R&D premium and Takeover Risk*

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To explain why firms with high R&D intensity offer their investors higher stock returns, we posit that (i) high R&D capacity relative to firm valuation makes R&D-intensive firms attractive takeover targets, and (ii) the higher takeover probability leads their investors to face higher takeover risk, as proposed by Cremers, Nair, and John (2009), and require higher returns. We find evidence consistent with our hypothesis. Furthermore, takeover probability is also related to large R&D increases, but not to innovation efficiency. Accordingly, we expect, and find, that takeover risk helps explain the premium associated with large R&D increases, but not the innovation efficiency premium, documented in the literature.

Keywords: R&D; Takeover risk; Risk premium.
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Abstract

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I. INTRODUCTION

Why do firms with high R&D intensity offer their investors higher stock returns? This issue has attracted considerable attention in the accounting and finance literatures since Lev and Sougiannis (1996) first noted the debate over mispricing of R&D-intensive firms and compensation for uncertainty and risk associated with R&D as explanations for the phenomenon. This is an interesting issue because while R&D usually has long-term implications for future earnings, R&D costs need to be expensed in the period they occur and thus could adversely affect reported earnings. Some studies suggest that this R&D expensing practice could lead to earnings distortion and mispricing,[1] but others argue that uncertainty about R&D outcomes may generate additional risk, which leads investors to require higher returns.[2]

Interestingly, Donelson and Resutek (2012) note that R&D premium is mainly due to the component of R&D firms' realized returns that are unrelated to their R&D investments but present in R&D firms. This raises an important question: What factor not directly related to R&D investments may drive the premium?

In this paper, based on two premises, we offer a new perspective on R&D premium. First, Blonigen and Taylor (2000), Bena and Li (2013), and Phillips and Zhdanov (2013) show that firms invest in R&D to increase their appeal as takeover targets since takeovers

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[1] For example, Lev, Sarath, and Sougiannis (2005) and Penman and Zhang (2002) suggest that investors could be misled by conservative accounting for expensing R&D costs. Chan, Lakonishok, and Sougiannis (2001) similarly argue that the market is inefficient because "the market is apparently too pessimistic about beaten-down R&D-intensive technology stocks' prospects."

[2] See, for instance, Chambers, Jennings, and Thompson (2002); Bens, Hanna and Zhang (2003); and, Li (2011).

generate huge premiums for target shareholders.[3] Second, according to Chan, Lakonishok, and Sougiannis (2001), firms with high R&D intensity (as measured by the ratio of R&D to equity market value) usually have beaten-down stocks.[4] Hence, for potential acquirers in need of R&D capacity to create growth opportunities, high R&D capacity relative to firm valuation makes R&D-intensive firms attractive takeover targets. Consequently, we hypothesize that a firm's probability of becoming a takeover target increases with its R&D intensity and that the takeover probability affects the pricing of its common stock.

Specifically, our hypothesis posits that R&D-intensive firms are more sensitive to shifts in takeover waves and face higher takeover risk, a systematic risk proposed by Cremers, Nair, and John (2009). They suggest that, for firms that are more likely to become takeover targets, their values will increase more when economic fundamentals are good and acquirers have more cash to engage in takeover activities. Conversely, if there is no bid and the takeover wave is receding, then the values of the firms with higher takeover probability will decline more. Thus, for firms facing higher takeover probability, their values will fluctuate more due to shifts in takeover waves. Cremers et al. (2009) construct a takeover factor to capture takeover waves, and use the sensitivity of a firm's stock returns to the takeover factor to measure its takeover risk.

[3] The average takeover announcement raw (abnormal) return of target firms in our sample is 21.4% (21.2%). Given that the average target size is $1,093 million, the average takeover announcement abnormal return implies an increase of $232 million in firm value. In the regression analysis, we also find that takeover announcement abnormal returns are positively related to target firms' R&D intensity.

[4] To confirm this argument, we regress log stock price on R&D intensity and a set of control variables, including EPS, log firm size, and log institutional ownership, as suggested by Dyl and Elliott (2006), and find a negative relationship between a firm's log stock price and its R&D intensity. The evidence is consistent with Chan, Lakonishok, and Sougiannis' (2001) observation that firms with high R&D intensity tend to have poor past stock returns.

We find robust evidence that a firm's R&D intensity is a significant determinant of its likelihood of becoming a takeover target, i.e., the higher the R&D intensity, the higher the takeover probability. Furthermore, the Fama and MacBeth (1973) regressions reveal that R&D premium is positively related to the takeover probability even after we control for many R&D-related factors. In particular, Li (2011) suggests that the risk of R&D-intensive firms increases with their financial constraints since financially constrained R&D-intensive firms are more likely to suspend or discontinue R&D projects, which could cause the firms to lose their competitive advantage, reducing their value considerably. Li (2011) finds that R&D intensity predicts stock returns only among financially constrained firms. Based on the Fama and MacBeth (1973) regression analysis, our results show that takeover probability has a larger effect on R&D premium than financial constraints.

We also control for several other factors suggested by recent R&D-related studies. For example, Donelson and Resutek (2012) suggest that R&D premium is mainly driven by the non-R&D component of stock returns. Cohen, Diether, and Malloy (2013) emphasize the effect of R&D ability on stock performance. Finally, Resutek (2013) suggests that operational distress risk may play a role in R&D premium. In the presence of these additional factors, takeover probability maintains a significant effect on R&D premium.

To provide a basis for using takeover risk to explain R&D premium and to see whether R&D premium itself can serve as a pricing factor, we compare the R&D factor and the takeover factor in explaining the cross-section of equity returns on 100 size and book-to-market sorted portfolios.[5] When the R&D factor and the takeover factor are separately included in the pricing regressions, either one is significant and helps explain the cross-sectional portfolio returns. However, when both factors are jointly considered in the same pricing regression, we find that the takeover factor largely subsumes the R&D factor.

While it is well known that R&D premium is large, we show that it is indeed large, about 2.81% per month, during the months when the takeover factor is positive. However, R&D premium is significantly negative, around -1.37% per month, during the months when the takeover factor is negative. Our findings suggest that R&D premium and the takeover factor strongly co-move together, and illustrate a major risk of holding high R&D-intensive firms' stocks when the takeover factor is not doing well, which usually occurs when takeover waves are receding.

Once we add the takeover factor to the commonly used asset pricing models, the abnormal return associated with R&D premium becomes small and largely insignificant.[6] Our estimation shows that takeover risk premium accounts for about 62 percent of R&D premium, while market risk premium and size premium account for 25 percent and 13 percent, respectively. The momentum factor and the value factor are insignificant. Thus, takeover risk plays a dominant role in the pricing of R&D-intensive firms.

In addition to R&D premium, two other anomalies related to R&D have also been noted in the literature: (i) the premium associated with large R&D increases documented by Eberhart, Maxwell, and Siddique (2004), and (ii) the innovation efficiency premium

[5] Following the methodology suggested by Cremers et al. (2009), we do a horse race between the R&D factor and the takeover factor to see which factor drives out the other in asset pricing.s

[6] Conversely, when we use R&D premium as a pricing factor and add it to the commonly used asset pricing models, they cannot explain away the takeover risk premium.

documented by Hirshleifer, Hsu, and Li (2013). Can takeover risk help explain these two R&D-related anomalies as well?

Interestingly, we find that, like R&D-intensive firms, firms with large R&D increases are also more likely to become takeover targets. This finding is consistent with Blonigen and Taylor (2000), Bena and Li (2013), and Phillips and Zhdanov (2013), who argue that many firms invest in R&D to increase their appeal as takeover targets. We further find that the premium associated with large R&D increases is positively related to takeover probability, and that takeover risk helps explain the premium.

However, we find that a firm's innovation efficiency—measured by its patent citations divided by its R&D investments—is not related to its likelihood of becoming a takeover target. This finding is not surprising, considering Bena and Li's (2013) finding that firms with large patent portfolios and low R&D expenses tend to be acquirers, instead of takeover targets. Consequently, we expect, and find, that takeover risk is not responsible for the abnormal return associated with innovation efficiency.

In sum, our study shows that firms with higher R&D intensity and those with large R&D growth are more likely to become takeover targets. The higher takeover probability makes such firms more sensitive to takeover waves, and affects the pricing of their common stocks. Thus, while the literature has recognized that takeover incentives are a strong driver of R&D investments, our study adds to the literature by showing that the systematic risk of R&D firms—and their cost of equity capital—increases with their likelihood of becoming takeover targets.

The remainder of our paper is organized as follows. In the next section, we describe our data. Section III presents evidence on the relationship between takeover probability and R&D intensity. This section also tests whether takeover probability is related to large R&D increases and innovation efficiency. Section IV reports the effect of takeover probability on stock returns, and section V discusses the extent to which takeover risk explains R&D premium. Finally, section VI contains our concluding remarks.

II. DATA

Our sample consists of all U.S. listed firms available between 1990 and 2009 in the Center for Research in Security Prices (CRSP) and Compustat files.[7] Data on mergers and acquisitions between 1982 and 2010 are collected from the Securities Data Company's (SDC) U.S. Mergers and Acquisitions database.[8] We exclude American depositary receipts, closed-end funds, non-U.S. firms, and real estate investment trusts from our analysis. We also discard firms with non-positive book assets, non-positive sales, or insufficient information for estimating takeover probability. Our final sample consists of 79,381 firm-year observations for 10,590 firms.

We employ two commonly-used R&D intensity measures.[9] The first one is R&D expenditure scaled by firm size, where firm size is the market value of common equity;

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[7] We estimate takeover probability for year *t+1* using R&D data and accounting variables in year *t* and then relate takeover probability to stock returns in year *t+2*. Hence, in our study, accounting data ends in 2009, M&A data ends in 2010, and return data ends in 2011. Furthermore, following Hirshleifer et al. (2013), we measure innovation efficiency using five-year forward patent citations, which are truncated in 2013 and matched well with R&D data ending in 2009.

[8] We start our sample from 1990 because SDC M&A information is relatively complete since 1980s and we need 10 years of M&A data to estimate takeover probability on a 10-year rolling-window basis.

[9] There are other measures of R&D intensity. In section IV, we examine abnormal returns associated with large R&D increases documented by Eberhart et al. (2004), and abnormal returns associated innovation efficiency documented by Hirshleifer et al. (2013). In addition, Chambers et al. (2002) measure R&D intensity in two ways: (i) the pro-forma R&D Asset scaled by the market value of equity, and (ii) the change in the variable in (i). While they find evidence consistent with risk premium when they use the first R&D intensity measure, they argue that abnormal returns associated with the second R&D intensity measure are due to mispricing. Similarly, Penman and Zhang (2002) find mispricing when R&D intensity is measured as the change in the R&D reserve (the difference between R&D expense and R&D amortization of an R&D asset) scaled by net operating assets. Following a referee's suggestion, we also examine

and the other one is R&D expenditure scaled by total assets.[10] Both Chan et al. (2001) and Li (2011) find that the return predictability of R&D intensity is stronger when R&D intensity is measured by the R&D-to-size ratio. Interestingly, we find that takeover probability is more related to the R&D-to-size ratio than to the R&D-to-assets ratio. Nevertheless, our inference that R&D premium is related to takeover probability holds under either measure. To save space, we focus on the R&D-to-size ratio as the R&D intensity measure and report only the regression results based on this measure in the sections that follow.

Table 1 presents summary statistics of firm characteristics. Because roughly 55% of firms do not disclose R&D information or have zero R&D spending as reported in their financial statements, we present summary statistics separately for R&D firms and no-R&D firms. Panel A shows summary statistics for the whole sample period and also for the 1991-1999 and 2000-2009 subperiods. The average size of R&D firms is $1,385 million at the 2010 price level, while it is $1,149 million for firms without R&D information. Average Tobin's Q for R&D firms is 2.81, which is higher than the average Tobin's Q of 1.72 for no-R&D firms. The higher average Tobin's Q indicates that R&D firms tend to have more growth opportunities. Their average R&D expenditure is $58.1 million. Mean R&D intensity is 9.1% when R&D is deflated by size, while the mean R&D-to-assets ratio of R&D firms is 11.2%.

Chambers et al.'s (2002) and Penman and Zhang's (2002) measures of R&D intensity, and find that takeover risk helps explain abnormal returns associated with Chambers et al.'s (2002) measures, but not with Penman and Zhang's (2002) measure of R&D intensity. To save space, we do not report the results. They are available upon request. In general, we infer that if an R&D intensity measure is (not) related to takeover probability, then takeover risk can (not) help explain the anomaly.

[10] For robustness checks, we also use R&D capital divided by firm size (Chan et al. (2001), and Lev and Sougiannis (1996)) as another alternative measure of R&D intensity. One drawback of this alternative measure is that it reduces the sample size since it requires R&D data for the previous five years. Nevertheless, this alternative measure of R&D intensity leads to similar results.

Following Chan et al. (2001), Table 1 also reports summary statistics for sub-periods and for the top five industries, in terms of the number of R&D firms. About 54% of R&D firms belong to five industries: medical equipment (Fama-French industry code 12), pharmaceutical products (code 13), computers (code 35), electronic equipment (code 36), and measuring and control equipment (code 37).

Insert Table 1 here

Table 2 presents firm characteristics sorted by R&D intensity quintiles. We find that R&D-intensive firms tend to have higher book-to-market (B/M) ratio, more cash, and exist in a more active M&A market. These firms also have smaller firm size, less dividend yield, less tangible assets, and lower Tobin's Q. Moreover, profitability of R&D-intensive firms is lower partly because R&D costs are expensed, which could drive earnings lower. Mean monthly return of high R&D-intensity firms is 1.328%, which is higher than the mean monthly return of 0.385% for low R&D-intensity firms. The pattern is consistent with the literature on R&D premium, which suggests that stock returns tend to increase with R&D intensity.

Insert Table 2 here

In the next section, we first examine the extent to which a firm's R&D intensity contributes to its likelihood of becoming a takeover target. We then present evidence linking R&D premium to R&D firms' takeover risk, as proposed by Cremers et al. (2009).

III. TAKEOVER PROBABILITY AND R&D INTENSITY

To show the relationship between takeover probability and R&D intensity, we add R&D intensity to the logit regression model used by Cremers et al. (2009). The dependent variable is *MA dummy*, which is equal to one if a firm is announced as a takeover target in year *t+1*, and zero otherwise.[11] The explanatory variables in the model are all available in year *t*, which allow us to infer *ex ante* takeover probability for each sample firm in a given year. More specifically, the logit model is

$$P(\textit{MA dummy}=1)=\Lambda(a_0 + a_1\,\textit{RD} + a_2\,\textit{No-RD dummy} + a_3\log(\textit{cash}) + a_4\,\textit{Leverage} + a_5\,\textit{PPE} + a_6\,\textit{Tobin's Q} + a_7\,\textit{ROA} + a_8\,\textit{Block} + a_9\,\textit{Industry} + a_{10}\log(\textit{size})), \quad (1)$$

where Λ is the cumulative density function of logistic distribution. *RD* is the R&D expenditure scaled by firm size. *No-RD dummy* is equal to one if the firm does not disclose R&D information or has zero R&D spending, and zero otherwise. *Cash* is the cash and cash equivalent divided by book assets. *Leverage* is the total debt (sum of long-term debt and short-term debt) divided by the sum of total debt and total equity. *PPE* is property, plant and equipment divided by book assets. *Tobin's Q* is the book value of liability plus market value of equity divided by book assets. *ROA* is EBITDA divided by book assets. *Block* is a dummy that equals one if a firm has an institutional investor who holds more than 5% of shares outstanding of the firm. *Industry* is a dummy equal to one if there is a takeover in the firm's industry, based on the Fama-French 48 industry

[11] To determine the takeover event, we follow Luo (2005) and find merger and acquisition events in the SDC database. Unlike Luo (2005), we do not restrict deal value to $10 million or higher. We collect 4,453 M&A events during 1982 to 2010. As a robustness check, we also focus on completed takeover cases, and our empirical findings are qualitatively the same.

classification, in year *t*. *Size* is the market value of common equity. Notice that *RD*, log(*cash*), *Leverage*, *PPE*, *Tobin's Q* and *ROA* are industry-adjusted by subtracting their Fama-French industry medians.[12] Year dummies are added in the logit analysis to control for time fixed effects.

To avoid looking-ahead bias, we regress the M&A target dummy on the independent variables using the past 10-year data, and roll the regression one year at a time from 1990 to 2009 (i.e., for estimating the takeover probability for 1991, we regress the *MA dummy* of 1982-1991 on firm characteristics of 1981-1990). The fitted value of the logit regression is our estimate of takeover probability.[13]

Table 3 reports the logit regression results. Model 1 reports the average coefficients for the explanatory variables from 1990 to 2009.[14] In Model 1, the average coefficient of *RD* is 1.878 with an average *t*-value of 5.35.[15] The result is consistent with our hypothesis that a firm's likelihood of becoming a takeover target is positively related to its R&D intensity. In other words, higher R&D-intensive firms are more attractive to acquirers. As we will demonstrate in the next section, this has an interesting implication for the pricing of R&D-intensive firms' common stocks.

<u>Insert Table 3 here</u>

[12] Gormley and Matsa (2014) argue that regression analysis with industry fixed effects is preferred when industry control is needed. Hence, we re-estimate Eq. (1) with unadjusted R&D intensity and add Fama-French industry dummies to control for industry fixed effects. The slope of R&D intensity is 0.384 with an average *t*-value of 3.39. Thus, our results are not sensitive to the ways we control for the industry effects.

[13] As a robustness check, we also run a whole sample panel regression, and find similar results. To save space, we do not report the results, which are available upon request.

[14] Expected signs of these variables are indicated beside variables, according to results of Cremers et al. (2009), Bena and Li (2013) and Phillips and Zhdanov (2013).

[15] The coefficient of R&D intensity ranges from 1.33 to 2.15 during the sample period from 1990-2009, which are all significant at the 1% level.

For other explanatory variables, the estimation results are largely consistent with those reported in the literature. Specifically, a firm's takeover probability is positively related to *Leverage*, *Block*, and *Industry*. These results suggest that firms burdened with debt and those having an institutional investor with a block holding are more likely to become takeover targets. A firm's takeover probability is also higher next year if there is a takeover in the firm's industry in the current year.

As we mentioned earlier that, in addition to R&D premium, the literature has also identified two R&D-related anomalies, i.e. the premiums associated with large R&D increases (Eberhart et al. (2004)) and innovation efficiency (Hirshleifer, Hsu and Li (2013)). One may wonder whether takeover probability is also related to large R&D increases and innovation efficiency.

To address this issue, we follow Eberhart et al. (2004) to identify a sample of firms with large R&D increases. They argue that an increase by more than 5% may be considered as an economically significant amount. Thus, Eberhart et al. (2004) set up five criteria to identify firms with large R&D increases in a year: (i) R&D-to-sales ratio more than 5%, (ii) R&D-to-assets ratio more than 5%, (iii) change in R&D-to-sales ratio more than 5%, (iv) change in R&D-to-assets ratio more than 5%, and (v) growth rate of R&D expenditure more than 5%. To be included in the large R&D increase sample in a given year, a firm must meet all five criteria in that year.

To measure innovation efficiency, we follow Hirshleifer et al. (2013). That is, for each firm, we compute the sum of truncation-adjusted citations received by patents that are granted in past five years. We then obtain innovation efficiency as the sum of patent citations divided by the sum of R&D expenditures between year t-3 and year t-7. Specifically,

$$\text{Innovation efficiency} = \frac{Citations}{CRD} = \frac{\sum_{j=1}^{5}\sum_{k=1}^{N_{t-j}} C_{ik}^{t-j}}{\sum_{j=3}^{7} R\,\&\,D_{i,t-j}}, \quad (2)$$

where C_{ik}^{t-j} is the number of (truncation-adjusted) citations received in year *t* by patent *k* that is granted in year *t-j* scaled by average citations in the same technology category of Hall, Jaffe and Trajtenberg (2001; 2005). N_{t-j} is the number of patents received by firm *i*.

To see how large R&D increases and innovation efficiency are related to takeover probability, we rewrite Eq. (1) as follows:

$$P(\textit{MA dummy}=1)=\Lambda(a_0 + a_1\, \textit{RD} + a_2\, \textit{No-RD dummy} + a_3\, \textit{R\&D increase dummy}$$
$$+ a_4\, \textit{Innovation efficiency} + a_5 \log(\textit{cash}) + a_6\, \textit{Leverage} + a_7\, \textit{PPE} + a_8\, \textit{Tobin's Q} + a_9\, \textit{ROA}$$
$$+ a_{10}\, \textit{Block} + a_{11}\, \textit{Industry} + a_{12} \log(\textit{size})), \quad (3)$$

where *R&D increase dummy* is equal to one if a firm is in the large R&D increase sample; and *Innovation efficiency* is defined in Eq. (4). Other variables are defined as in Eq. (1). Year dummies are added in the logit analysis.

Models 2 to 4 of Table 3 reports logit regression results with addition of *R&D increase dummy* and *Innovation efficiency*. Specifically, Model 2 shows that the coefficient of *R&D increase dummy* is 0.533 (*t*-value=2.62) when R&D intensity is removed from the logit regression. In Model 4 in which R&D intensity is present, *R&D increase dummy* becomes marginally significant with a coefficient of 0.312 (*t*-value=1.63). The results suggest that, like R&D-intensive firms, those firms with large

R&D increases are also susceptible to becoming takeover targets, consistent with the notion that many firms invest in R&D to increase their appeal as takeover targets (Blonigen and Taylor (2000), Bena and Li (2013), and Phillips and Zhdanov (2013)).

However, in light of Bena and Li's (2013) finding that firms with large patent portfolios and low R&D expenses tend to be acquirers, we predict that a firm's innovation efficiency will not contribute to its likelihood of becoming a takeover target. Indeed, Models 3 and 4 show that the coefficient of *Innovation efficiency* is very small and insignificant.

Since a large R&D increase affects the firm's likelihood of becoming a takeover target and its innovation efficiency has no effect, we expect that the premium associated with large R&D increases documented by Eberhart et al. (2004) should be related to takeover risk premium and that the innovation efficiency premium of Hirshleifer et al. (2013) should not. We will present evidence for these asset pricing implications in a later section.

Regarding the takeover probability estimation, endogeneity may in part induce a positive association between R&D intensity and takeover probability, as previous studies have noted that R&D and acquisition activities may be either directly or inversely related. For example, Blonigen and Taylor (2000) and Phillips and Zhdanov (2013) suggest that the incentive of being acquired is a strong motivation for many firms to invest in R&D and be innovative. Conversely, when firms are vulnerable to takeover threats and subject to the discipline of the market for corporate control, they may cut R&D spending to increase their short-term earnings. These arguments suggest that takeover activities may affect R&D spending. Thus, we next use a two-stage logit model to address the endogeneity (reversed causality) issue and provide a robustness check for our finding that a firm's takeover probability is positively related to its R&D intensity.

In the first-stage regression, we consider potential determinants of R&D intensity. First, Mortensen (1982) suggests that a firm's decision to invest in R&D depends on its competitors' R&D. Hence, we use *Rivals' RD*, the average R&D intensity of rival firms in the same Fama-French-48 industry, to capture the extent of the innovation race and the product market competition in the industry. The more the *Rivals' RD*, the more the firm's *RD* is expected.

According to Levy and Terleckyj (1983), if local governments, universities, and other non-profit organizations spend more on R&D, it may induce firms in the area to invest more in R&D in order to benefit from the public sector R&D spending. Hence, we include in the *RD* regression a dummy variable, *GRD*, which is equal to one if the firm's headquarter is in California, Washington, Massachusetts, Texas, or Michigan; and zero otherwise. National Science Foundation reports that these five states are at the top of the list in R&D spending from local governments, universities, and other non-profit organizations.[16]

Since rivals' R&D and public sector R&D spending may potentially affect a firm's R&D investments but are not directly responsible for the firm to become a takeover target, we use these two variables—*rivals' RD* and *GRD*—as instrumental variables for the firm's *RD*.

To capture the effect of takeover incentives on a firm's R&D decision, we use *CNJ (2009) MA prob*, the takeover probability from Cremers et al.'s (2009) model, which does not involve R&D variables. We also include *Industry*, a dummy equal to 1 if there was a

[16] The data is obtained from http://www.nsf.gov/statistics/natlpatterns/.

takeover in a firm's industry in the previous year, to see how industry consolidation may affect the firm's R&D decision.

Furthermore, as we show in Table 2, *RD* is strongly associated with certain firm characteristics. For example, firms with higher R&D intensity tend to have more cash but lower Tobin's Q. Hence, to capture such associations, we include in the first-stage regression *log(cash)* and *Tobin's Q*. Finally, we include lagged *RD* to help capture omitted firm characteristics. According to Arellano and Bond (1991) and Roberts and Whited (2011), including lagged *RD* as an instrumental variable for *RD* can help deal with possible moving-average errors in the regression model.

Thus, we specify the first-stage regression as follows:

$$RD = b_0 + b_1 \log(cash) + b_2\, Tobin's\ Q + b_3\, Industry + b_4\, lagged\ RD + b_5\, rivals'\ RD + b_6\, GRD + b_7\, CNJ\ (2009)\ MA\ prob + \varepsilon. \quad (4)$$

After obtaining RD^F, the predicted *RD* from the first-stage regression, we perform the second-stage logit regression with the following specification:

$$P(MA\ dummy=1) = \Lambda(a_0 + a_1 RD^F + a_2\, No\text{-}RD\ dummy + a_3\, R\&D\ increase\ dummy + a_4\, Innovation\ efficiency + a_5 \log(cash) + a_6\, Leverage + a_7\, PPE + a_8\, Tobin's\ Q + a_9\, ROA + a_{10}\, Block + a_{11}\, Industry + a_{12} \log(size)), \quad (5)$$

Model 5 of Table 3 shows the estimation results from the first-stage regression (for *RD* determinants) and the second-stage regression (the takeover logit model). In the first-stage regression, we find that both *rivals' RD* and *GRD* are significantly positive. These results suggest that rival firms' R&D and public sector R&D spending in states where firms are headquartered do have strong effects on a firm's industry-adjusted R&D intensity. *CNJ (2009) MA prob* is also significantly positive, consistent with the notion that takeover incentives are a driver for firms to invest in R&D.

In the second-stage logit regression, RD^F is significant with a coefficient of 1.248 (*t*-value=2.89). The evidence confirms our earlier finding that firms with higher R&D intensity are more likely to become takeover targets. Furthermore, *R&D increase dummy* is also significant with a coefficient of 0.480 (*t*-value=2.84) while *Innovation efficiency* remains insignificant.

Since takeover probability is positively related to both *RD* and *R&D increase dummy*, we expect R&D premium and the premium associated with large R&D increases to be related to takeover probability. Conversely, since takeover probability is not related to *Innovation efficiency,* the innovation efficiency premium should not be related to takeover probability. We next test these pricing implications.

IV. R&D PREMIUM AND TAKEOVER PROBABILITY

This section applies the Fama and MacBeth (1973) regressions to examine the extent to which takeover likelihood affects the pricing of R&D firms. We obtain takeover probability for each sample firm in each year, using the fitted value from Model 1 reported in Table 3.

For assessing the effect of takeover probability on R&D premium, the Fama and MacBeth (1973) cross-sectional regression analysis allows us to easily control for the determinants of stock returns identified in previous studies. We start with a baseline model, Model 1, in which the explanatory variables include *R&D intensity*, the logarithm of firm size (log(*Size*)), book-to-market ratio (*BM*), past 11-month buy-and-hold return by skipping one month (*Momentum*), and the SA index in Hadlock and Pierce (2010) as the financial constraint proxy (*Constraint*).[17] Using the Fama-French 48 industry classification, we also include industry dummies in the analysis, and report the regression results in Table 4.[18] Specifically, Model 1 shows that the coefficient for *Constraint* is -0.0018 (*t*-value=-1.43), for *R&D intensity* is 0.0764 (*t*-value=4.31), and for the interaction term, *R&D intensity* x *Constraint*, is 0.0277 (*t*-value=2.60). Thus, consistent with Li (2011), the financial constraint proxy has an insignificant effect, but its interaction term with *R&D intensity* is positive and significant. These results suggest that stock returns increase with *R&D intensity* and that the positive relation is stronger for constrained firms. For robustness checks, we have experimented to replace the SA index by the KZ index (Kaplan and Zingales (1997)), the WW index (Whited and Wu (2006)), or firm age. The results using these alternative constraint variables are similar.

<u>Insert Table 4 here</u>

Model 2 of Table 4 adds *takeover probability* and the interaction term of *takeover probability* and *R&D intensity* to the set of explanatory variables. The coefficient for *takeover probability* is 0.0858 (*t*-value=2.77) while for the interaction term, *takeover*

[17] Li (2011) suggests that financial constraints have significant effects on R&D premium. She uses four proxies for financial constraints, the SA index (Hadlock and Pierce (2010)), the KZ index (Kaplan and Zingales (1997)), the WW index (Whited and Wu (2006)) and firm age, and shows that the SA index has the strongest effect on R&D premium. Hence, we mainly use the SA index to control for the financial constraint effect in the regression analysis, and apply other financial constraint proxies in robustness checks.

[18] Expected signs of the explanatory variables are indicated, according to Ang, Hodrick, Xing and Zhang (2006), Chan et al. (2001), Cohen et al. (2013), Cremers et al. (2009), Donelson and Resutek (2012), Fama and French (1992; 1993), Fu (2009), Jegadeesh and Titman (1993), Penman and Zhang (2002) and Resutek (2013).

probability x *R&D intensity*, is 0.3221 (*t*-value=2.02). The results suggest that stock returns are positively related to takeover probability and this relation is stronger for firms with higher R&D intensity. Note that the coefficient for *R&D intensity* decreases from 0.0764 (*t*-value=4.31) in Model 1 to 0.0478 (*t*-value=3.07) in Model 2, and the coefficient for *R&D intensity* x *Constraint* slightly decreases from 0.0277 (*t*-value=2.60) to 0.0209 (*t*-value=2.13). The changes suggest that *takeover probability* and *takeover probability* x *R&D intensity* take away part of the valuation effect of *R&D intensity*. Further, the results suggest that R&D premium exists and that the premium increases with takeover probability.

Specifically, Model 2 suggests that R&D premium can be written as

[0.0478 + 0.0209 x *Constraint* + 0.3221 x *takeover probability*] x *R&D intensity*.

Hence, given that the standard deviation of *takeover probability* is 0.16, our estimation results reveal that, holding other things constant, a one standard deviation increase in takeover probability leads to a 5.2% increase in R&D premium. By contrast, since the standard deviation of *Constraint* is 0.61, a one standard deviation increase in *Constraint* leads to a 1.3% increase in R&D premium. Thus, the effect of takeover probability on R&D premium is much larger than that of financial constraints.

Model 3 adds additional control variables, including *idiosyncratic volatility* (Ang et al. (2006)); *total expenses growth*, the logarithm of the future growth rate of non-R&D total expenses, as defined by Resutek (2013); *high R&D dummy* and *high R&D ability* of Cohen et al. (2013); *R&D reserve* of Penman and Zhang (2002), and *non-R&D component of log return* as defined by Donelson and Resutek (2012). The regression results show that *total expenses growth*, *high R&D dummy* x *high R&D ability*, and *non-R&D component of log return* have significant effects on stock returns. Nevertheless, adding these additional control variables does not materially change the valuation effects of *takeover probability* and *takeover probability* x *R&D intensity*. Their coefficients remain significant, at 0.0819 (*t*-value=2.68) and 0.3318 (*t*-value=2.08), respectively.

Models 4 and 5 add *R&D increase dummy* and *Innovation efficiency*, respectively; and Model 6 puts all R&D related variables together. As expected, Model 4 shows that the coefficient of *R&D increase dummy* is 0.010 (*t*-value=2.96), and that the coefficient of *takeover probability* x *R&D increase dummy* is 0.1812 (*t*-value=2.05). Thus, consistent with Eberhart et al. (2004), the results suggest that large R&D increases are associated with higher stock returns. Moreover, this premium of large R&D increases is larger for firms facing higher takeover probability.

However, Models 5 and 6 show that, while there is some evidence that stock returns increase with innovation efficiency, as documented by Hirshleifer et al. (2013), the innovation efficiency premium is not related to takeover probability. We draw this inference from the finding that the coefficient of *takeover probability* x *Innovation efficiency* is statistically insignificant.

For robustness checks, we also consider corporate governance variables, including the G-index of Gompers, Ishii, and Metrick (2003) and the E-index of Bebchuk, Cohen and Ferrell (2009). Although not tabulated in the paper, we find that adding the G-index or the E-index to the cross-sectional regressions does not materially change the above inferences.

In addition, we run several sensitivity analyses on the takeover probability estimations. First, we use the R&D intensity without industry adjustment. Second, we exclude R&D intensity and re-estimate the takeover probability. Third, we estimate takeover probability using Model 5, the second-stage logit regressions, reported in Table 3 in which we control for endogeneity issues. These alternative estimations of takeover probability produce similar results for the effect of takeover probability on R&D premium, as reported in Table 4.

Furthermore, we use a portfolio analysis by carrying out a two-way, independent sort on R&D intensity and takeover probability. We partition all firms into three takeover probability tercile portfolios and split R&D firms into five quintile portfolios. For each takeover probability tercile portfolio, we compute its R&D premium for each month from 1992 to 2011 as the value-weighted average return of firms in the top R&D intensity quintile portfolio minus the value-weighted average return of firms in the bottom R&D intensity quintile portfolio. The portfolio approach shows that the mean of the R&D premium is 1.24% per month for the high takeover probability subsample, while it is 0.65% per month for the low takeover probability subsample. The difference in the mean R&D premium of 0.59% (t-value=3.67) between the high and the low takeover probability tercile is significant at the 1% level. This further confirms that R&D premium is related to takeover probability.[19]

In sum, the evidence presented in Tables 3 and 4 is consistent with our hypothesis that firms with higher R&D intensity (and those with large R&D increases) are more likely to become takeover targets and that takeover probability affects the pricing of their common stocks. In contrast, innovation efficiency appears to have no effect on takeover

[19] We similarly conduct the portfolio analysis for the large R&D increases sample, and find that the premium following large R&D increases is higher in the high takeover probability subsample than in the low takeover probability subsample. However, we find no clear pattern related to takeover probability for the innovation efficiency premium. The results for the portfolio analyses are available upon request.

probability. Accordingly, we expect and find evidence that the innovation efficiency premium of Hirshleifer et al. (2013) is not related to takeover probability.

V. R&D PREMIUM CONTROLLED FOR TAKEOVER RISK

Mitchell and Stafford (2000) and Fama (1998) argue that many anomalies disappear when an asset pricing model with appropriate systematic risks is adopted. This raises two important questions: What systematic risks are important in pricing R&D stocks? To what extent can R&D premium be explained by systematic risks?

Previous studies have shown that the systematic risks associated with the market, size, book-to-market, and momentum factors are insufficient to explain R&D premium. Our findings in the previous section suggest that firms with higher R&D intensity face higher takeover probability and that R&D premium increases with takeover probability. In this section, we further investigate to what extent takeover risk, a systematic risk proposed by Cremers et al. (2009) to capture the sensitivity of stock returns to shifts in takeover waves, can help explain R&D premium.

Following Cremers et al. (2009), we use the logit model without the R&D variables in estimation of takeover probability for each firm,[20] and then create a takeover factor, which is a value-weighted hedge portfolio, long on firms in the top takeover probability quintile and short on those in the bottom takeover probability quintile. Cremers et al.

[20] For two reasons, we remove the R&D variables in the takeover probability estimation for constructing the takeover factor. First, we would like to use the takeover factor just as Cremers, Nair, and John (2009) propose it. Second, if we do not remove the R&D variables, then both R&D premium (the dependent variable) and the takeover factor (an independent variable) are related to R&D intensity, which could induce a spurious correlation between the dependent and the independent variables. To minimize such a correlation, we remove the R&D variables from the takeover probability estimation. Nevertheless, we experiment to retain the R&D variables in the takeover probability estimation, and find that the results are almost the same.

show that this takeover factor can capture aggregate takeover activities and exhibits strong correlations with economic fundamentals.

Table 5 reports summary statistics of the takeover factor and its correlations with the commonly used pricing factors. The takeover factor's mean monthly return is 0.836%, which is higher than the mean WML factor return of 0.601%, the mean market excess return of 0.496%, and the mean SMB and HML factor returns of around 0.2%. The takeover factor has a correlation of 0.45 with SMB, consistent with the notion that small firms are more susceptible to takeover waves.

Also included in Table 5 is an R&D factor, which is a value-weighted hedge portfolio, long on firms in the top R&D intensity quintile and short on those in the bottom R&D intensity quintile. It is essentially the R&D premium and has a mean monthly return of 0.944%. Since the literature has characterized R&D activities as risky ventures and described R&D-intensive firms as inherently having high risk (see, e.g., Chambers et al. (2002), Li (2011), and Resutek (2013)), this suggests that a firm's R&D intensity may manifest its riskiness. Hence, we use the R&D factor to capture R&D-related systematic risk.[21]

<u>Insert Table 5 here</u>

Among the pricing factors, the R&D factor is the most highly correlated with the takeover factor, with a correlation of 0.47. The next highest one is the SMB, with a correlation of 0.46. The R&D factor is also highly correlated with the market factor, with a correlation of 0.40.

Following the two-stage cross-sectional regression approach used by Cremers et al. (2009), we compare and contrast the R&D factor and the takeover factor in explaining

[21] We thank a referee for this suggestion.

the cross-section of equity returns on 100 size and book-to-market sorted portfolios. More specifically, we first estimate the factor-beta for each of the 100 test portfolios in a time-series regression of portfolio returns on a constant and the particular factor. Then, we run a cross-sectional regression of the value-weighted average returns of the 100 test portfolios on their factor-betas, and report the results in Table 6.

In Models 1 and 2, the betas of the R&D and takeover factors are separately presented, along with the betas of the *market*, *SMB*, *HML*, and *WML* factors, in the regressions. The results show that either beta of the R&D factor or the takeover factor is significant and helps explain the cross-section of portfolio returns. The coefficients of R&D beta and takeover beta are 2.44 (*t*-value=2.40) and 1.566 (*t*-value=2.88) in Models 1 and 2, respectively. However, when putting them together in Model 3, we find that R&D beta becomes insignificant, whereas takeover beta remains significant with a coefficient of 1.346 (*t*-value=2.11). The evidence indicates that the takeover factor largely subsumes the R&D factor's pricing power.

<u>Insert Table 6 here</u>

In addition, Table 5 also reports the premium associated with large R&D increases and the innovation efficiency premium. We follow Eberhart et al. (2004) to measure the premium associated with large R&D increases as the value-weighted average of excess returns following R&D increases. Similarly, we follow Hirshleifer et al. (2013) to calculate the innovation efficiency premium as the value-weighted average return of firms in the top innovation efficiency quintile portfolio minus the value-weighted average return of firms in the bottom innovation efficiency quintile portfolio. On average, the innovation efficiency premium is 0.356% per month; and the premium associated with large R&D increases is 1.047% per month.

Models 4 and 5 of Table 6 test whether we could consider the large R&D increase premium and the innovation efficiency premium as pricing factors. The results show that either one has insignificant pricing power. Finally, Model 6 includes all factor betas in an asset pricing test, which upholds our inference that the takeover factor is a pricing factor and that it can subsume the pricing power of the R&D factor.

To intuitively show takeover risk in R&D premium, we examine R&D premium in the months when the takeover factor returns are positive versus the months when they are negative. If R&D premium is in large part due to takeover risk, we expect the R&D premium to be positive when the takeover factor returns are positive, which tend to occur when takeover waves are arriving, driving up the stock prices of firms with higher likelihood of becoming takeover targets. On the other hand, R&D premium should be negative during the months when takeover waves are receding and stock prices of firms with higher takeover probability are declining.

Indeed, Panel A of Table 7 shows that R&D premium is 2.81% (*t*-value=4.39) during the months with positive takeover factor returns, and is -1.37% (*t*-value=-2.19) during the months with negative takeover factor returns. The results illustrate a major risk of holding high R&D-intensive firms' stocks. The risk shows up when the takeover factor is not doing well.

<u>Insert Table 7 here</u>

In Panel B of Table 7, we augment the Carhart (1997) four-factor model with the takeover factor and use it to analyze R&D premium. The results show that R&D

premium has a large and significant takeover beta of 0.704 (*t*-value=6.02). The evidence suggests that high R&D-intensive firms indeed face higher takeover risk than low R&D-intensive firms, as we hypothesize. The market and the SMB factors are also significant with betas of 0.476 (*t*-value=5.28) and 0.544 (*t*-value=4.19), respectively. The findings imply that high R&D-intensive firms also face more market risk and are more vulnerable to shocks that affect small firms. However, the HML and the momentum factors appear to have no effect on R&D premium. This suggests that R&D premium is not due to the value premium or the premium associated with buying winners and selling losers (Jegadeesh and Titman (1993)).

To provide a more detail accounting of R&D premium, the estimation results show that, on average, the takeover risk premium contributes about 0.59% per month (i.e., 0.70x0.84%) to R&D premium. This accounts for around 62 percent of 0.94% per month of the R&D premium. In comparison, market risk premium accounts for about 25 percent and size premium accounts for about 13 percent of 0.94% per month of the R&D premium. Thus, among these systematic risks, takeover risk plays a dominant role in R&D premium.

As expected, Pane B of Table 7 also shows that the premium associated with large R&D increases contains a significant takeover beta, consistent with the notion that firms with large R&D increases face high takeover risk. Conversely, the takeover beta of the innovation efficiency premium is insignificant, which is in line with our earlier inference that a firm's likelihood of becoming a takeover target is not related to its innovation efficiency, and that takeover risk should not be responsible for the innovation efficiency anomaly.

VI. CONCLUSION

This paper addresses the issue of why firms with high R&D intensity tend to offer their investors higher stock returns. Based on the premise that firms invest in R&D to increase their appeal to acquirers and that high R&D-intensive firms tend to have beaten-down stocks, we hypothesize that firms with higher R&D intensity face a higher likelihood of becoming takeover targets, and that their investors face higher takeover risk and thus demand higher stock returns.

Consistent with our hypothesis, we find robust evidence that a firm's takeover probability increases with its R&D intensity and that its takeover probability affects its stock returns. The effect of takeover probability on R&D firms' returns is larger than that of financial constraints, as documented by Li (2011). Furthermore, we find that the differences in Cremers et al.'s (2009) takeover risk between high and low R&D-intensive firms are large and very significant. Our estimation shows that takeover risk premium can account for about 62 percent of R&D premium, while market risk premium and size premium can account for 25 percent and 13 percent, respectively. Thus, takeover risk plays a dominant role in the pricing of R&D-intensive firms.

Like R&D-intensive firms, firms with large increases in R&D are also more likely to become takeover targets. Accordingly, we expect, and find, that takeover risk helps explain the abnormal returns associated with R&D increases, as documented by Eberhart et al. (2004).

Thus, while the literature has recognized that takeover incentives are a strong driver for firms to invest in R&D, our study adds to the literature that R&D firms' systematic risk increases with their likelihood of becoming takeover targets. While the literature has also recognized that R&D activities are risky ventures, our study shows that the most important pricing factor for the pricing of R&D firms is takeover risk, which is essentially an external risk. Identifying this role of takeover risk in R&D premium helps us understand Donelson and Resutek's (2012) finding that R&D premium is mainly due to the component of the R&D firms' realized returns that are unrelated to R&D investments but present in R&D firms.

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TABLE 1.
Summary Statistics of R&D Firms

	No-R&D firms			R&D firms					
	N	Size	Q	N	Size	Q	R&D expense	R&D expense to asset	R&D expense to size
Panel A: Summary Statistics by Subperiods									
All	44,038	1,149	1.719	35,343	1,385	2.813	58.1	0.112	0.091
1991-1999	24,350	570	1.809	18,340	816	3.126	31.3	0.107	0.078
2000-2009	19,688	1865	1.606	17,003	1,999	2.475	86.9	0.119	0.104
Panel B: Summary Statistics of Main Industries									
12_Medical Equipment	197	162	1.912	2,584	954	3.390	28.7	0.113	0.066
13_Pharmaceutical Products	178	314	2.803	3,827	1,878	4.267	126.3	0.257	0.123
35_Computers	4,381	608	2.181	6,033	933	3.428	39.7	0.152	0.120
36_Electronic Equipment	241	1,784	1.837	2,529	1,176	2.640	74.2	0.131	0.134
37_Measuring and Control Equipment	446	213	1.748	4,098	1,252	2.717	75.1	0.111	0.108

This table reports summary statistics for R&D firms and no-R&D firms. 'No-R&D firms' and 'R&D firms' indicate firms without R&D expenses (or no R&D disclosure) and firms with reported R&D expenditure, respectively. Panel A reports the averages of each variable for the whole sample and for two sub-periods, and Panel B for the five top industries doing R&D, based on Fama-French 48 industries. The variables include *Size* (in million), which is stock price multiplied by shares outstanding and then deflated by 2010 Consumer Price Index; Q is the book value of liability plus market value of equity divided by book assets. R&D expense, research and development expenditure (in million), which is deflated by 2010 Consumer Price Index. We also show R&D ratios, which are scaled by either book assets or *Size*.

TABLE 2.
Firm Characteristics Sorted by R&D Intensity Quintile

	No-R&D firms	R&D firm				
		1 (low)	2	3	4	5 (high)
RD		0.007	0.021	0.042	0.085	0.287
RD-to-assets		0.024	0.060	0.093	0.142	0.234
Size	1148.7	2572.1	1964.2	1580.7	693.0	226.4
B/M	0.769	0.367	0.414	0.478	0.597	0.933
EPS	2.881	2.492	2.194	1.830	1.117	0.309
Dividend yield	0.014	0.009	0.008	0.007	0.005	0.005
Cash	0.112	0.190	0.231	0.267	0.311	0.334
Leverage	0.410	0.288	0.243	0.233	0.250	0.257
PPE	0.324	0.249	0.209	0.187	0.167	0.162
Tobin's Q	1.719	4.184	3.431	2.733	2.235	1.602
ROA	0.098	0.111	0.084	0.042	-0.026	-0.150
Block	0.536	0.552	0.608	0.594	0.569	0.492
Industry	0.602	0.503	0.550	0.590	0.637	0.680
% of takeover	0.031	0.023	0.025	0.031	0.037	0.044
Mean monthly return	0.402 (1.44)	0.385 (1.29)	0.527 (1.70)	0.829 (2.61)	0.968 (2.21)	1.328 (2.26)
Average number of firms	2,201.9	338.1	348.2	355.5	359.5	365.0

This table reports the means of firm characteristics for R&D firms and no-R&D firms. 'No-R&D firms' and 'R&D firms' indicate firms without R&D expenses (or no R&D disclosure) and those with reported R&D expenditure, respectively. We sort R&D firms into Quintile 1 (low) to 5 (high) according to ranks of R&D-to-size ratio. *RD* is the R&D expenditure divided by firm size. *RD-to-asset* is the R&D expenditure divided by book assets. *Size* is the market value of common equity. *B/M* is the book common equity divided by market value of common equity. *EPS* is the EBITDA divided by shares outstanding. *Dividend yield* is the cash dividend divided by stock price. *Cash* is the cash and cash equivalent divided by book assets. *Leverage* is the total debt (sum of long-term debt and short-term debt) divided by the sum of total debt and total equity. *PPE* is property, plant and equipment divided by book assets. *Tobin's Q* is the book value of liability plus market value of equity divided by book assets. *ROA* is EBITDA divided by book assets. *Block* is a dummy that equals one if a firm has institutional investor who holds more than 5% of shares outstanding of the firm. *% of takeover* is the percentage of firms being the takeover target. *Mean monthly return* is the average of value-weighted monthly portfolio return. Numbers in the parentheses are *t*-values.

TABLE 3.
Takeover Probability Estimation

	Expected sign	Model 1	Model 2	Model 3	Model 4	Model 5 Stage 1	Model 5 Stage 2
Intercept		-4.359	-4.039	-4.121	-4.344	-0.005	-4.147
		(-20.35)	(-17.23)	(-16.72)	(-18.50)	(-1.44)	(-18.33)
RD	+	1.878			1.674		1.248
		(5.35)			(4.72)		(2.89)
No-RD dummy	+/-	0.111			0.088		0.064
		(1.95)			(1.05)		(0.75)
R&D increase dummy	+		0.533		0.312		0.480
			(2.62)		(1.63)		(2.84)
Innovation efficiency	+/-			0.003	0.003		0.000
				(0.70)	(0.82)		(-0.21)
Log(cash)	+	0.017	0.012	0.013	0.016	0.003	-0.005
		(0.60)	(0.52)	(0.55)	(0.55)	(3.05)	(-0.32)
Leverage	+/-	0.282	0.332	0.330	0.292		0.016
		(2.51)	(2.45)	(2.45)	(2.43)		(0.71)
PPE	+/-	-0.276	-0.297	-0.281	-0.316		-0.264
		(-1.61)	(-1.54)	(-1.47)	(-1.73)		(-1.52)
Tobin's Q	+/-	-0.021	-0.044	-0.042	-0.025	-0.004	-0.030
		(-1.48)	(-2.16)	(-2.16)	(-1.54)	(-8.13)	(-2.05)
ROA	+/-	-0.035	0.106	-0.027	0.072		-0.012
		(-0.54)	(-0.62)	(-1.23)	(-0.09)		(-0.65)
Block	+	0.743	0.765	0.767	0.749		0.736
		(11.96)	(10.65)	(10.70)	(11.35)		(11.17)
Industry	+	0.328	0.358	0.363	0.358	-0.002	0.358
		(5.24)	(5.02)	(5.03)	(5.24)	(-0.61)	(5.23)
Log(size)	+/-	0.036	0.010	0.011	0.022		0.012
		(2.29)	(0.77)	(0.88)	(1.57)		(0.98)
CNJ (2009) M&A prob	+					0.266	
						(2.21)	
Lagged R&D	+					0.234	
						(23.32)	
Rival's R&D	+					0.294	
						(9.29)	
GRD	+					0.011	
						(3.87)	
Average number of firm-years		42,392	42,392	42,392	42,392	42,392	42,392
Pseudo R-sq		0.031	0.030	0.030	0.032	0.147	0.031

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TABLE 3. (continued)

This table presents the coefficients of the logit regression. We use a binary dependent variable that is equal to one if a firm is announced as a takeover target, and zero otherwise. *RD* is the R&D expenditure divided by firm size. *R&D increase dummy* is equal to one if a firm belongs to the large R&D increase sample as in Eberhart, Maxwell and Siddique (2004), which includes firms with R&D intensity and changes in R&D intensity both exceeding 5%. Innovation efficiency is measured by Hirshleifer, Hsu and Li (2013). For each firm, they compute the sum of truncation-adjusted citations received by patents that are granted in past five years. They then compute innovation efficiency as the sum of patent citations divided by the sum of R&D expenditures between year *t*-3 and year *t*-7. Control variables are as follows. *No-RD dummy* is equal to one if a firm does not disclose R&D information or it has zero R&D spending, and zero otherwise. *Cash* is the cash and cash equivalent divided by book assets. *Leverage* is the total debt (sum of long-term debt and short-term debt) divided by the sum of total debt and total equity. *PPE* is property, plant and equipment divided by book assets. *Tobin's Q* is the book value of liability plus market value of equity divided by book assets. *ROA* is EBITDA divided by book assets. *Block* is a dummy that equals one if a firm has institutional investor who holds more than 5% of shares outstanding of the firm. *Industry* is a dummy equal to 1 if, based on the Fama-French 48 industry classification, there was a takeover in a firm's industry in year *t*. *Size* is the market value of common equity. All abovementioned accounting variables are measured at *t* fiscal year end, *MA dummy* is measured at year *t+1*. *RD*, log(*cash*), *Leverage*, *PPE*, *Tobin's Q* and *ROA* are industry-adjusted by subtracting their Fama-French industry medians. Year dummies are added in the logit analysis. In Models 1 to 4, we regress the M&A target dummy on independent variables with past 10-year data, and roll the regression from 1990 to 2009. We then show the average coefficients and *t*-values across time. In Model 5, we use two-stage regression to estimate takeover probability. In stage 1, we specify a RD regression on a set of control variables and instrument variables. *CNJ (2009) MA prob* is the takeover probability from Cremers et al. (2009) that does not include R&D variables in the model. Lagged *RD* is last year's *RD*. *Rival's RD* is the average R&D intensity of rival firms in the same Fama-French-48 industry. *GRD* is a dummy that is equal to one if the headquarter is at California, Washington, Massachusetts, Texas or Michigan, and zero otherwise. We then perform logit regression in the stage 2 by replacing *RD* with fitted value of *RD* from stage 1. Numbers in the parentheses are *t*-values.

TABLE 4.
Fama and Macbeth (1973) Regression Analysis

	Expected sign	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept		0.0192	0.0229	0.0250	0.0251	0.0245	0.0244
		(1.83)	(2.18)	(2.35)	(2.36)	(2.30)	(2.30)
log(size)	-	-0.0011	-0.0013	-0.0012	-0.0012	-0.0012	-0.0012
		(-1.65)	(-2.12)	(-1.91)	(-1.97)	(-1.90)	(-1.97)
BM	+	0.0052	0.0044	0.0040	0.0046	0.0041	0.0046
		(3.98)	(4.17)	(3.86)	(4.48)	(3.90)	(4.51)
Momentum	+	-0.0024	-0.0023	-0.0024	-0.0025	-0.0024	-0.0025
		(-0.75)	(-0.85)	(-0.90)	(-0.92)	(-0.90)	(-0.92)
Constraint	-	-0.0018	-0.0016	-0.0010	-0.0014	-0.0013	-0.0017
		(-1.43)	(-1.24)	(-0.89)	(-1.25)	(-1.14)	(-1.48)
R&D intensity	+	0.0277	0.0209	0.0201	0.0198	0.0193	0.0193
× constraint		(2.60)	(2.13)	(2.09)	(2.06)	(2.00)	(2.01)
R&D intensity	+	0.0764	0.0478	0.0421	0.0309	0.0428	0.0314
		(4.31)	(3.07)	(2.71)	(1.99)	(2.74)	(2.02)
Takeover probability	+		0.0858	0.0819	0.0760	0.0840	0.0755
			(2.77)	(2.68)	(2.57)	(2.53)	(2.35)
R&D intensity	+		0.3221	0.3318	0.3703	0.3207	0.3708
× takeover probability			(2.02)	(2.08)	(2.21)	(2.01)	(2.21)
R&D increase dummy	+				0.0099		0.0098
					(2.96)		(2.93)
R&D increase dummy	+				0.1812		0.1808
× takeover probability					(2.05)		(2.05)
Innovation efficiency	+					0.0126	0.0135
						(1.87)	(2.02)
Innovation efficiency	+/-					0.1461	0.0643
× takeover probability						(0.51)	(0.23)
Idiosyncratic volatility	+/-			0.0001	0.0001	0.0001	0.0001
				(0.47)	(0.56)	(0.57)	(0.65)
Total expenses growth	-			-0.0046	-0.0044	-0.0047	-0.0044
				(-2.70)	(-2.54)	(-2.74)	(-2.57)
High R&D dummy	+			0.0000	0.0003	0.0003	0.0007
				(-0.03)	(0.40)	(0.38)	(0.80)
High R&D dummy	+			0.0064	0.0049	0.0061	0.0047
× High R&D ability				(2.41)	(1.88)	(2.32)	(1.80)
R&D reserve	+			0.0000	0.0000	0.0000	0.0000
				(0.34)	(0.56)	(0.35)	(0.59)
Non-R&D component	-			-0.0017	-0.0015	-0.0017	-0.0015
of log return				(-2.01)	(-1.81)	(-2.02)	(-1.81)
Average number of firms		1621.6	1621.6	1608.5	1608.5	1608.5	1608.5
Adj. R-sq.		0.0422	0.0423	0.0452	0.0464	0.0454	0.0465

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TABLE 4. (continued)

This table presents coefficient estimations of the Fama-MacBeth (1973) regression analysis. We exclude R&D missing firms. The dependent variable is monthly raw returns. Log(*size*) is the logarithm of firm size. *BM* is book-to-market ratio as book value of common equity divided by *size*. *Momentum* is past 11-month buy-and-hold return by skipping one month. *Constraint* is the SA index in Hadlock and Pierce (2010). *R&D intensity* is measured as R&D expenditure divided by size. *Takeover probability* is the takeover probability estimated from the logit regression Model 1 as reported in Table 3. *R&D increase dummy* is equal to one if a firm belongs to the large R&D increase sample as in Eberhart, Maxwell and Siddique (2004), which includes firms with R&D intensity and changes in R&D intensity both exceeding 5%. Innovation efficiency is measured by Hirshleifer, Hsu and Li (2013). For each firm, they compute the sum of truncation-adjusted citations received by patents that are granted in past five years. They then compute innovation efficiency as the sum of patent citations divided by the sum of R&D expenditures between year *t*-3 and year *t*-7. *Idiosyncratic volatility* is the sum of squared residuals from the CAPM using monthly returns in the past three years. *Total expenses growth* is the logarithm of the future growth rate of non-R&D total expenses, as defined in Resutek (2013). *High R&D dummy* follows the definition of Cohen, Diether and Malloy (2013) and is equal to one if the R&D-to-sales ratio exceeds 70th percentile; zero otherwise. *High R&D ability dummy* is equal to one if the R&D ability exceeds 70th percentile; zero otherwise. *R&D ability* is measured as in Cohen, Diether and Malloy (2013). *R&D reserve* is measured as in Penman and Zhang (2002). *Non-R&D component of log return* is the residual from regressing stock returns on lagged R&D intensity and R&D return measure (all in logarithm), as defined in Donelson and Resutek (2012). Industry dummies, based on the Fama-French 48-industry classification, are included but not reported. Numbers in the parentheses are *t*-statistics by using the time-series volatility of the coefficients.

TABLE 5.
Summary Statistics of the Takeover Factor

Panel A: Summary Statistics

	Mean	SD	Q1	Median	Q3
Market	0.496	4.551	-2.230	1.005	3.510
SMB	0.219	3.450	-1.790	-0.015	2.120
HML	0.242	3.275	-1.530	0.180	1.795
WML	0.601	5.165	-1.000	0.790	3.050
Takeover	0.836	3.747	-1.582	0.404	2.333
R&D	0.944	7.174	-2.959	0.418	4.172
Innovation efficiency	0.356	3.293	-1.558	0.316	2.236
R&D increases	1.047	8.896	-3.932	1.054	5.894

Panel B: Correlation Coefficients

	Market	*SMB*	*HML*	*WML*	*Takeover*	*R&D*	*Innovation efficiency*	*R&D increases*
Market	1.000	0.296	-0.253	-0.129	0.008	0.399	0.048	0.708
		(0.00)	(0.00)	(0.04)	(0.90)	(0.00)	(0.46)	(0.00)
SMB		1.000	-0.161	0.011	0.454	0.460	-0.148	0.430
			(0.01)	(0.86)	(0.00)	(0.00)	(0.02)	(0.00)
HML			1.000	-0.081	0.149	-0.081	-0.156	-0.421
				(0.19)	(0.02)	(0.19)	(0.02)	(0.00)
WML				1.000	-0.078	-0.069	0.043	-0.093
					(0.23)	(0.27)	(0.51)	(0.15)
Takeover					1.000	0.473	-0.186	0.162
						(0.00)	(0.00)	(0.01)
R&D						1.000	-0.047	0.445
							(0.47)	(0.00)
Innovation efficiency							1.000	-0.012
								(0.85)
R&D increases								1.000

This table presents summary statistics for the pricing factors and their correlation coefficients. *Market* is the market factor (CRSP value-weighted index return minus risk-free rate). *SMB* is the size factor. *HML* is the book-to-market factor. *WML* is the momentum factor. *Market, SMB, HML* and *WML* are obtained from Professor Kenneth French's website. *Takeover* is the takeover factor as in Cremers, Nair, and John (2009). *R&D* is the value-weighted R&D premium. *R&D increases* are the value-weighted premium associated with large R&D increases. *Innovation efficiency* is the value-weighted innovation efficiency premium. Panel A shows summary statistics and Panel B shows the Spearman correlation coefficients. Numbers in the parentheses are p-values.

TABLE 6.
Asset Pricing Tests Based on 100 BM/Size-Sorted Portfolios

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	1.281	1.224	1.215	1.408	1.612	1.395
	(3.61)	(3.56)	(3.51)	(4.07)	(5.50)	(5.17)
Market	-0.339	-0.188	-0.267	-0.506	-0.464	-0.589
	(-0.55)	(-0.31)	(-0.44)	(-0.65)	(-0.84)	(-0.84)
SMB	-0.021	0.351	0.176	0.468	0.800	0.363
	(-0.06)	(1.28)	(0.47)	(1.35)	(2.78)	(0.90)
HML	0.954	0.174	0.279	1.161	0.966	0.265
	(3.50)	(0.51)	(0.73)	(2.90)	(3.50)	(0.70)
WML	2.033	1.535	1.567	2.121	1.751	1.219
	(2.91)	(2.29)	(2.31)	(3.04)	(2.41)	(1.96)
R&D	2.440		0.796			0.375
	(2.40)		(0.67)			(0.30)
Takeover		1.556	1.346			1.447
		(2.88)	(2.11)			(2.21)
R&D increases				1.570		0.226
				(0.78)		(0.11)
Innovation efficiency					-0.401	-0.276
					(-0.84)	(-0.57)
Adj. R-sq	0.296	0.298	0.334	0.282	0.295	0.363

We report the results of regressing value-weighted average returns of the 100 book-to-market/size-sorted test portfolios on their factor-betas. The factor-betas are estimated in a time-series regression of each portfolio on a constant and the particular factor. *SMB* is the size factor. *HML* is the book-to-market factor. *WML* is the momentum factor. *Market*, *SMB*, *HML* and *WML* are obtained from Professor Kenneth French's website. *Takeover* is the takeover factor as in Cremers, Nair, and John (2009). *R&D* is the value-weighted R&D premium. *R&D increases* are value-weighted premium associated with large R&D increases. *Innovation efficiency* is the value-weighted innovation efficiency premium. Numbers in the parentheses are *t*-values.

TABLE 7.
Analyses on R&D Premium

Panel A: Premium Sorted by the Sign of Takeover Factor Returns

	R&D Premium		*Premium Associated with R&D Increases*		*Innovation Efficiency Premium*	
	Positive takeover factor	Negative takeover factor	Positive takeover factor	Negative takeover factor	Positive takeover factor	Negative takeover factor
Raw return	2.806	-1.371	1.967	-0.096	-0.099	0.921
	(4.39)	(-2.19)	(2.70)	(-0.11)	(-0.33)	(3.11)
CAPM AR	2.980	-1.596	2.180	-2.118	0.124	0.814
	(4.44)	(-3.17)	(3.56)	(-3.69)	(0.37)	(2.95)
Fama-French AR	1.525	-0.819	1.565	-0.995	0.188	0.647
	(2.38)	(-1.79)	(2.70)	(-2.09)	(0.52)	(2.27)
Carhart AR	1.528	-1.034	1.522	-1.004	0.102	0.677
	(2.37)	(-2.15)	(2.66)	(-1.61)	(0.28)	(2.24)

Panel B: Regression Analysis of R&D Related Factor

	R&D Premium	*Premium Associated with R&D Increases*	*Innovation Efficiency Premium*
	Model 1	Model 2	Model 3
Intercept	0.2215	0.282	0.478
	(0.57)	(0.82)	(2.10)
Market	0.4757	0.972	0.071
	(5.28)	(12.12)	(1.33)
SMB	0.5438	0.408	-0.171
	(4.19)	(3.52)	(-2.28)
HML	-0.0845	-0.829	-0.158
	(-0.70)	(-7.86)	(-2.25)
WML	0.0594	0.038	0.056
	(0.77)	(0.56)	(1.23)
Takeover	0.7045	0.490	-0.069
	(6.02)	(4.03)	(-1.03)
Adj. R-sq	0.403	0.652	0.052

This table presents the R&D premiums, premiums associated with R&D increases and innovation efficiency premiums sorted by the sign (positive or negative) of the takeover factor in Panel A and the regressions of these premiums in Panel B. CAPM AR, Fama-French AR, and Carhart AR indicate the abnormal returns under the CAPM, the Fama-French three-factor model, and the Carhart (1997) four-factor model, respectively. Panel B presents regression analyses of the R&D premium, premium associated with R&D increases and innovation efficiency premium. *Market* is the market factor (CRSP value-weighted index return minus risk-free rate). *SMB* is size factor. *HML* is the book-to-market factor. *WML* is the momentum factor. *Market*, *SMB*, *HML* and *WML* are obtained from Professor Kenneth French's website. *Takeover* is the takeover factor as in Cremers, Nair, and John (2009). Numbers in the parentheses are *t*-values.