertainty affects stock returns, we conduct Fama-MacBeth regressions. Table V presents the results. All independent variables are standardized to zero mean and 1 standard deviation. The variable of interest is *CAP/R&D* in all columns. In column (1) we report the regression results in which we control only for *R&D*. The coefficient on *R&D* is positive and statistically significant and that on *CAP/R&D* is negative and statistically significant. The coefficient estimate on *CAP/R&D* suggests that firms whose R&D expenditures consist only of capitalized components of R&D earn 24.9 basis points less per month than firms whose R&D expenditures consist only of expensed components. Therefore, the effect is economically significant. In column (2), we control for firm characteristics. The estimated coefficient on *CAP/R&D* is still negative and statistically significant at the 10% level, although the magnitude of the coefficient is approximately half of that shown in column (1). The significant decrease suggests that the negative *CAP/R&D*-return relationship may to some extent be explained by risk proxy variables that we control for. We additionally control for industry fixed effects in columns (3) and (4). The coefficient on *CAP/R&D* remains negative and statistically significant in both columns, although the magnitudes of the coefficients decrease slightly. The results shown in this table overall support the prediction that significant progress toward R&D completion lowers the risk that R&D itself entails.

Table V About Here

3.2.2. Portfolio analysis

An alternative explanation that is consistent with both the positive *CAP*-return relationship and the negative *CAP/R&D*-return relationship is that capitalized components of R&D suffer less severe mispricing than expensed components of R&D for reasons unrelated to differential accounting treatments. For example, investors may pay limited attention to R&D but pay relatively more attention to capitalized components of R&D because those components are less complex and easier to process than expensed components. According to this mispricing-based explanation, the negative *CAP/R&D*-return relationship should not be fully explained by risk factors. Therefore, to address this alternative, we investigate whether conventional risk factors explain the negative *CAP/R&D*-return relationship.

At the end of June of year t, we sort sample firms into four groups based on *CAP/R&D*. In particular, we first form a group that consists of observations that report zero *CAP*. We then sort the remaining observations with positive *CAP* into three groups based on *CAP/R&D* intensity. We hold these portfolios over the next 12 months and calculate the monthly portfolio returns as the equal-weighted average of stock returns. In Panel A of Table VI we report the summary statistics for the portfolios. The book-to-market ratio decreases monotonically with *CAP/R&D* intensity. Compared with zero- and low-*CAP/R&D* portfolios, high-*CAP/R&D* portfolios consist of small firms in terms of the market value of equity. *EXP* (*CAP*) decreases (increases) monotonically with *CAP/R&D* intensity but there is no particular relationship between *R&D* and *CAP/R&D* intensity.

In Panel B we report the average monthly excess returns, alphas, and factor loadings of the *CAP/R&D*-intensity portfolios. Mkt, SMB, HML, and MOM are the market factor, the size factor, the book-to-market factor, and the momentum factor, respectively. The returns decrease monotonically with *CAP/R&D* intensity. In particular, the low-*CAP/R&D* portfolio earns 1.26% (t=2.31) per month and the zero-*CAP* portfolio earns 1.25% (t=2.52) per month. On the other hand, the high-*CAP/R&D* portfolio earns 0.69% (t=1.06) per month. The return on the high-minus-zero (-low) *CAP/R&D* portfolio is -0.56% (-0.57%) with a t-statistic of -2.10 (-2.31). These results are consistent with the negative *CAP/R&D*-return relationship documented in Table V. However, the alpha of the high-minus-zero (-low) *CAP/R&D* portfolios is 0.08% (-0.14%) and statistically insignificant, suggesting that the negative *CAP/R&D*-return relationship can be fully explained by risk factors. Indeed, the returns on high-minus-zero (-low) *CAP/R&D* portfolios are driven mostly by loadings on the book-to-market factor. The loadings of the high-minus-zero (-low) *CAP/R&D* portfolio on the book-to-market factor are -0.404 (-0.243), with a t-statistic of -7.11 (-3.95). The loadings on the momentum factor also decrease with *CAP/R&D*. The loadings on the momentum factor do not, however, seem to be a primary factor that drives the return pattern we document because prior studies show that momentum effects in the Korean stock market are weak at best.[9] To the extent that *CAP/R&D* proxies for progress towards completion of R&D projects, this result corroborates BGN's predictions that R&D projects entail a systematic risk component even though technological uncertainty is purely idiosyncratic and that systematic risk decreases as R&D projects near completion. In sum, the results shown in this table suggest that the negative *CAP/R&D*-return relationship can be fully explained by conventional risk factors and thus is inconsistent with the explanation that it is attributable to less severe mispricing of capitalized components of R&D than of expensed components.

TABLE VI ABOUT HERE

[9] A number of studies report that a momentum strategy is not profitable on the Korean stock market (Chui, Titman, and Wei (2010), Hameed and Kusnadi (2002), Chae and Eom (2009)).

3.3. q^5 factors

In this section we examine whether q^5 factors can explain the positive R&D-return relationship and the negative *CAP/R&D*-return relationship in Korean firms. We construct q^5 factors following Hou, Mo, Xue, and Zhang (2020).[10] Mkt, ME, IA, ROE, and EG are the market factor, the size factor, the investment factor, the profitability factor, and the expected growth factor, respectively. We use yearly frequency data to construct the ROE factor instead of using quarterly data since only yearly data are available in the DataGuide database.

We first conduct portfolio-sort analyses to examine whether the q^5 factors explain the positive relationship between returns and *R&D*, *EXP*, and *CAP*. In Table VII we report the average monthly excess returns, alphas, and loadings on the q^5 factors of the *R&D*-intensity portfolios, the *EXP*-intensity portfolios, and the *CAP*-intensity portfolios. As in Table IV, in which we use the Carhart's four factors, here the alphas of the high-minus-low *R&D* portfolio, the high-minus-low *EXP* portfolio, and the high-minus-low *CAP* portfolio are all positive and statistically significant. For example, the alpha of the high-minus-low *R&D* portfolio is 0.96%, with a t-statistic of 4.44, suggesting that the q^5 factors cannot account for the returns on high-minus-low *R&D* portfolios in Korea. This result differs from that reported in Hou, Mo, Xue, and Zhang's (2020) finding that the q^5 model reduces the alpha in the U.S. Similar to their results, in our sample the loadings on the expected growth factor are positive and statistically significant and the loadings on the ROE factor are negative and statistically significant. These results are consistent with their intuition that R&D expenses depress current earnings but raise intangible capital that generates future growth opportunities. In our sample, the loadings on the investment factor are positive and significant. The loadings on the size factor are positive while the loadings on the market factor are insignificant, as in the four-factor analysis.

The alphas on the high-minus-low *EXP* portfolio and the high-minus-low *CAP* portfolio are 1.15% and 0.63%, with t-statistics of 5.78 and 2.39, respectively, suggesting that the q^5 factors can explain neither the returns on the high-minus-low *EXP* portfolio nor the returns on the

[10] Refer to Hou, Mo, Xue, and Zhang (2020) for details on the variable construction.

high-minus-low *CAP* portfolio. The loadings on the size factor and the investment factor are positive for both portfolios. Although the loadings on the ROE factor are negative for both portfolios, the results are statistically significant only for the high-minus-low *CAP* portfolio. The negative loadings of the high-minus-low *CAP* portfolio on the ROE factor are consistent with the summary statistics finding that *CAP* firms are unprofitable as measured by ROA. This finding is however contrary to the intuition that R&D expenses reduce current earnings to a greater extent than capitalized R&D. The loadings on the expected growth factor are positive for both portfolios, but again these findings are statistically and economically more significant for the high-minus-low *CAP* portfolio. To the extent that investors regard *CAP* to be a successful aspect of R&D, this finding is consistent with the intuition that *CAP* likely generates more intangible capital that increases growth opportunities than *EXP* does. The results shown in this table suggest overall that q^5 factors cannot explain the R&D-to-market anomaly in Korean firms.

Table VII About Here

To examine whether the q^5 factors can explain the negative *CAP/R&D*-return relationship, we conduct the portfolio-sort analysis. In Table VIII we report the average monthly excess returns, alphas, and loadings on the q^5 factors of the *CAP/R&D*-intensity portfolios. The alpha of the high-minus-low (zero) *CAP/R&D* portfolio is -0.54% (-0.54%), with a t-statistic of -2.25 (-2.28), suggesting that the negative *CAP/R&D*-return relationship cannot be explained by the q^5 factors. The loadings on the market and size factors of the high-minus-low (zero) *CAP/R&D* portfolio are positive, as in Table VI, in which we consider the Carhart four factors. The loadings of the high-minus-low (zero) *CAP/R&D* portfolio on the ROE factor are negative. The loadings of the high-minus-low (zero) *CAP/R&D* portfolio on the expected growth factor and the investment factor are insignificant. The results shown in this table suggest overall that the negative *CAP/R&D*-return relationship cannot be explained by the q^5 factors. It appears that the book-to-market factor, which is the primary factor that accounts for the negative returns on high-minus-low *CAP/R&D* portfolios, plays an important role in explaining the risk premium associated with R&D progress towards completion.

Table VIII About Here

4. Conclusion

Although it is well established that there exists a positive R&D-return relationship, there is no consensus on the mechanism for this phenomenon. At least two contrasting explanations are offered in the literature for the R&D-to-market anomaly: mispricing of R&D due to limited investor attention to R&D spending that is expensed under generally accepted accounting principles or the failure of conventional risk factors to completely capture the risk of R&D. To distinguish between the two explanations, we exploit R&D accounting treatments in Korea, in which R&D expenditures are capitalized under certain conditions. Contrary to the explanation based on investor inattention to R&D due to conservative accounting treatments, we find that both expensed components and capitalized components of R&D are positively associated with returns. Consistent with Berk, Green, and Naik's (2004) risk-based theoretical prediction, the positive R&D-return relationship weakens with progress toward R&D completion, proxied by the ratio of capitalized components of R&D to total R&D (*CAP/R&D*), increases. The negative *CAP/R&D*-return relationship can be fully explained by the conventional risk factors, which is inconsistent with the explanation that capitalized components of R&D suffer less severe mispricing than expensed components of R&D, for example because they are less complex and easier to process than expensed components of R&D. As such, our paper contributes to discussions of the mechanism underlying the R&D-to-market anomaly. This paper also adds to the literature on the information benefits of R&D capitalization by providing evidence that R&D capitalization provides useful information regarding risk to investors, and we thereby contribute to the debate among academics and practitioners over capitalization versus expensing of R&D expenditures.

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Table I. Summary statistics
Panel A of this table reports the average values of the variables for the entire sample of firms, firms reporting positive *EXP*, and firms reporting positive *CAP* in columns (1), (2), and (3), respectively. *R&D* is defined as total R&D expenditure scaled by the market value of equity for the fiscal year ending in year t-1. *EXP* (*CAP*) is defined as expensed (capitalized) components of R&D expenditures scaled by the market value of equity for the fiscal year ending in year t-1. *BTM* is the ratio of book equity to market equity for the fiscal year ending in year t-1. *ROA* is net income for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending in year t-2. *CAPX* is capital expenditures for the fiscal year ending for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending for the fiscal year ending in year t-2. *ACCR* denotes accruals, which is the difference between net income and operating cash flow for the fiscal year ending for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending for the fiscal year ending in year t-2. All variables are winsorized at the top and bottom 1%. Panel B reports 20-year averages of cross-sectional Pearson correlation coefficients among *R&D*, *EXP*, and *CAP* separately for sample firms that report positive *EXP* and sample firms that report positive *CAP*.

Panel A: summary statistics	(1) *ALL*	(2) *EXP* >0	(3) *CAP* >0
# of observations	231,172	220,796	83,193
Total R&D (KRW in mil.)	10,700	11,100	15,100
Expensed R&D (KRW in mil.)	9,080	9,508	11,000
Capitalized R&D (KRW in mil.)	1,097	1,069	3,047
Market value of equity (KRW in bil.)	472	481	545
Total assets (KRW in bil.)	995	1,010	1,280
R&D	0.048	0.049	0.067
EXP	0.036	0.038	0.035
CAP	0.011	0.010	0.030
ROA	0.008	0.009	-0.004
BTM	1.357	1.364	1.180
CAPX	0.042	0.042	0.046
Firm age	25.56	25.71	22.28
ACCR	-0.038	-0.038	-0.042

Panel B: correlations

(1) *EXP*>0

	R&D	*EXP*	*CAP*
R&D	1		
EXP	0.8763	1	
CAP	0.5867	0.1595	1

(2) *CAP* >0

	R&D	*EXP*	*CAP*
R&D	1		
EXP	0.7872	1	
CAP	0.7632	0.2553	1

Table II. Fama-MacBeth regressions

This table presents the Fama-MacBeth (1973) regression results. The main variables of interest are *R&D*, *EXP*, and *CAP* in columns (1)-(2), (3)-(4), and (5)-(8), respectively. *R&D* is defined as total R&D expenditure scaled by the market value of equity for the fiscal year ending in year t-1. *EXP* (*CAP*) is defined as expensed (capitalized) components of R&D expenditures scaled by the market value of equity for the fiscal year ending in year t-1. *Size* is the natural logarithm of market capitalization at the end of June of year t. *BTM* is the ratio of book equity to market equity for the fiscal year ending in year t-1. *MOM* is prior six-month returns with a one-month gap between the holding period and the current month, and *REV* is prior one-month returns. *ROA* is net income for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending in year t-2. *CAPX* is capital expenditures for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending in year t-2. *ACCR* denotes accruals, which is the difference between net income and operating cash flow for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending in year t-2. All independent variables are winsorized at the top and bottom 1% and standardized to zero mean and 1 standard deviation. We control for industry fixed effects in all columns. The t-statistics are reported in parentheses. ***, ** , and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	ALL		*EXP*>0		*CAP*>0			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D	0.418***	0.279***						
	(5.13)	(3.44)						
EXP			0.410***	0.237***			0.263***	0.097
			(5.63)	(3.29)			(2.81)	(1.10)
CAP					0.232**	0.179**	0.204**	0.170**
					(2.55)	(2.10)	(2.25)	(1.99)
Size		-0.594***		-0.591***		-0.582***		-0.586***
		(-3.52)		(-3.47)		(-3.27)		(-3.29)
BTM		0.588***		0.580***		0.667***		0.590***
		(5.69)		(5.76)		(4.96)		(4.34)
MOM		-0.275**		-0.218*		-0.277*		-0.278*
		(-2.11)		(-1.69)		(-1.80)		(-1.80)
REV		-0.099		-0.065		-0.193		-0.195
		(-0.70)		(-0.47)		(-1.26)		(-1.27)
ROA		0.775***		0.762***		0.764***		0.750***
		(6.67)		(6.20)		(5.41)		(5.36)
CAPX		-0.144**		-0.152**		-0.118		-0.107
		(-2.87)		(-2.96)		(-1.43)		(-1.28)
ACCR		-0.352***		-0.352***		-0.447***		-0.439***
		(-5.02)		(-4.39)		(-4.26)		(-4.23)
IND FE	Y	Y	Y	Y	Y	Y	Y	Y
N	231,172	231,172	220,706	220,706	83,193	83,193	83,193	83,193

Table III. Portfolio summary statistics

Panels A, B, and C of this table report the average values of the main variables for portfolios sorted on *R&D*, *EXP*, and *CAP*, respectively. At the end of June of year t, we sort firms into three groups based upon sorts on *R&D*, *EXP*, and *CAP*, respectively. In doing so, we use sample firms that report positive *R&D*, *EXP*, and *CAP*, respectively. *R&D* is defined as total R&D expenditure scaled by the market value of equity for the fiscal year ending in year t-1. *EXP* (*CAP*) is defined as expensed (capitalized) components of R&D expenditures scaled by the market value of equity for the fiscal year ending in year t-1. *CAP/R&D* is defined as the proportion of capitalized component of R&D to total R&D for the fiscal year ending in year t-1. *BTM* is the ratio of book equity to market equity for the fiscal year ending in year t-1. The market value of equity is measured in millions of Korean Won. All variables are winsorized at the top and bottom 1%.

Panel A: *R&D*-intensity portfolios

	R&D	*EXP*	*CAP*	*CAP/R&D*	*BTM*	Market value of equity	# of firms
low	0.0052	0.0049	0.0035	0.6486	1.2410	687,975	304
mid	0.0279	0.0233	0.0149	0.4917	1.2674	611,245	406
high	0.1301	0.0985	0.0675	0.4530	1.1749	707,806	304

Panel B: *EXP*-intensity portfolios

	R&D	*EXP*	*CAP*	*CAP/R&D*	*BTM*	Market value of equity	# of firms
low	0.0106	0.0040	0.0213	0.6554	1.1643	660,832	290
mid	0.0316	0.0217	0.0296	0.4081	1.2732	595,628	388
high	0.1226	0.1037	0.0540	0.2739	1.2819	806,880	290

Panel C: *CAP*-intensity portfolios

	R&D	*EXP*	*CAP*	*CAP/R&D*	*BTM*	Market value of equity	# of firms
low	0.0269	0.0283	0.0027	0.3244	1.1134	1,790,993	109
mid	0.0499	0.0369	0.0172	0.5118	1.0947	721,207	147
high	0.1480	0.0635	0.0916	0.6699	0.7569	265,989	109

Table IV. Portfolio analysis

This table reports the average monthly excess returns (returns in excess of the risk-free rate), alphas, and factor loadings of the portfolios sorted on *R&D*, *EXP*, and *CAP* in panels A, B, and C, respectively. At the end of June of year t, we sort firms into three groups based upon sorts on *R&D*, *EXP*, and *CAP*, respectively. In doing so, we use sample firms that report positive *R&D*, *EXP*, and *CAP*, respectively. We hold this portfolio for the next 12 months and calculate the monthly portfolio returns as the equal-weighted average of stock returns. We calculate monthly risk-free rates using one-year yields from monetary stabilization bonds. Mkt, SMB, HML, and MOM are the market factor, the size factor, the book-to-market factor, and the momentum factor, respectively. *R&D* is defined as total R&D expenditure scaled by the market value of equity for the fiscal year ending in year t-1. *EXP* (*CAP*) is defined as expensed (capitalized) components of R&D expenditures scaled by the market value of equity for the fiscal year ending in year t-1. The t-statistics are reported in parentheses.

Panel A: *R&D*-intensity portfolios

	Ex. ret.	Alpha	Mkt	SMB	HML	MOM
low	0.597	-0.044	1.090	0.729	0.171	-0.200
	(1.12)	(-0.28)	(48.30)	(22.53)	(4.10)	(-6.32)
middle	1.085	0.384	1.068	0.841	0.147	-0.074
	(2.08)	(3.33)	(63.78)	(35.03)	(4.76)	(-3.16)
high	1.648	0.884	1.062	0.987	0.179	-0.050
	(2.99)	(5.09)	(42.19)	(27.36)	(3.85)	(-1.43)
H-L	1.051	0.928	-0.028	0.259	0.008	0.150
	(4.64)	(4.09)	(-0.85)	(5.48)	(0.13)	(3.25)

Panel B: *EXP*-intensity portfolios

	Ex. ret.	Alpha	Mkt	SMB	HML	MOM
low	0.511	-0.128	1.099	0.752	0.153	-0.174
	(0.96)	(-0.91)	(54.04)	(25.80)	(4.05)	(-6.10)
middle	1.194	0.485	1.058	0.851	0.147	-0.056
	(2.30)	(4.03)	(60.82)	(34.11)	(4.55)	(-2.31)
high	1.736	0.855	1.029	0.950	0.263	-0.039
	(3.29)	(5.15)	(42.78)	(27.54)	(5.91)	(-1.17)
H-L	1.224	0.983	-0.069	0.198	0.111	0.134
	(6.03)	(4.87)	(-2.37)	(4.72)	(2.05)	(3.28)

Panel C: *CAP*-intensity portfolios

	Ex. ret.	Alpha	Mkt	SMB	HML	MOM
low	0.637	0.205	1.164	0.684	0.060	-0.298
	(1.09)	(1.02)	(40.03)	(16.40)	(1.11)	(-7.30)
middle	0.799	0.315	1.157	0.885	0.001	-0.128
	(1.36)	(1.80)	(45.74)	(24.42)	(0.02)	(-3.60)
high	1.330	0.946	1.135	1.099	-0.094	-0.064
	(2.12)	(4.13)	(34.20)	(23.10)	(-1.53)	(-1.38)
H-L	0.693	0.740	-0.029	0.415	-0.154	0.234
	(2.34)	(2.65)	(-0.72)	(7.16)	(-2.06)	(4.12)

Table V. *CAP/R&D*: Fama-MacBeth regressions

This table reports the Fama-MacBeth regressions of stock returns on R&D progress (*CAP/R&D*). The variable of interest is *CAP/R&D* in all columns. *CAP/R&D* is defined as the proportion of capitalized component of R&D to total R&D for the fiscal year ending in year t-1. *R&D* is defined as total R&D expenditure scaled by the market value of equity for the fiscal year ending in year t-1. *Size* is the natural logarithm of market capitalization at the end of June of year t. *BTM* is the ratio of book equity to market equity for the fiscal year ending in year t-1. *MOM* is the prior six-month returns with a one-month gap between the holding period and the current month, and *REV* is prior one-month returns. *ROA* is net income for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending in year t-2. *CAPX* is capital expenditures for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending in year t-2. *ACCR* denotes accruals, which is the difference between net income and operating cash flow for the fiscal year ending in year t-1 scaled by total assets for the fiscal year ending in year t-2. All independent variables are winsorized at the top and bottom 1% and standardized to zero mean and 1 standard deviation. We control for industry fixed effects in columns (3) and (4). The t-statistics are reported in parentheses. ***, ** , and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
CAP/R&D	-0.249***	-0.110*	-0.189***	-0.0994*
	(-3.21)	(-1.89)	(-3.01)	(-1.79)
R&D	0.387***	0.238***	0.439***	0.289***
	(-4.51)	(-2.98)	(-5.48)	(-3.66)
Size		-0.539***		-0.594***
		(-3.21)		(-3.53)
BTM		0.579***		0.577***
		(4.83)		(5.72)
MOM		-0.216		-0.276**
		(-1.57)		(-2.11)
REV		-0.0188		-0.1
		(-0.13)		(-0.71)
ROA		0.715***		0.760***
		(6.07)		(6.58)
CAPX		-0.144***		-0.140***
		(-2.97)		(-2.83)
ACCR		-0.336***		-0.346***
		(-4.56)		(-4.98)
IND FE	N	N	Y	Y
N	231,088	231,088	231,088	231,088

Table VI. *CAP/R&D*: Portfolio analysis

At the end of June of year t, we first form a group that consists of observations that report zero *CAP*. We then sort the remaining observations with positive *CAP* into three groups based on *CAP/R&D*-intensity and hold these portfolios for the next 12 months. Panel A of this table reports the average values of main variables for these portfolios. *CAP/R&D* is defined as the proportion of capitalized component of R&D to total R&D for the fiscal year ending in year t-1. *R&D* is defined as total R&D expenditure scaled by the market value of equity for the fiscal year ending in year t-1. *EXP* (*CAP*) is defined as expensed (capitalized) components of R&D expenditures scaled by the market value of equity for the fiscal year ending in year t-1. *BTM* is the ratio of book equity to market equity for the fiscal year ending in year t-1. The market value of equity is measured in millions of Korean Won. All variables are winsorized at the top and bottom 1%. Panel B of this table reports the average monthly excess returns (returns in excess of the risk-free rate), alphas, and factor loadings of the portfolios sorted on *CAP/R&D*. We calculate the monthly portfolio returns as the equal-weighted average of stock returns. We calculate monthly risk-free rates using one-year yields from monetary stabilization bonds. Mkt, SMB, HML, and MOM are the market factor, the size factor, the book-to-market factor, and the momentum factor, respectively. The t-statistics are reported in parentheses.

Panel A: Mean

CAP/R&D	*R&D*	*EXP*	*CAP*	*CAP/R&D*	*BTM*	Market value of equity	*# of firms*
zero	0.0401	0.0402	0.0066	0	1.3629	521,421	662
low	0.0747	0.0640	0.0106	0.0106	1.1087	1,872,294	113
mid	0.0812	0.0401	0.0411	0.4846	0.9892	579,678	151
high	0.0584	0.0120	0.0517	0.9112	0.9025	320,472	113

Panel B: Portfolio analysis

Cap/R&D	Ex. ret.	Alpha	Mkt	SMB	HML	MOM
zero	1.245	0.384	1.017	0.826	0.272	-0.071
	(2.52)	(3.57)	(65.39)	(37.02)	(9.46)	(-3.27)
low	1.258	0.599	1.114	0.773	0.111	-0.089
	(2.31)	(3.62)	(46.52)	(22.53)	(2.51)	(-2.64)
mid	0.781	0.398	1.167	0.943	-0.050	-0.162
	(1.29)	(2.13)	(43.06)	(24.29)	(-1.00)	(-4.27)
high	0.688	0.459	1.218	0.943	-0.132	-0.233
	(1.06)	(2.09)	(38.23)	(20.65)	(-2.24)	(-5.22)
high- zero	-0.557	0.076	0.201	0.117	-0.404	-0.162
	(-2.10)	(0.36)	(6.53)	(2.66)	(-7.11)	(-3.76)
high-low	-0.571	-0.140	0.104	0.169	-0.243	-0.145
	(-2.31)	(-0.61)	(3.12)	(3.55)	(-3.95)	(-3.11)

Table VII. q^5 factors: *R&D*, *EXP*, and *CAP*

This table reports the average monthly excess returns, alphas, and q^5 factor loadings of the portfolios sorted on *R&D*, *EXP*, and *CAP* in panels A, B, and C, respectively. At the end of June of year t, we sort firms into three groups based upon sorts on *R&D*, *EXP*, and *CAP*, respectively. In doing so, we use sample firms that report positive *R&D*, *EXP*, and *CAP*, respectively. We hold this portfolio for the next 12 months and calculate the monthly portfolio returns as the equal-weighted average of stock returns. We calculate monthly risk-free rates using one-year yields from monetary stabilization bonds. *R&D* is defined as total R&D expenditure scaled by the market value of equity for the fiscal year ending in year t-1. *EXP* (*CAP*) is defined as expensed (capitalized) components of R&D expenditures scaled by the market value of equity for the fiscal year ending in year t-1. We construct q^5 factors following Hou, Mo, Xue, and Zhang (2020). Mkt, ME, IA, ROE, and EG are the market factor, the size factor, the investment factor, the profitability factor, and the expected growth factor, respectively. The t-statistics are reported in parentheses.

Panel A: *R&D*-intensity portfolios

R&D	Ex. ret.	Alpha	Mkt	ME	IA	ROE	EG
low	0.597	0.003	1.062	0.666	-0.107	-0.106	-0.349
	(1.12)	(0.02)	(37.69)	(18.27)	(-1.58)	(-1.85)	(-5.38)
middle	1.085	0.483	1.052	0.776	0.014	-0.188	-0.180
	(2.08)	(3.89)	(49.79)	(28.41)	(0.27)	(-4.40)	(-3.70)
high	1.648	0.967	1.067	0.934	0.207	-0.279	-0.121
	(2.99)	(5.92)	(38.36)	(25.99)	(3.10)	(-4.97)	(-1.90)
H-L	1.051	0.964	0.005	0.269	0.314	-0.173	0.227
	(4.64)	(4.44)	(0.12)	(5.64)	(3.54)	(-2.33)	(2.68)

Panel B: *EXP*-intensity portfolios

R&D	Ex. ret.	Alpha	Mkt	ME	IA	ROE	EG
low	0.511	-0.088	1.070	0.683	-0.069	-0.167	-0.314
	(0.96)	(-0.59)	(42.17)	(20.83)	(-1.14)	(-3.25)	(-5.39)
middle	1.194	0.594	1.048	0.799	0.012	-0.165	-0.159
	(2.30)	(4.80)	(49.81)	(29.40)	(0.23)	(-3.89)	(-3.29)
high	1.736	1.065	1.022	0.863	0.234	-0.239	-0.165
	(3.29)	(6.38)	(36.02)	(23.53)	(3.43)	(-4.18)	(-2.53)
H-L	1.224	1.152	-0.048	0.180	0.303	-0.073	0.149
	(6.03)	(5.78)	(-1.42)	(4.10)	(3.72)	(-1.06)	(1.92)

Panel C: *CAP*-intensity portfolios

R&D	Ex. ret.	Alpha	Mkt	ME	IA	ROE	EG
low	0.637	0.061	1.140	0.640	-0.297	-0.141	-0.327
	(1.09)	(0.28)	(30.75)	(13.36)	(-3.34)	(-1.88)	(-3.84)
middle	0.799	0.164	1.164	0.864	-0.001	-0.299	-0.092
	(1.36)	(0.92)	(38.35)	(22.01)	(-0.01)	(-4.87)	(-1.32)
high	1.330	0.694	1.147	1.098	0.046	-0.451	-0.014
	(2.12)	(3.22)	(31.30)	(23.18)	(0.53)	(-6.09)	(-0.16)
H-L	0.693	0.634	0.007	0.457	0.344	-0.310	0.313
	(2.34)	(2.39)	(0.15)	(7.85)	(3.18)	(-3.41)	(3.03)

Table VIII. q^5 factors: *CAP/R&D*

This table reports the average monthly excess returns (returns in excess of the risk-free rate), alphas, and q^5 factor loadings of the portfolios sorted on *CAP/R&D*. At the end of June of year t, we first form a group that consists of observations that report zero *CAP*. We then sort the remaining observations with positive *CAP* into three groups based on *CAP/R&D*-intensity and hold these portfolios for the next 12 months. *CAP/R&D* is defined as the proportion of capitalized component of R&D to total R&D. We calculate the monthly portfolio returns as the equal-weighted average of stock returns. We calculate monthly risk-free rates using one-year yields from monetary stabilization bonds. Mkt, ME, IA, ROE, and EG are the market factor, the size factor, the investment factor, the profitability factor, and the expected growth factor, respectively. The t-statistics are reported in parentheses.

CAP/R&D	Ex. ret.	Alpha	Mkt	ME	IA	ROE	EG
zero	1.245	0.626	0.998	0.742	0.095	-0.115	-0.239
	(2.52)	(5.15)	(48.26)	(27.75)	(1.90)	(-2.74)	(-5.04)
low	1.258	0.626	1.106	0.727	-0.044	-0.170	-0.127
	(2.31)	(3.79)	(39.40)	(20.02)	(-0.65)	(-3.00)	(-1.96)
mid	0.781	0.149	1.178	0.947	-0.074	-0.295	-0.106
	(1.29)	(0.78)	(36.22)	(22.52)	(-0.95)	(-4.49)	(-1.42)
high	0.688	0.089	1.219	0.940	-0.180	-0.397	-0.140
	(1.06)	(0.38)	(30.36)	(18.10)	(-1.87)	(-4.90)	(-1.51)
high- zero	-0.557	-0.537	0.221	0.198	-0.275	-0.283	0.100
	(-2.10)	(-2.28)	(5.51)	(3.82)	(-2.85)	(-3.49)	(1.08)
high-low	-0.571	-0.537	0.113	0.213	-0.136	-0.227	-0.013
	(-2.31)	(-2.25)	(2.79)	(4.06)	(-1.40)	(-2.77)	(-0.14)