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軟體業研發資本化與研發過度投資之關聯性：論管理者權益薪酬之影響

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摘要

過去研究發現，研發費用化的規定誘發了研發投資不足的問題。然而，以 2001 年至 2011 年美國軟體業公司為樣本進行實證分析，本研究發現研發資本化與研發過度投資呈正向關係，顯示研發資本化決策可能引發的過度投資代理問題，故此證據對於投資人和主管機關在評估研發資本化的後果時具有涵意。此外，本研究檢測提供管理者權益薪酬對於減緩此種代理問題的效果，實證結果獲得支持，顯示管理者權益薪酬係抑制前述研發過度投資問題的重要機制。此證據對於公司薪酬委員會具有參考價值，可藉由薪酬結構中設計提供權益薪酬，激勵管理者以長期觀點進行研發投資相關決策。最後，本研究進行額外測試，排除內生性問題和競爭性解釋的潛在影響，以加強本研究結論的堅實性。

關鍵詞：研發支出、研發資本化、過度投資、管理者權益薪酬

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Relationship between R&D Capitalization and R&D Overinvestment in the Software Industry: The Effect of Executive Equity-Based Compensation

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Abstract

Prior studies show that immediate expensing of R&D expenditures creates R&D underinvestment problems. In contrast, from data on firms listed in the U.S. software industry for 2001 to 2011, we provide evidence that R&D capitalization is positively associated with R&D overinvestment. This evidence sheds light on one kind of agency problem- R&D overinvestment- caused by R&D capitalization decisions and, in turn, provides implications for investors and regulators in assessing the consequences of R&D capitalization. Moreover, we examine the effect of executive equity-based compensation on mitigating such agency problem. Our results support that executive equity-based compensation serves as an important mechanism to alleviate R&D overinvestment problems driven by R&D capitalization. This evidence is of value to firms' compensation committees in designing executive compensation structures to motivate managers' R&D investment decisions from long-term perspectives. We finally conduct additional tests to ensure that our empirical results are robust to potential endogeneity concerns and competing explanations.

Keywords: *R&D Expenditures, R&D Capitalization, Overinvestment, Executive Equity-Based Compensation.*

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1. INTRODUCTION

This study examines whether research and development (hereafter, R&D) capitalization is associated with firms' overinvestment in R&D for a larger dataset. In particular, we examine whether executive equity-based compensation affects R&D overinvestment attributable to R&D capitalization. R&D investment is a primary source of corporate competitiveness in today's knowledge economy. One line of research offers evidence that supports the positive effects of R&D expenditures, such as enhancing future earnings and market value (e.g., Sougiannis 1994) and increasing value-relevance after capitalizing R&D expenditures (e.g., Aboody and Lev 1998; Lev and Zarowin 1999; Healy, Myers, and Howe 2002; Mohd 2005; Oswald and Zarowin 2007). Another line of research offers evidence of R&D investment inefficiency associated with agency problems (e.g., Baber, Fairfield, and Haggard 1991; Dechow and Sloan 1991; Bushee 1998; Roychowdhury 2006). The present study extends the latter by focusing on R&D overinvestment driven by capitalized R&D projects and by considering executive incentive compensation as a potential moderating mechanism.

Initially, Statement of Financial Accounting Standards (SFAS) No. 2 required all R&D expenditures to be expensed as incurred (FASB 1974) for U.S. listed firms except for those of the software industry. This mandatory expensing rule has been widely criticized not only for compromising the relevance of accounting information (Francis and Schipper 1999; Lev and Zarowin 1999) but also for creating managerial agency problems of underinvestment in R&D (e.g., Perry and Grinaker 1994; Bushee 1998; Mande, File, and Kwak 2000; Cheng 2004). Until 1985, SFAS No. 86 stated that software costs were to be capitalized when technological feasibility could be achieved. Therefore, whether paradigms shift from full expensing to a conditional capitalization of R&D costs can alleviate agency problems associated with R&D investment inefficiency is an interesting issue.

Agency theory suggests that self-interested managers may make suboptimal investment decisions resulting in over- or underinvestment. Although R&D capitalization appears to mitigate agency problems associated with underinvestment in R&D (Oswald and Zarowin 2007), it seems that R&D capitalization may induce overinvestment in R&D. From a practical perspective (e.g., Entwistle 1999), as capitalizing R&D expenditures may result in the occurrence of large lump-sum write-offs having a significant income-decreasing effect, managers with specific earnings goals may engage in certain measures to avoid such write-offs. From an experimental analysis with M.B.A. student participants, Seybert (2010) found that managers responsible for initiating an R&D project are more likely to overinvest in the continuing project and then forgo the new R&D project with positive NPV. Recently, Seybert (2016) studied 79 experienced executives to replicate the above experimental analysis and found similar results. Seybert's (2010, 2016) experimental results highlight that in the real world the overall consequences of moving from expensing to capitalizing R&D may require further assessment.[1] From an archival dataset of the U.S. software industry for a limited research period of 2007-2010, Tsai, Young, Chen, and Hsu (2014) found a positive relationship between capitalized R&D and subsequent overinvestment in R&D, consistent with the views of Seybert (2010, 2016). Given major concerns regarding whether the previously identified benefits of R&D capitalization in terms of increased value relevance (e.g., Lev and Sougiannis 1996; Lev and Zarowin 1999) could be offset by induced overinvestment behavior, we first re-examine this issue by employing a larger dataset of hand-collected capitalized software costs incurred under the U.S. GAAP for 2001-2011.[2]

Overinvestment in R&D is a cause of concern because such an inefficient form of resource allocation may compromise firm value and obstruct economic growth. This is especially the case when overinvestment in R&D driven by R&D capitalization is associated with managerial opportunistic incentive of avoiding future large lump-sum write-offs so as to increase accounting earnings and support market valuation. Based on agency theory, tying executive compensation to firm performance will motivate managers to make more value-maximizing decisions for shareholders (Holmstrom 1979; Grossman and Hart 1983). Therefore, this study considers the compensation plan as a potential mechanism for solving or mitigating such agency problems. In particular, given that long-term oriented R&D activities are characterized by higher levels of information asymmetry and by more agency conflicts, compensation programs used to reward R&D decisions must be associated with long-term compensation packages. Relative to cash compensation, equity-based compensation can better link executive compensation to shareholders' interests, for which the value of inducement is more closely related to a firm's long-term value (Lewellen, Loderer, Martin, and Blum 1992).[3] In terms of R&D-related agency problems, studies have found that the self-interested decision to cut R&D expenditures can be mitigated by using higher equity-based compensation (e.g., Ryan and Wiggins 2002, Cheng 2004, Wu and Tu 2007). Therefore, the second purpose of this study is to examine

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1 In examining changes made to the U.K.'s accounting standards through U.K. GAAP to IFRS in 2005, Oswald, Simpson, and Zarowin (2016) investigate the effect of R&D accounting (i.e., capitalization vs. expensing) on U.K. firms' R&D expenditures. They find that firms that switched from expensing under U.K. GAAP to capitalizing under IFRS had increased their R&D expenditures more than firms that continued to capitalize, supporting the effect of accounting methods on firms' R&D investments. However, their study focuses on a firm's R&D investment level rather than on overinvestment levels.

2 This reexamination can help alleviate confounding effects associated with the financial crisis of 2007-2008, which Tsai et al.'s (2014) findings may be subject to.

3 As Milgrom and Roberts (1992) identified, an executive compensation problem involves cash-based compensation, i.e., base salaries and annual bonuses, and equity-based compensation, i.e., stock options and stock awards. Cash compensation is paid as a short-term lump sum at the end of the financial year. In contrast, equity-based compensation is referred to as a long-term incentive plan that tends to better link executive compensation to shareholders' interests because the value of inducement is directly related to the firm's future stock price (Lewellen et al. 1992).

whether executive equity-based compensation can serve as a key means of mitigating R&D overinvestment driven by R&D capitalization.

Using a sample of listed firms in the U.S. software industry for 2001-2011, capitalized R&D data are manually collected from firms' annual financial reports. Our results indicate that more R&D capitalization may drive firms to invest in a higher level of R&D than would be expected. Moreover, the results indicate that the relationship between R&D capitalization and the degree of R&D overinvestment is negatively moderated by executive equity-based compensation. This implies that equity-based compensation is effective to some degree in mitigating R&D capitalization-driven agency problems. Through additional analyses, we find no apparent relationship between excess R&D investment and future performance. This additional result alleviates concerns regarding whether our finding of a positive relationship between R&D overinvestment and R&D capitalization is caused by a firm's superior R&D capabilities, which may simultaneously spur more R&D investment and R&D capitalization. In addition, we rerun our main models by additionally including a lagged dependent variable to control for endogeneity concerns. The results of our additional analyses are qualitatively the same and thus the conclusions of this study are robust in terms of potential alternative explanations.

This study contributes to related literature on R&D capitalization as well as on executive equity-based compensation. First, regarding R&D capitalization-related agency problems, many prior studies focus on accounting choices made regarding R&D expenditures in terms of capitalizing and expensing to boost short-term reported earnings. This study offers evidence of subsequent overinvestment behaviors associated with R&D capitalization for the U.S. software industry.[4] Such evidence sheds light on the other kind of agency problem caused by R&D capitalization decisions and, in turn, provides implications for investors and regulators in assessing the consequences of R&D capitalization. Next, relative to previous research empirically demonstrating negative impacts of equity-based incentives on financial reporting quality, i.e., accounting decisions, we examine the impact on R&D investment decisions. Our finding provides insight into the positive role of executive equity-based compensation in mitigating R&D overinvestment driven by R&D capitalization, as suggested by agency theory. This helps us better understand the benefits of equity-based incentive in a context of R&D capitalization, which serves as a potential mechanism for suppressing opportunistic investment behavior. Accordingly, such evidence is of value to firms' compensation committees in arranging executive compensation structure to align shareholders' and managers' interests.

[4] Our evidence is built on an archival dataset covering a longer period, which aids in complementing Seybert's (2010, 2016) experimental evidence and Tsai et al.'s (2014) archival evidence generated from a limited research period.

The remainder of this paper is organized as follows. In Section II we summarize the relevant literature and propose our hypotheses. Section III describes our research design, including the research sample, variable definitions and empirical models used. In Section IV we present our empirical results and additional analysis. Finally, Section V presents this study's conclusions and a summary of our findings and outlines avenues for future work.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Accounting for R&D Costs under U.S. GAAP

As it is uncertain whether R&D expenditures are associated with future economic benefits, the U.S. standard setter issued SFAS No.2 "Accounting for Research and Development Costs," which recommends that all R&D expenditures be expensed when incurred. The full expensing rule does not apply to the software cost defined in SFAS No.86. In 1985, the U.S issued SFAS No. 86 "Accounting for the Costs of Computer Software to Be Sold, Leased, or Otherwise Marketed." This standard calls for a different accounting treatment of software development costs. Specifically, firms are allowed to capitalize software development costs until technological feasibility has been achieved.

2.2 Prior Evidence of Agency Problems Associated with R&D Underinvestment

Shareholders are allowed to diversify away firm specific risks because of holding diversified portfolios, and thus they are risk neutral with respect to the firm's investment decisions. In contrast, executives are often risk averse because their reputational and human capital is closely tied to firm performance. Given differences in their risk preferences, risk-averse managers may pursue their own benefits by making suboptimal investment decisions at the expense of shareholders (e.g., Jensen and Meckling 1976; Fama 1980). This is particularly the case for R&D investments due to the uncertainty of future benefits (e.g., Chan, Lakonishok, and Sougiannis 2001; Kothari, Laguerre, and Leone 2002), information asymmetries (e.g., Clinch 1991) and monitoring difficulties. These features cause investment in R&D activities to generate high returns together with high risks (Millet-Reyes 2004), and stock prices may not fully reflect the future benefits of R&D spending (Lev and Sougiannis 1996). In turn, executives' concerns regarding current stock price performance lead to underinvestment in R&D (Cheng 2004).

Existing accounting standards applied in the U.S. require R&D expenditures to be immediately expensed when incurred in most industries, but allow those of the software industry to be capitalized when meeting specific criteria. Therefore, given that executive compensation and job security are often affected by current accounting earnings (Murphy 1999; Dechow and Skinner 2000), they have incentives to cut long-term R&D expenditures to meet specific short-term earnings goals (e.g., Baber et al. 1991; Dechow and Sloan 1991; Bushee 1998; Roychowdhury 2006). The earnings-based compensation design, together with accounting requirements for expensing R&D, usually spurs myopic underinvestment in R&D.

2.3 Executive Equity-Based Compensation

Publicly traded firms often suffer from agency conflicts between shareholders (principal) and managers (agent) due to a separation of ownership and control (Jensen and Meckling 1976). In the agency-principal model, equity-based compensation is identified as a scheme that involves aligning the interests of managers and shareholders to mitigate agency problems (e.g., Mirrlees 1976; Jensen and Meckling 1976; Jensen 1986; Agrawal and Mandelker 1987). Nevertheless, a number of empirical studies present mixed results on interest alignment effects of equity-based incentives (overall equity compensation or option-based equity).[5]

Some prior studies support the interest-alignment view of equity-based compensation. For example, a higher proportion of equity-based compensation has been found to provide incentives to promote firm value (Kosnik and Bettenhausen 1992; Shleifer and Vishny 1997), to reduce managerial reluctance to disclose private information (Nagar, Nanda, and Wysocki 2003), to ensure better firm performance (Core and Larcker 2002; Hanlon, Rajgopal, and Shevlin 2003) and to improve business results over the long term (Frye 2004). Erickson, Hanlon, and Maydew (2006) find no consistent evidence that executive equity incentives are associated with fraud. Furthermore, Armstrong, Guay, and Weber (2010) find some evidence that accounting irregularities occur less frequently in firms in which CEOs have more equity incentives.

Regarding how executive equity compensation affects riskier long-term R&D investment, prior studies provide evidence of a positive incentive effect. For example, equity incentives are used more often in R&D intensive (Kole 1997) and information technology firms (Anderson, Banker, and Ravindran 2000). Moreover, Xue (2007) finds that firms that rely more on equity compensation for executives are more likely to perform R&D than firms that rely more heavily on accounting-based compensation. Ryan and Wiggins (2002) find that the value of executive stock options helps explain the current level of R&D expenditures. Cheng (2004) finds that R&D spending is positively related to changes in the value of CEO annual option grants in the presence of horizon and myopia problems and is insignificant in the absence of these two problems. This result suggests that CEO option compensation is effective in mitigating opportunistic reductions in R&D spending. Lerner and Wulf (2007) find that among firms with centralized R&D organizations, more long-term incentives (such as stock options and restricted stock) are

5 The current study focuses mainly on the proportion of equity compensation relative to cash compensation (the proportion of total compensation or a compensation structure decision made on cash- vs. equity-based components as explored in the prior literature). We thus do not focus on literature examining the differential effects of differential sets of equity incentives.

associated with more heavily cited patents. These incentives also appear to be associated with more patent awards and with more original patents. Erkens (2011) finds that long-term equity incentives prevent the leakage of R&D-related information. Banker, Byzalov, and Xian's (2016) recent findings also show that R&D intensive firms rely more heavily on long-term equity incentives to attract CEOs with more technology-related abilities.

Some research documents a negative impact of executives' equity-based incentives mainly associated with opportunistic financial reporting. Executives may seek to maximize the short-term value of their shares and options. In turn, they may intend to manipulate accrual earnings to boost stock prices in the short term. Several analytical papers (e.g., Stein 1989; Bar-Gill and Bebchuk 2002; Crocker and Slemrod 2005; Kadan and Yang 2016) present models to demonstrate that equity-based incentives can cause CEOs to manage earnings, though these models do not deny the incentive alignment role of equity-based incentives. Empirically there is evidence that equity incentives are positively related to abnormal accruals, which indicates that equity-based compensation motivates accrual earnings manipulation (e.g., Cheng and Warfield 2005; Bergstresser and Philippon 2006; Weber 2006; Larcker, Richardson, and Tuna 2007). Harris and Bromiley (2007) report evidence showing a positive association between equity incentives and the incidence of accounting restatements. Their results indicate that the percentage of CEO compensation delivered through stock option grants significantly influences financial misrepresentation. Similarly, Johnson, Ryan, and Tian (2009) find that the likelihood of corporate fraud is positively related to incentives from unrestricted stockholdings.

Collectively, most of the above studies document a positive effect of executives' equity-based compensation while several find negative incentives to manipulate earnings for the purpose of boosting stock price. Despite such mixed effects on financial reporting quality, prior studies consistently find that relative to cash-based compensation, higher proportions of equity-based compensation are used to motivate R&D-related activities.

2.4 Hypothesis Development

2.4.1 Alternative agency problem induced by R&D capitalization: overinvestment in R&D

The agency problem related to underinvestment in R&D has received much attention in the accounting literature. Nevertheless, Seybert (2010) documents the possibility of another form of real earnings management resulting from R&D capitalization. Specifically, he examines whether the capitalization of R&D expenditures leads to an overinvestment in continuing projects, as abandoning a capitalized project involves recognizing asset impairment, which spurs a large decrease in reported earnings that can damage managers' reputations. His evidence shows that high self-monitors (those most likely to alter their behaviors to maintain a positive image) are most likely to overinvest, suggesting that reputation concerns drive this behavior consistent with the long-standing concerns of practitioners on the consequences of R&D capitalization. In a series of interviews by Entwistle (1999), analysts and executives indicate that capitalizing R&D costs enhances the possibility of large lump-sum write-offs, further causing executives to manage future write-offs in advance. Recently, experienced executives described in Seybert (2016) suggest that abandoning a failing project has a more negative impact on stock prices when R&D is capitalized, and they personally recommend continuing such a project to avoid missing the consensus analysts' forecast. Using a sample of the U.S. software industry for a limited research period of 2007-2010, Tsai et al. (2014) find a positive relationship between capitalized R&D and subsequent overinvestment in R&D.

Moreover, the behavioral finance literature suggests that the overoptimism of investors and/or managers may spur overinvestment (Heaton 2002; Malmendier and Tate 2005). Optimistic managers who overvalue their own projects may undertake negative NPV projects when they have free cash flows. Jensen (1993) proposes that many corporate R&D investments are in fact not profitable and that investors systematically overlook this possibility. Therefore, as capitalized R&D projects may particularly draw investor attention, this study infers that managers may overinvest in capitalized R&D projects to support the market's valuation on capitalized R&D assets, thereby avoiding disappointing investors.

Taken together, given that managers may have concerns regarding their compensation, job security, and reputation and regarding investors' overvaluation of capitalized R&D assets, managers may overinvest in capitalized R&D to avoid lump-sum write-offs. Accordingly, we predict that software firms with more capitalized R&D tend to engage in more R&D overinvestment. The first hypothesis is as follows:

H1: Firms that recognize more capitalized R&D experience more overinvestment in R&D.

2.4.2 Effect of executive equity-based compensation on overinvestment in R&D induced by R&D capitalization

It is well known that R&D expenditures are viewed as a great source of future benefits and competitive advantage. However, they are also characterized by high levels of risk and by unpredictability in income, which amplifies information asymmetry and R&D-related agency problems. In addition, R&D activities are generally quite long-term-oriented in terms of inputs and outputs in contrast to managers' short-term financial goals.

We expect that, as discussed above, firms capitalizing more on R&D would have more incentives to overinvest in R&D to avoid a lump-sum write-off of R&D assets, thus avoiding a significant decline in reported earnings. This distorted investment decision will hamper firms' long-term value. In this regard, proper compensation policies can create value-increasing incentives (McKnight and Tomkins 1999). Regarding different compensation packages, agency theory suggests that equity-based compensation can better align the interests of managers and shareholders over the long-term (e.g., Jensen and Meckling 1976; Mirrlees 1976; Jensen 1986; Agrawal and Mandelker 1987) and thereby provide managers with incentives to make R&D investment decisions on behalf of shareholders. Empirically, the studies discussed above almost consistently find that relative to cash-based compensation, higher proportions of equity-based compensation are used to motivate and guide R&D related activities toward generating long-term firm value (e.g., Kole 1997; Anderson et al. 2000; Ryan and Wiggins 2002; Cheng 2004; Lerner and Wulf 2007; Erkens 2011; Banker et al. 2016). Therefore, based on this line of literature, this study considers executive equity-based compensation as a potential mechanism that alleviates R&D overinvestment driven by R&D capitalization.

We describe above the role of equity-based compensation in aligning shareholders' and managers' interests. In addition to revealing the positive impact of equity-based compensation on R&D activities, some of the studies described above show an interest-alignment effect of higher levels of equity-based compensation from other aspects. Such effects include creating incentives to promote firm value (Kosnik and Bettenhausen 1992; Shleifer and Vishny 1997) and to disclose private information (Nagar et al. 2003), improving firm performance (Core and Larcker 2002; Hanlon et al. 2003) and business results over the long-term (Frye 2004) and mitigating accounting irregularities (Armstrong et al. 2010).

However, it is also argued that managers may intend to increase short-term earnings and thereby boost stock prices to maximize the short-term value of their own shares and options. Indeed, there is evidence indicating a positive association between opportunistic accrual manipulation and equity-based compensation (e.g., Cheng and Warfield 2005; Bergstresser and Philippon 2006; Weber 2006; Larcker et al. 2007). Nevertheless, prior studies suggest that opportunistic financial reporting associated with equity compensation specifically occurs when manipulating accruals rather than when manipulating real transactions (e.g., cutting R&D expenditures). Given the long-term nature of R&D activities, it is more likely that long-term-based equity compensation better helps firms motivate managers to engage in R&D investment with firm well-being in mind than short-term-based cash compensation.[6]

[6] Prior evidence indicates that equity-based compensation causes managers' accrual manipulation to increase short-term reported earnings. Accordingly, under our setting of R&D capitalization, managers granted more equity-based compensation may keep reported earnings in mind and then intend to overinvest in specific R&D projects to avoid the subsequent write-offs of capitalized R&D. Even when this occurs, our second hypothesis will be difficult to be supported. As such, if the test for hypothesis 2 is supported, our result is strong and robust.

Based on the above discussion, the interests of managers granted more equity-based compensation are more aligned with those of shareholders' because the value of their total compensation depends more heavily on firm value. In terms of R&D investment decisions, we accordingly argue that paying managers the long-term-based compensation package, i.e., a higher proportion of equity compensation, can mitigate myopic R&D overinvestment associated with capitalized R&D to some degree. Thus, we expect that managers with greater equity-based compensation tend to take on R&D projects that indeed increase firm value and thus they are less likely to engage in R&D overinvestment activities. Accordingly, the second hypothesis is as follows:

H2: The positive relationship between R&D capitalization and R&D overinvestment is attenuated by executive equity-based compensation.

3. RESEARCH DESIGN

3.1 Regression Models

3.1.1 Test for hypothesis 1－the relationship between R&D capitalization and overinvestment in R&D

First, we test whether firm R&D capitalization is associated with subsequent overinvestment in R&D by estimating model (1). We refer to Biddle, Hilary, and Verdi (2009) and Chen, Hope, Li, and Wang (2011) to specify model (1) as follows.

$$EXRD_{i,\ t+1} = \alpha_0 + \alpha_1 RDCAP_{i,\ t} + \sum \alpha_j Control_{j,i,t} + \varepsilon_{i,\ t+1}. \tag{1}$$

Definitions of variables used in model (1) are given below.

(1) Dependent Variable－Excess R&D Investment (EXRD)

Under the hypothesis that R&D capitalization is associated with overinvestment in R&D, firms with more capitalized R&D should exhibit excess investment levels deviating from their fundamentals. To capture R&D investment decisions made after capitalizing R&D outlays, the expected R&D investment level based on fundamentals (the predicted R&D level) is estimated and the unexpected investment level is then calculated. In referring to previous studies on the determinants of R&D spending (e.g., Fedyk and Singer 2010; Qian, Zhong, and Zhong 2012), we construct the expected R&D forecasting model as follows:

$$RD_{i,\ t} = \gamma_0 + \gamma_1 RD_{i,\ t-1} + \gamma_2 TOBINQ_{i,\ t-1} + \gamma_3 \Delta SALE_{i,\ t} + \gamma_4 CF_{i,\ t} + \tau_{i,\ t}. \tag{2}$$

where $RD_{i,t}$ is R&D expenditures for firm i in year t. $RD_{i,t-1}$ is prior period R&D, which captures the persistent effect of R&D investment because firms are likely to use last year's R&D results to set the budget for the current year's R&D efforts. In addition, the lagged R&D captures a firm-specific component of R&D investment decisions not captured by the other variables of the model. $TOBINQ_{i,t-1}$ is calculated as the ratio of the sum of the market value of equity and the book value of liabilities to the book value of assets at the beginning of year t-1, capturing growth opportunities. $\Delta SALES_{i,t}$ is the change in sales, which proxies for potential funds available for R&D investment, growth in R&D spending due to the product life cycle, and R&D budgets based on sales (Berger 1993). $CF_{i,t}$ is a measure of firm-level cash flows capturing differences in internal financing capability. In this work, when firms do not report R&D expenditures, we treat this as a zero reported amount and not as a missing value to maintain the sample size (Kothari et al. 2002; Francis, Huang, Rajgopal, and Zang 2008). All variables except for Tobin's Q are scaled by beginning-of-year total assets to minimize heteroskedasticity problems.

In addition, following McNichols and Stubben (2008) a modified version of model (2) is also employed as shown in model (3). This version allows for variation in the relationship between R&D investment and Tobin's Q. Residual investment is measured incremental to the persistent portion of the prior year's investment. The R&D investment model is estimated separately for each year, which implicitly assumes that the responsiveness of R&D investment to investment opportunities measured by Tobin's Q is constant across firms for the same year. However, Abel and Eberly (2011) show that adjustment costs are not linear and thus that the relationship between investment and Tobin's Q is a function of Tobin's Q. Therefore, we also modify model (2) to include incremental coefficients for the quartiles of Tobin's Q.

$$\begin{aligned} RD_{i,\,t} = {} & \theta_0 + \theta_1 RD_{i,\,t-1} + \theta_2 Q_{i,\,t-1} + \theta_3 Q\_QRT2_{i,\,t-1} + \theta_4 Q\_QRT3_{i,\,t-1} + \theta_5 Q\_QRT4_{i,\,t-1} \\ & + \theta_6 \Delta SALE_{i,\,t} + \theta_7 CF_{i,\,t} + \eta_{i,t}. \end{aligned} \quad (3)$$

where $Q\_\ QRT2_{i,\,t-1}$ ($Q\_\ QRT3_{i,\,t-1}$, $Q\_\ QRT4_{i,t-1}$) is equal to $Q_{i,t-1}$ times an indicator variable which is equal to 1 if $Q_{i,t-1}$ is in the second (third or fourth) quartile of its year distribution. We also allow the intercept, θ_0, to vary across the quartiles of $Q_{i,t-1}$.

R&D overinvestment is measured as the excess R&D investment level (*EXRD*), which is calculated as the difference between expected and actual R&D. We calculate two proxies for expected R&D using the given firm's actual accounting measures and coefficients estimated from its corresponding year t in models (2) and (3). Then, a firm's unexpected R&D is constructed by subtracting the predicted R&D from the actual R&D. Specifically, we use the residuals as a firm-specific proxy for deviations from expected R&D investment. A higher value of *EXRD* suggests a higher degree of overinvestment.

(2) Primary Independent Variable-R&D Capitalization (RDCAP)

RDCAP denotes the capitalized R&D assets of firm i in fiscal year t and is scaled by lagged total assets. According to hypothesis 1, we predict that firms with more capitalized

R&D will be more likely to overinvest in R&D and thus that the coefficient on *RDCAP* will be positively significant (α_1>0).

(3) Control Variables

Following prior studies (e.g., Biddle et al. 2009; Chen et al. 2011), we use several control variables that may confound our regression findings. First, we use three cash-related variables (*CashAT, CFOSale,* and *Slack*) to control the effect of financial constraints on investment behavior. *CashAT* is the ratio of cash to total assets. *CFOSale* is the ratio of cash flows from operations to sales. *Slack* is the ratio of cash to property, plant and equipment (PP&E).

Second, as firms may adopt different investment decisions in various stages of the business cycle, we use the length of the operating cycle (*OperatingCycle*) and the frequency of losses (*Loss*) as two proxy variables. *OperatingCycle* is the log of receivables to sales plus inventory to the cost of goods sold multiplied by 360. *Loss* is an indicator variable equal to one if the net income before extraordinary items is negative and equal to zero otherwise.

Third, we control several firm specific characteristics related to investment decisions. *LNTA* is the log of total assets, which proxies for size effects. *MTB* is the market-to-book value of total assets capturing growth opportunities. *Zscore* is a measure of bankruptcy risk, which is calculated according to Biddle and Hilary (2006) and Biddle et al. (2009).[7] A higher Z-score implies a lower probability of a corporate default and in turn a higher level of financial health. *Tangibility* is the ratio of PP&E to total assets. *Kstructure* is the ratio of long-term debt to the sum of long-term debt and the market value of equity, capturing the effect of firm leverage. *Dividend* is the dividend payout ratio, which is measured by an indicator variable equal to one when a firm has paid a dividend and equal to zero otherwise. As such, we introduce a control variable, *RDDummy*, which is set to one when *RDCAP* is missing and which is set to zero otherwise (Kothari et al. 2002; Biddle et al. 2009). Finally, we control year fixed effects and winsorize all continuous variables at the 1st and 99th percentiles to mitigate effects of outliers.

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[7] Following prior studies we use a common measure, the Z-score, to capture financial distress and to thereby control for the effect of financial constraints on investment efficiency. Many studies use the measure based on Altman's (1968) formula (e.g., Cheng, Dhaliwal, and Zhang 2013; Eisdorfer, Giaccotto, and White 2013; Gomariz and Ballesta 2014; Lai, Liu, and Wang 2014; Edwards, Schwab, and Shevlin 2016; Cho, Lee, Lee, and Sohn 2017). More recently, Biddle and Hilary (2006) and Biddle et al. (2009) employed Altman's (1968) approach to measure Z-scores as follows: (3.3 × pretax income + sales + 0.25 × retained earnings + 0.5 × (current assets - current liabilities)) / total assets. This measurement is also commonly used in recent papers examining investment efficiency (e.g., Lara, Osma, and Penalva 2016; Chen, Xie, and Zhang 2017). In this study, we use the Z-score, based on Biddle and Hilary (2006) and Biddle et al. (2009), to control for the effect of financial distress on investment efficiency. We also adopt Altman's (1968) formula to measure Z-scores, and our results remain qualitatively the same as a result.

3.1.2 Test for hypothesis 2: the effect of executive equity-based compensation on overinvestment in R&D induced by R&D capitalization

Model (4) is used to examine whether executive equity-based compensation moderates the relationship between the R&D capitalization and R&D investment deviations.

$$EXRD_{i,\,t+1} = \beta_0 + \beta_1 RDCAP_{i,\,t} + \beta_2 EComp_{i,\,t} + \beta_3 RDCAP \times EComp_{i,\,t} + \sum \beta_j Control_{j,i,t} + \upsilon_{i,\,t+1}. \quad (4)$$

In addition to the variables included in model (1), model (4) includes individual term *EComp* (executive equity-based compensation) and interaction term *RDCAP×EComp*. In particular, *RDCAP×EComp* is used to test for the moderating effect of executive equity-based compensation. Executive equity-based compensation (*EComp*) is defined as the ratio of option and share compensation to total compensation. Based on hypothesis 2, it is expected that executive equity-based compensation will alleviate the relationship between R&D capitalization and the degree of R&D overinvestment. Accordingly, the coefficient on *RDCAP×EComp* is expected to be negative (i.e., $\beta_3<0$).

All variables used are described in Table 1.

Table 1 Variable Definitions

Variables	Definitions
Dependent Variable	
EXRD1	The excess R&D investment level estimated by Equation (2).
EXRD2	The excess R&D investment level estimated by Equation (3).
Independent Variable	
RDCAP	Capitalized R&D assets scaled by lagged total assets.
Moderating Variable	
EComp	The ratio of option and share compensation to total compensation.
Control Variables	
CashAT	The ratio of cash to total assets.
CFOSale	The ratio of cash flows from operations to sales.
Slack	The ratio of cash to PP&E.
OperatingCycle	The log of receivables to sales plus the inventory to the cost of goods sold multiplied by 360.
Loss	An indicator variable equal to one when net income before extraordinary items is negative and equal to zero otherwise.
LNTA	The log of total assets.
MTB	The market-to-book value of total assets.
Zscore	(3.3 × pretax income + sales + 0.25 × retained earnings + 0.5 × (current assets - current liabilities)) / total assets.
Tangibility	The ratio of PP&E to total assets.
Kstructure	The ratio of long-term debt to the sum of long-term debt to the market value of equity.
Dividend	An indicator variable that equal to one if the firm paid a dividend and equal to zero otherwise.
RDDummy	An indicator variable equal to one if *RDCAP* is missing and equal to zero otherwise.

3.2 Data and Sample Selection

We use a sample of U.S. listed firms in the software industry (i.e., SIC codes 7370 to 7374) for 2001 to 2011. Financial and stock-related data are retrieved from the COMPUSTAT and Center for Research in Security Prices (CRSP) databases, respectively. As COMPUSTAT does not provide data on R&D capitalization, we manually collect R&D capitalization data from firms' annual reports stored in the SEC Edgar database. For executive compensation data used to test H2, we use related data from the ExecuComp database.

Based on several sample selection criteria, the final sample for H1 includes 5,421 firm-year observations. Furthermore, after excluding firm-years without executive compensation data, the total number of firm-year observations for testing hypothesis 2 is 1,239. The sample selection approach used is described in Table 2.

Table 2 Sample Selection

Sample selection	Firm-Years (2001-2011)
Initial sample	9,140
Less:	
Missing data for estimating EXRD	(1,993)
Firm-years with negative book values of equity	(1,399)
Missing financial data	(327)
Final sample for testing H1	5,421
Less:	
Firm-years without executive equity-based compensation data	(4,182)
Final sample for testing H2	1,239

4. EMPIRICAL ANALYSIS

4.1 Descriptive Statistics and Correlation Analyses

Panel A of Table 3 provides descriptive statistics of variables examined in the study. The means (medians) of one-year-ahead *EXRD1* and *EXRD2* are -0.0002 (-0.0057) and -0.0001 (-0.0043), respectively. The results of these two variables are similar.[8] The mean R&D capitalization value is equal to 0.91% for prior years' assets. On average, the ratio of executive options and share compensation to total compensation is 45.87%.

[8] The expected R&D investment levels are estimated by Equations (2) and (3) for each year. The mean adjusted R^2 values of Equations (2) and (3) are 73.49% and 74.14%, respectively. Model *F*-values are significant at the 1% level, indicating that each model is well specified (untabulated).

Table 3 Descriptive Statistics

Panel A: Descriptive statistic for the full sample

Variable	N	Mean	Lower Quartile	Median	Upper Quartile	Standard Deviation
EXRD1	5,421	-0.0002	-0.0153	-0.0057	0.0120	0.0304
EXRD2	5,421	-0.0001	-0.0140	-0.0043	0.0118	0.0271
RDCAP	5,421	0.0091	0.0000	0.0000	0.0000	0.0297
EComp	1,239	0.4587	0.3226	0.4817	0.6097	0.2178
CashAT	5,421	0.2583	0.1054	0.2111	0.3700	0.1970
CFOsale	5,421	-0.0857	-0.0793	0.0716	0.1834	0.5672
Slack	5,421	6.0889	1.3489	3.4271	8.0746	6.8004
OperatingCycle	5,421	4.3415	4.0366	4.3701	4.7042	0.7031
Loss	5,421	0.4820	0.0000	0.0000	1.0000	0.4997
LNTA	5,421	4.6736	3.2247	4.6269	5.9680	2.0381
MTB	5,421	4.3241	1.4255	2.5490	4.7136	6.0280
Zscore	5,421	-0.0251	-0.3124	0.7384	1.3351	2.6687
Tangibility	5,421	0.0857	0.0312	0.0572	0.1068	0.0884
Kstructure	5,421	0.0508	0.0000	0.0001	0.0416	0.1100
Dividend	5,421	0.1727	0.0000	0.0000	0.0000	0.3780
RDDummy	5,421	0.8043	1.0000	1.0000	1.0000	0.3968

Panel B: Descriptive statistics for subsamples with low and high levels of R&D capitalization

	(1) Low_*RDCAP*			(2) High_*RDCAP*			Difference Tests (1)-(2)	
Variable	N	Mean	Median	N	Mean	Median	Mean *t*-statistics	Median Wilcoxon
EXRD1	459	0.0034	-0.0032	460	0.0047	-0.0006	-0.61	-0.67
EXRD2	459	0.0030	-0.0014	460	0.0045	-0.0006	-0.79	-0.62
CashAT	459	0.2438	0.1974	460	0.2263	0.1845	1.55	1.21
CFOsale	459	0.0643	0.1130	460	0.0099	0.0988	2.21**	2.54***
Slack	459	5.4361	3.1456	460	5.2494	3.1632	0.48	0.29
OperatingCycle	459	4.3355	4.3676	460	4.2600	4.3703	1.67*	1.13
Loss	459	0.3508	0.0000	460	0.5022	1.0000	-4.69***	-4.64***
LNTA	459	5.5105	5.5113	460	4.3560	4.1577	9.77***	9.43***
MTB	459	4.1163	2.7074	460	4.4833	2.6590	-1.02	0.78
Zscore	459	0.5896	0.9246	460	0.1684	0.7216	3.29***	2.90***
Tangibility	459	0.0895	0.0603	460	0.0865	0.0594	0.53	0.94
Kstructure	459	0.0658	0.0012	460	0.0571	0.0030	1.15	-0.64
Dividend	459	0.1917	0.0000	460	0.1717	0.0000	0.78	0.78
EComp	124	0.4449	0.4791	124	0.4553	0.4918	-0.38	-0.29

Notes: Variable definitions are shown in Table 1.

In this study, only roughly 16.95% (919/5421) of sample firms recognize R&D assets. For these firms, we show descriptive statistics of related variables for high-capitalization (High_*RDCAP*) and low-capitalization (Low_*RDCAP*) groups in panel B of Table 3. These two groups are divided by the median of R&D capitalization. Most variables are not significantly different between these two groups except for firm size (*LNTA*), operation cash flows from each dollar sales (*CFOsale*), the frequency of losses (*Loss*), and Z scores. Specifically, the high-capitalization group exhibits more frequent losses, lower operation cash flows from dollar sales, and lower Z scores (lower levels of financial health). These results imply that, on average, high-capitalization firms may have higher R&D expenditures and then experience a significant decrease in earnings, an increase in operating cash outflows and thereby a lower Z score.

Table 4 shows Pearson (upper diagonal) and Spearman (lower diagonal) correlations for the dependent and independent variables. As predicted, R&D capitalization (*RDCAP*) is significantly and positively correlated with excess R&D investment (*EXRD1* and *EXRD2*), indicating that firms with more capitalized R&D are more likely to overinvest in R&D. Regarding correlations among the independent variables, we find no signs of collinearity. To further investigate this issue, the variance inflation factor is calculated for the latter regression results.

Table 4 Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 *EXRD1*	1.000	0.936***	0.075***	-0.010	0.111***	0.093***	0.066***	0.010	-0.072***	-0.026*	0.024*	0.087***	-0.044***	-0.076***	-0.030**	-0.093***
2 *EXRD2*	0.915***	1.000	0.080***	-0.026	0.085***	0.086***	0.056***	0.021	-0.053***	-0.018	-0.034**	0.082***	-0.044***	-0.062***	-0.039***	-0.091***
3 *RDCAP*	0.081***	0.076***	1.000	-0.039	-0.067***	0.050***	-0.051***	-0.033**	0.017	-0.081***	0.000	0.015	0.009	0.023*	-0.008	-0.391***
4 *Ecomp*	0.002	-0.030	-0.016	1.000	-0.045	0.163***	-0.024	-0.046	-0.130***	0.368***	0.080***	-0.003	-0.016	0.066**	0.043	-0.059**
5 *CashAT*	0.126***	0.095***	-0.041***	-0.028	1.000	-0.165***	0.664***	-0.180***	0.043***	-0.196***	0.130***	-0.146***	-0.137***	-0.279***	-0.067***	0.048***
6 *CFOsale*	0.165***	0.110***	0.096***	0.240***	-0.001	1.000	-0.062***	-0.154***	-0.445***	0.398***	-0.148***	0.656***	-0.084***	0.021	0.039***	-0.140***
7 *Slack*	0.125***	0.102***	-0.037***	-0.001	0.730***	0.044***	1.000	-0.066***	-0.041***	-0.155***	0.049***	-0.029**	-0.458***	-0.198***	-0.068***	0.046***
8 *OperatingCycle*	0.018	0.033**	-0.022	-0.048*	-0.163***	-0.115***	-0.067***	1.000	0.027*	0.033**	-0.028**	-0.011	-0.045***	0.022*	0.018	0.005
9 *Loss*	-0.090***	-0.053***	-0.042***	-0.128***	0.027**	-0.654***	-0.039***	0.014	1.000	-0.397***	0.049***	-0.490***	0.101***	0.043***	-0.116***	0.109***
10 *LNAT*	0.031**	0.013	0.049***	0.384***	-0.146***	0.518***	-0.111***	0.043***	-0.405***	1.000	-0.217***	0.389***	-0.026*	0.172***	0.141***	-0.094***
11 *MTB*	0.104***	-0.047***	0.026*	0.154***	0.154***	0.182***	0.068***	-0.034**	-0.147***	-0.008	1.000	-0.220***	0.046***	-0.090***	0.026*	0.013
12 *Zscore*	0.058***	0.029**	0.038***	-0.031	-0.066***	0.576***	-0.056***	-0.027**	-0.681***	0.340***	0.089***	1.000	-0.110***	-0.017	0.029**	-0.105***
13 *Tangibility*	-0.038***	-0.039***	0.028**	-0.013	-0.085***	-0.050***	-0.697***	-0.050***	0.075***	0.042***	0.057***	0.016	1.000	0.159***	0.065***	0.000
14 *Kstructure*	-0.070***	-0.067***	0.079***	0.111***	-0.350***	-0.010	-0.354***	0.063***	0.026*	0.174***	-0.064***	-0.066***	0.172***	1.000	0.106***	-0.003
15 *Dividend*	-0.042***	-0.047***	0.010	0.047*	-0.078***	0.098***	-0.098***	0.014	-0.116***	0.111***	0.079***	0.111***	0.066***	0.091***	1.000	-0.043***
16 *RDDummy*	-0.128***	-0.116***	-0.502***	-0.067**	0.019	-0.180***	0.021	0.000	0.109***	-0.098***	-0.047***	-0.079***	-0.027**	-0.035**	-0.043***	1.000

Notes: 1. Pearson correlations are shown in the upper diagonal and Spearman correlations are shown in the lower diagonal.
2. *, **, *** denote two-tailed significance at the 0.10, 0.05, and 0.01 levels, respectively.
3. Variable definitions are shown in Table 1.

4.2 Empirical Results for the Relationship Between R&D Capitalization and R&D Overinvestment

Table 5 presents regression results for hypothesis 1. Adjusted R^2 values of the models range from 3 to 22 percent and are well specified (significant at the 1% level). The main variable of interest is individual term *RDCAP*. Regarding results of the full sample, *RDCAP* is significantly and positively related to *EXRD1* (coefficient = 0.051, significant at the 1% level) and *EXRD2* (coefficient = 0.050, significant at the 1% level), as predicted by hypothesis 1. This result is consistent with the notion that a firm's R&D capitalization will lead to overinvestment in continuing R&D projects, as evidenced by Seybert (2010; 2016). This evidence implies that, given the managerial concerns regarding their compensation, job security, and reputation and regarding investors' overvaluation of capitalized R&D assets, managers may overinvest in capitalized R&D to avoid a significant earnings-decreasing effect because of the subsequent lump-sum write-offs.

We further partition the full sample into over- and underinvestment firms. We define *OVER-INVT1*(*2*) as the residual of Equation 2 (3) when the residual is positive (overinvestment firms). *UNDER-INVT1*(*2*) is equal to the absolute value of the residual of Equation 2 (3) when the residual is negative (underinvestment firms). As shown in Table 5, coefficients on *RDCAP* for two overinvestment groups are significantly positive at the 1% level (coefficient = 0.032 and 0.033). This result reveals that, for overinvestment firms, overinvestment in R&D is positively associated with the level of capitalized R&D. This means that R&D overinvestment attributable to R&D capitalization exists for overinvestment subsample. However, Table 5 shows that *RDCAP* is not significantly related to *UNDER-INVT1* and *UNDER-INVT2*. That is, there is no evidence supporting that firms with R&D underinvestment make R&D overinvestment decisions on account of the level of R&D capitalization. As such, the positive association between R&D overinvestment and R&D capitalization is mainly driven by R&D overinvestment firms.

With respect to the control variables, the coefficient on *CashAT* is positive and significant in all models, indicating that firms with large cash balances are more likely to overinvest in R&D. *Slack* is negatively correlated with deviations from expected investment. The coefficient on *LNAT* is negative and significant in all models, indicating that larger firms are more cautious about making R&D investment decisions. In most models, *OperatingCycle* and *MTB* are positively associated with *EXRD1* and *EXRD2* (significant at the 10% level or below), suggesting that firms with longer operating cycles and larger market-to-book values experience more R&D overinvestment problems. Most coefficients on *Kstructure* are negative and significant, indicating that firms are less likely to overinvest in R&D when they incur more long-term debt.

Table 5 Results for the Relationship between R&D Capitalization and R&D Overinvestment

$$EXRD_{i,\,t+1} = \alpha_0 + \alpha_1 RDCAP_{i,\,t} + \sum \alpha_j Control_{j,i,t} + \varepsilon_{i,\,t+1}. \quad (1)$$

	Dependent Variables					
	Excess R&D investment is measured as the residual from Equation (2)			Excess R&D investment is measured as the residual from Equation (3)		
	Full sample	Subsample		Full sample	Subsample	
Independent Variables (Predicted Sign)	*EXRD1*	*UNDER−INVT1*	*OVER−INVT1*	*EXRD2*	*UNDER−INVT2*	*OVER−INVT2*
Intercept(?)	-0.004	0.031***	0.037***	-0.004	0.026***	0.033***
	(-1.14)	(13.10)	(7.70)	(-1.06)	(11.37)	(8.26)
***RDCAP*(+)**	**0.051*** **	**-0.002**	**0.032** **	**0.050*** **	**0.003**	**0.033*** **
	(3.02)	**(-0.18)**	**(2.07)**	**(3.32)**	**(0.21)**	**(2.51)**
RDDummy(?)	-0.005***	-0.003***	0.003**	-0.004***	-0.002***	0.001
	(-4.18)	(-2.91)	(2.27)	(-3.98)	(-2.78)	(0.70)
CashAT(?)	0.024***	0.004**	0.015***	0.018***	0.005***	0.014***
	(7.75)	(2.23)	(3.82)	(6.49)	(2.85)	(4.54)
CFOsale(?)	0.005***	-0.001*	-0.002	0.004***	-0.001**	-0.001
	(4.17)	(-1.67)	(-1.44)	(3.94)	(-2.09)	(-0.43)
Slack(?)	-0.001**	-0.001*	-0.001**	-0.001**	-0.001**	-0.001***
	(-2.54)	(-1.92)	(-2.45)	(-2.00)	(-2.21)	(-2.79)
OperatingCycle(?)	0.002***	-0.001	0.002**	0.002***	-0.001	0.001*
	(4.01)	(-0.16)	(2.34)	(4.41)	(-0.27)	(1.75)
Loss(?)	-0.002**	0.001	-0.002	-0.001	0.001	-0.002**
	(-2.43)	(1.32)	(-1.43)	(-1.35)	(0.93)	(-2.38)
LNAT(?)	-0.001***	-0.001***	-0.003***	-0.001***	-0.001***	-0.002***
	(-4.09)	(-5.83)	(-10.25)	(-3.81)	(-2.67)	(-8.48)
MTB(?)	0.001	0.001***	0.001***	-0.001**	0.001***	0.001***
	(1.45)	(2.81)	(3.53)	(-2.46)	(4.11)	(4.29)
Zscore(?)	0.001***	-0.001***	0.001***	0.001**	-0.001**	0.001**
	(2.64)	(-3.50)	(4.09)	(2.05)	(-2.07)	(2.08)
Tangibility(?)	-0.010**	-0.009***	0.008	-0.008*	-0.008***	-0.009
	(-2.12)	(-3.51)	(0.99)	(-1.93)	(-3.17)	(-1.60)
Kstructure(?)	-0.007**	-0.004*	-0.009	-0.006*	-0.005**	-0.003
	(-2.03)	(-1.93)	(-1.36)	(-1.81)	(-2.45)	(-0.79)
Dividend(?)	-0.002	0.001	0.002	-0.002**	0.001	0.001
	(-1.56)	(1.62)	(1.49)	(-2.10)	(1.25)	(0.64)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	5,421	3,373	2,048	5,421	3,208	2,213
Model *F* value	11.74***	41.12***	21.11***	9.47***	33.14***	22.85***
Adj. R^2	4.36%	21.49%	18.43%	3.47%	18.73%	18.51%

Notes: 1. Reported *t*-value statistics are presented in parentheses below coefficients and are corrected for heteroskedasticity and cross-sectional and time-series correlations using a two-way cluster for the firm and year levels (Petersen 2009).

2. *, **, *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively (a one-tailed test for coefficients with the predicted sign and a two-tailed test otherwise).

3. An analysis of the Variance Inflationary Factor (VIF) of each model reveals VIFs of less than 3, suggesting that multicollinearity is not an issue.

4. *OVER−INVT1(2)*=the residual from Equation 2 (3) when the residual is positive; *UNDER−INVT1(2)*=the absolute value of the residual of Equation 2 (3) when the residual is negative; other variable definitions are shown in Table 1.

4.3 Empirical Results for the Effect of Executive Equity-based Compensation on R&D Overinvestment Attributable to R&D Capitalization

Table 6 summarizes results for the moderating effect of executive equity-based compensation. Adjusted R^2 values of all of the models range between 3 and 27 percent and are well specified (significant at the 1% level). The coefficients on *RDCAP* are also positive and significant when excess R&D investment (*EXRD1* and *EXRD2*) and overinvestment variables (*OVER-INVT1* and *OVER-INVT2*) are used as dependent variables.

In Table 6, the main variable of interest is *RDCAP*×*EComp* in model (4). We find that, for the full sample, the coefficients of *RDCAP*×*EComp* are negative (coefficient = -0.651 and -0.554) and significant at the 1% level regardless of using *EXRD1* or *EXRD2* to measure R&D overinvestment. The result shows that the relationship between R&D capitalization and R&D overinvestment is attenuated by executive equity-based compensation, which is consistent with the perspective of agency theory. Specifically, this evidence is in line with prior research that higher proportions of equity-based compensation are used to motivate and guide R&D related activities toward generating long-term firm value (e.g., Banker et al. 2016). In addition, our evidence supports the interest-alignment effect of equity-based compensation in a context of mitigating R&D overinvestment driven by R&D capitalization. This evidence is consistent with prior research demonstrating positive effects of executive equity-based compensation on firm value (e.g., Shleifer and Vishny 1997), firm performance (Core and Larcker 2002; Hanlon et al. 2003) and mitigated accounting irregularities (Armstrong et al. 2010).

We further partition the full sample into over- and underinvestment firms. For underinvestment firms, we do not find significant evidence supporting hypothesis 2 when excess R&D investment is measured as the residual from Equation (2). When excess R&D investment is measured as the residual from Equation (3), the coefficients on *RDCAP*×*EComp* are the same negative for *UNDER-INVT2* and *OVER-INVT2* but are only significant for the overinvestment group. Therefore, the results of subsamples, shown in Table 6, reveal that the mitigation effect of executive equity compensation on R&D overinvestment mainly exists for R&D overinvestment firms.

Table 6 Results for the Effect of Executive Equity-based Compensation on R&D Overinvestment Attributable to R&D Capitalization

$$EXRD_{i,t+1} = \beta_0 + \beta_1 RDCAP_{i,t} + \beta_2 EComp_{i,t} + \beta_3 RDCAP \times EComp_{i,t} + \sum \beta_j Control_{j,i,t} + \upsilon_{i,t+1}. \quad (4)$$

	Dependent Variables					
	Excess R&D investment is measured as the residual from Equation (2)			Excess R&D investment is measured as the residual from Equation (3)		
	Full sample	Subsample		Full sample	Subsample	
Independent Variables (Predicted Sign)	*EXRD1*	*UNDER−INVT1*	*OVER−INVT1*	*EXRD2*	*UNDER−INVT2*	*OVER−INVT2*
Intercept(?)	-0.014*	0.022***	0.034***	-0.009	0.019***	0.030***
	(-1.70)	(4.54)	(3.48)	(-1.17)	(3.80)	(3.60)
***RDCAP*(+)**	**0.301*** **	**0.059**	**0.084* **	**0.270*** **	**0.077**	**0.104** **
	(4.17)	**(0.86)**	**(1.31)**	**(4.35)**	**(1.13)**	**(2.10)**
***Ecomp*(-)**	**0.005* **	**0.001**	**-0.003**	**0.005* **	**0.001**	**0.003**
	(1.47)	**(0.47)**	**(-0.41)**	**(1.51)**	**(0.67)**	**(0.52)**
***RDCAP×Ecomp*(-)**	**-0.651*** **	**-0.100**	**-0.138**	**-0.554*** **	**-0.150**	**-0.243** **
	(-3.60)	**(-0.63)**	**(-0.76)**	**(-3.47)**	**(-0.98)**	**(-1.73)**
RDDummy(?)	-0.001	0.002	0.004*	0.001	0.001	0.002
	(-0.25)	(1.45)	(1.70)	(0.34)	(0.70)	(0.95)
CashAT(?)	0.006	0.005	0.020**	0.004	0.007	0.014*
	(0.81)	(0.96)	(2.24)	(0.53)	(1.23)	(1.83)
CFOsale(?)	0.009	-0.007**	-0.014**	0.007	-0.006	-0.005
	(1.06)	(-1.98)	(-2.06)	(1.05)	(-1.44)	(-0.88)
Slack(?)	0.001	-0.001	-0.001	0.001	-0.001	-0.001**
	(0.96)	-0.640)	(-1.05)	(0.75)	(-0.43)	(-2.09)
OperatingCycle(?)	0.002	0.001*	-0.001	0.002*	0.001	0.001
	(1.53)	(1.66)	(-0.80)	(1.91)	(1.30)	(0.30)
Loss(?)	0.001	-0.003**	-0.002	0.001	-0.003***	-0.003
	(0.28)	(-2.39)	(-0.67)	(0.59)	(-2.59)	(-1.25)
LNAT(?)	-0.001*	-0.001	-0.001	-0.002***	-0.001	-0.002**
	(-1.96)	(-1.05)	(-1.43)	(-3.02)	(-0.50)	(-2.31)
MTB(?)	0.001***	0.001	0.001*	0.001	0.001	0.001**
	(2.65)	(1.03)	(1.79)	(1.28)	(1.40)	(2.45)
Zscore(?)	0.001	-0.001	0.003**	0.001	-0.001	0.001
	(0.74)	(-0.58)	(2.24)	(0.31)	(-0.64)	(0.12)
Tangibility(?)	0.007	0.007	0.007	0.005	0.010	-0.009
	(0.62)	(1.02)	(0.65)	(0.53)	(1.41)	(-1.05)
Kstructure(?)	-0.009	-0.008**	-0.001	-0.002	-0.009**	-0.005
	(-1.49)	(-2.22)	(-0.13)	(-0.39)	(-2.05)	(-0.60)
Dividend(?)	-0.005***	-0.001	0.002	-0.004***	-0.001	-0.002
	(-2.62)	(-0.36)	(0.79)	(-2.65)	(-0.14)	(-0.73)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	1,239	765	474	1,239	739	500
Model *F* value	3.44***	12.23***	5.14***	2.79***	9.84***	5.49***
Adj. R^2	4.69%	26.87%	17.95%	3.48%	23.05%	18.36%

Notes: 1. Reported *t*-value statistics are presented in parentheses below coefficients and are corrected for heteroskedasticity and cross-sectional and time-series correlations using a two-way cluster of the firm and year levels (Petersen 2009).
2. *, **, *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively (a one-tailed test for coefficients with the predicted sign and a two-tailed test otherwise).
3. An analysis of the Variance Inflationary Factor (VIF) for each model reveals that all VIFs are less than 10, suggesting that multicollinearity is not an issue.
4. Variable definitions are shown in Tables 1 and 5.

4.4 Additional Analyses

4.4.1 Is the positive relationship between R&D overinvestment and R&D capitalization attributable to a firm's R&D capabilities and resulting R&D success?

A firm with stronger R&D capabilities may make more R&D investments, improving R&D outcomes and thus resulting in more R&D capitalization. This raises concerns regarding whether the positive relationship between R&D overinvestment and R&D capitalization is driven by a firm's superior R&D capabilities rather than by manager self-interest. To address this concern, we provide the following explanation and perform an additional test.

This study focuses on R&D overinvestment behavior, which is measured as the difference between firms' actual R&D levels and their expected levels of R&D activity. In considering robustness, we use two expectation models based on existing research (McNichols and Stubben 2008; Biddle et al. 2009; Abel and Eberly 2011; Chen et al. 2011) to calculate two proxies for overinvestment in R&D. The expectation model considers prior R&D level, prior sales growth, and Tobin's Q as predictors that can capture the effect of a firm's R&D capabilities on subsequent normal R&D investment decisions. Thus, it is less likely that our measurement of R&D overinvestment is related to a firm's superior R&D capabilities.

Nonetheless, expectation models are inevitably subject to issues of quality to some degree. We thus test the relationship between R&D overinvestment and future performance (ROA_{t+1} and ROE_{t+1}) to address concerns regarding whether R&D capability drives the positive relationship between excess R&D investment and R&D capitalization. As is shown in Table 7, R&D overinvestment is not significantly associated with (or even is negatively associated with) one-year-ahead accounting performance while R&D capitalization (*RDCAP*) presents a significantly positive association. In particular, the coefficient of $EXRD \times RDCAP$ is significantly negative, suggesting that performance attributable to R&D capitalization declines with the level of R&D overinvestment. This result shows that our finding of a positive relationship between R&D capitalization and subsequent "overinvestment" in R&D is less likely driven by a firm's superior R&D capabilities and resultant R&D success.

4.4.2 Potentially simultaneous nature of the relationship between R&D overinvestment and R&D capitalization

There is another concern that overinvestment in R&D may lead to greater R&D success and in turn in greater R&D capitalization. That is, our finding of a positive relationship between R&D capitalization and R&D overinvestment may be driven by the simultaneous nature of this relationship. As our models are based on the relationship between current-period R&D capitalization and next-period overinvestment in R&D, this simultaneity problem may be less serious. Nevertheless, to further check for robustness, we follow prior studies (Klein 1998; Weir, Laing, and McKnight 2002) by introducing a lagged dependent variable into the model[9] to mitigate endogeneity caused by the potential simultaneous nature of the relationship between R&D overinvestment and R&D capitalization. Test results for H1 and H2 are shown in Tables 8 and 9, respectively. All of the results show that inferences drawn from the results presented above remain unchanged. Hence, the findings reported in this work are robust to endogeneity issues.

Table 7 Results for the Relationship between R&D Overinvestment Attributable to R&D Capitalization and Future Performance

$$ROA(ROE)_{i,t+1} = \alpha_0 + \alpha_1 EXRD_{i,t} + \alpha_2 RDCAP_{i,t} + \alpha_3 \text{EXRD} \times RDCAP_{i,t} + \alpha_4 ROA(ROE)_{i,t} + \alpha_y YR_y + \varepsilon_{i,t+1}. \quad (5)$$

	Dependent Variables			
	Excess R&D investment is measured as the residual from Equation (2)		Excess R&D investment is measured as the residual from Equation (3)	
Independent Variables (Predicted Sign)	ROA_{t+1}	ROE_{t+1}	ROA_{t+1}	ROE_{t+1}
Intercept(?)	-0.009	0.030	-0.009	0.029
	(-1.12)	(1.43)	(-1.10)	(1.40)
EXRD(-)	-0.046	-0.060	-0.076	-0.383**
	(-0.62)	(-0.30)	(-0.92)	(-1.74)
RDCAP(+)	0.335*	1.417***	0.312*	1.572***
	(1.53)	(2.43)	(1.41)	(2.66)
***EXRD*×*RDCAP*(-)**	**-5.781*****	**-11.744****	**-5.941****	**-12.788***
	(-2.50)	**(-1.90)**	**(-2.04)**	**(-1.64)**
ROA_t(+)	0.774***		0.773***	
	(86.70)		(86.57)	
ROE_t(+)		0.380***		0.381***
		(37.00)		(37.15)
Year Dummy	Yes	Yes	Yes	Yes
N	4,959	4,960	4,957	4,958
Model *F* value	592.34***	117.66***	591.06***	118.90***
Adj. R^2	62.54%	24.78%	62.50%	24.98%

Notes: 1. Reported *t*-value statistics are shown in parenthesis below coefficients and are corrected for heteroskedasticity and cross-sectional and time-series correlation using a two-way cluster for the firm and year levels (Petersen 2009).
2. *, **, *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively (a one-tailed test for coefficients with the predicted sign and a two-tailed test otherwise).
3. An analysis of the Variance Inflationary Factor (VIF) for each model reveals that all VIFs are less than 3, suggesting that multicollinearity is not an issue.
4. *ROA*=net income before extraordinary items divided by total assets; *ROE*=net income before extraordinary items divided by total equity; YR_y are represented as the year fixed effects. Other variable definitions are shown in Tables 1.

9 The two-stage least squares method is a basic technique used to address issues of simultaneity. However, similar to that used in Weir et al. (2002), our model is constructed such that subsequent overinvestment in R&D is dependent on the current period's R&D capitalization, which is impossible to determine based on future R&D overinvestment. Thus, the two-stage least square approach is not appropriate to use in this study.

Table 8 Results for the Relationship between R&D Capitalization and R&D Overinvestment after Including a Lagged Dependent Variable

	Dependent Variables					
	Excess R&D investment is measured as the residual from Equation (2)			Excess R&D investment is measured as the residual from Equation (3)		
	Full sample	Subsample		Full sample	Subsample	
Independent Variables (Predicted Sign)	*EXRD1*	*UNDER−INVT1*	*OVER−INVT1*	*EXRD2*	*UNDER−INVT2*	*OVER−INVT2*
Intercept (?)	-0.003	0.030***	0.035***	-0.003	0.027***	0.031***
	(-0.74)	(12.29)	(6.91)	(-0.83)	(10.68)	(7.50)
RDCAP(+)	**0.055*****	**0.001**	**0.038*****	**0.051*****	**-0.001**	**0.034*****
	(3.19)	**(0.10)**	**(2.47)**	**(3.40)**	**(-0.02)**	**(2.60)**
RDDummy(?)	-0.001	-0.001	0.004***	-0.001	-0.001	0.001
	(-0.99)	(-1.01)	(2.94)	(-1.04)	(-1.26)	(1.12)
CashAT(?)	0.019***	0.005***	0.017***	0.014***	0.007***	0.015***
	(5.84)	(2.62)	(4.02)	(4.78)	(3.26)	(4.60)
CFOsale(?)	0.005***	-0.002**	-0.002	0.004***	-0.002***	-0.001
	(4.07)	(-2.26)	(-1.15)	(3.73)	(-3.17)	(-0.24)
Slack(?)	-0.001**	-0.001*	-0.001***	-0.001	-0.001**	-0.001***
	(-2.39)	(-1.83)	(-2.88)	(-1.60)	(-2.31)	(-2.88)
OperatingCycle(?)	0.002***	-0.001	0.002**	0.002***	-0.001	0.001
	(2.80)	(-0.38)	(2.12)	(3.30)	(-0.89)	(1.47)
Loss(?)	-0.003***	0.001	-0.002	-0.002**	0.001	-0.002**
	(-3.34)	(0.68)	(-1.62)	(-2.37)	(0.46)	(-2.31)
LNAT(?)	-0.001***	-0.001***	-0.003***	-0.001***	-0.001*	-0.002***
	(-4.74)	(-5.17)	(-9.90)	(-4.50)	(-1.68)	(-8.61)
MTB(?)	0.001***	0.001**	0.001***	-0.001	0.001***	0.001***
	(2.98)	(2.27)	(3.63)	(-0.35)	(4.31)	(5.09)

Table 8 Results for the Relationship between R&D Capitalization and R&D Overinvestment after Including a Lagged Dependent Variable (Continued)

Independent Variables (Predicted Sign)	Dependent Variables					
	Excess R&D investment is measured as the residual from Equation (2)			Excess R&D investment is measured as the residual from Equation (3)		
	Full sample	Subsample		Full sample	Subsample	
	EXRD1	*UNDER−INVT1*	*OVER−INVT1*	*EXRD2*	*UNDER−INVT2*	*OVER−INVT2*
Zscore(?)	0.001**	-0.001***	0.001***	0.001**	-0.001	0.001**
	(2.23)	(-3.19)	(3.32)	(1.98)	(-1.33)	(2.18)
Tangibility(?)	-0.009*	-0.006**	0.008	-0.006	-0.007**	-0.007
	(-1.82)	(-2.41)	(0.97)	(-1.49)	(-2.46)	(-1.23)
Kstructure(?)	-0.004	-0.004*	-0.008	-0.003	-0.005**	-0.002
	(-1.02)	(-1.65)	(-1.28)	(-0.95)	(-2.31)	(-0.39)
Dividend(?)	-0.002	0.001*	0.002	-0.002*	0.001	0.001
	(-1.44)	(1.82)	(1.08)	(-1.89)	(1.37)	(0.17)
Lag_EXRD(?)	0.202***	0.112***	0.069***	0.200***	0.094***	0.074***
	(10.90)	(7.48)	(3.73)	(11.27)	(6.10)	(4.29)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	4,960	3,077	1,883	4,958	2,916	2,042
Model F value	19.58***	42.43***	20.08***	16.49***	32.94***	22.77***
Adj. R^2	8.25%	24.43%	19.57%	6.98%	20.82%	20.39%

Notes: 1. Reported t-value statistics are presented in parentheses below coefficients and are corrected for heteroskedasticity and cross-sectional and time-series correlation using a two-way cluster for the firm and year levels (Petersen 2009).
2. *, **, *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively (a one-tailed test for coefficients with the predicted sign and a two-tailed test otherwise).
3. An analysis of the Variance Inflationary Factor (VIF) for each model reveals that all VIFs are less than 3, suggesting that multicollinearity is not an issue.
4. Variable definitions are shown in Tables 1 and 5.

Table 9 Results for the Effect of Executive Equity-based Compensation on R&D Overinvestment Attributable to R&D Capitalization after Including a Lagged Dependent Variable

	Dependent Variables					
	Excess R&D investment is measured as the residual from Equation (2)			Excess R&D investment is measured as the residual from Equation (3)		
	Full sample	Subsample		Full sample	Subsample	
Independent Variables (Predicted Sign)	*EXRD1*	*UNDER−INVT1*	*OVER−INVT1*	*EXRD2*	*UNDER−INVT2*	*OVER−INVT2*
Intercept (?)	-0.011	0.023***	0.034***	-0.008	0.019***	0.030***
	(-1.42)	(4.95)	(3.37)	(-1.02)	(3.81)	(3.55)
***RDCAP* (+)**	**0.221*****	**0.012**	**0.086***	**0.210*****	**0.049**	**0.093****
	(3.10)	**(0.17)**	**(1.29)**	**(3.36)**	**(0.69)**	**(1.81)**
***Ecomp* (-)**	**0.005***	**0.001**	**-0.001**	**0.006****	**0.001**	**0.003**
	(1.40)	**(0.21)**	**(-0.22)**	**(1.72)**	**(0.66)**	**(0.60)**
***RDCAP×Ecomp* (-)**	**-0.464*****	**-0.048**	**-0.151**	**-0.416*****	**-0.121**	**-0.220***
	(-2.57)	**(-0.29)**	**(-0.80)**	**(-2.57)**	**(-0.77)**	**(-1.51)**
RDDummy (?)	0.001	0.003***	0.003	0.001	0.002*	0.002
	(0.46)	(2.77)	(1.60)	(0.86)	(1.73)	(0.91)
CashAT (?)	0.007	0.006	0.019**	0.004	0.007	0.014*
	(0.93)	(1.09)	(2.15)	(0.54)	(1.29)	(1.92)
CFOsale (?)	0.007	-0.008**	-0.017***	0.005	-0.006*	-0.008
	(0.85)	(-2.56)	(-2.72)	(0.79)	(-1.85)	(-1.35)
Slack (?)	0.001	-0.001	-0.001	0.001	-0.001	-0.001**
	(0.65)	(-0.60)	(-1.11)	(0.52)	(-0.53)	(-2.03)
OperatingCycle (?)	0.001	0.001	-0.001	0.002	0.001	0.001
	(1.06)	(1.43)	(-0.82)	(1.53)	(1.09)	(0.22)
Loss (?)	-0.001	-0.003***	-0.003	0.001	-0.004***	-0.003
	(-0.11)	(-2.82)	(-0.95)	(0.12)	(-3.00)	(-1.43)
LNAT (?)	-0.001*	-0.001	-0.001	-0.002***	-0.001	-0.002**
	(-1.74)	(-0.78)	(-1.45)	(-2.77)	(-0.16)	(-2.34)

Table 9 Results for the Effect of Executive Equity-based Compensation on R&D Overinvestment Attributable to R&D Capitalization after Including a Lagged Dependent Variable (Continued)

	Dependent Variables					
	Excess R&D investment is measured as the residual from Equation (2)			Excess R&D investment is measured as the residual from Equation (3)		
	Full sample	Subsample		Full sample	Subsample	
Independent Variables (Predicted Sign)	*EXRD1*	*UNDER−INVT1*	*OVER−INVT1*	*EXRD2*	*UNDER−INVT2*	*OVER−INVT2*
MTB (?)	0.001**	0.001	0.001**	0.001	0.001	0.001**
	(2.16)	(1.08)	(2.04)	(1.02)	(1.60)	(2.50)
Zscore (?)	0.001	-0.001	0.003***	0.001	-0.001	0.001
	(0.97)	(-0.41)	(2.87)	(0.57)	(-0.47)	(0.65)
Tangibility (?)	0.005	0.013*	0.007	0.004	0.013*	-0.008
	(0.50)	(1.82)	(0.67)	(0.45)	(1.78)	(-0.91)
Kstructure (?)	-0.004	-0.009**	0.005	0.001	-0.010**	-0.001
	(-0.73)	(-2.41)	(0.46)	(0.01)	(-2.37)	(-0.13)
Dividend (?)	-0.004**	-0.001	0.001	-0.004**	0.001	-0.003
	(-2.15)	(-0.21)	(0.14)	(-2.27)	(0.19)	(-1.29)
Lag_EXRD (?)	0.203***	0.174***	0.025	0.179***	0.148***	0.052
	(5.02)	(5.38)	(0.49)	(4.60)	(4.66)	(1.17)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	1,209	744	465	1,209	721	488
Model *F* value	5.19***	15.14***	5.08***	4.13***	11.74***	5.50***
Adj. R^2	8.28%	33.10%	18.59%	6.31%	27.94%	19.35%

Notes: 1. Reported *t*-value statistics are presented in parentheses below coefficients and are corrected for heteroskedasticity and cross-sectional and time-series correlation using a two-way cluster for the firm and year levels (Petersen 2009).
2. *, **, *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively (a one-tailed test for coefficients with the predicted sign and a two-tailed test otherwise).
3. An analysis of the Variance Inflationary Factor (VIF) for each model reveals that all VIFs are less than 10, suggesting that multicollinearity is not an issue.
4. Variable definitions are shown in Tables 1 and 5.

5. CONCLUSIONS

Prior studies show that R&D expensing may lead firms to underinvest in R&D projects to reach current earnings benchmarks. Accordingly, proponents of R&D capitalization suggest that R&D expenditures capitalizing can mitigate underinvestment behavior and allow management to present more value-relevant information on R&D success. However, there is another concern that R&D capitalization may lead firms to overinvest in R&D. In the U.S., all R&D expenditures must be expensed as incurred with the exception of software costs as allowed by SFAS No.86 when R&D expenditures achieve technical feasibility. Given this, we employ a setting allowing for R&D capitalization to test overinvestment aspects of suboptimal R&D investment decisions. We also examine whether executive equity compensation may mitigate R&D overinvestment behavior induced by R&D capitalization.

Using a sample of listed firms in the software industry, this work offers empirical evidence showing that capitalizing R&D expenditures may cause managers to overinvest in R&D. This result, based on a large archival dataset, is consistent with the experimental evidence proposed by Seybert (2010; 2016), which suggests that reputation concerns and potential negative capital market consequences of project abandonment cause managers to continue failing projects when R&D is capitalized. Moreover, our results also show that the relationship between R&D capitalization and levels of R&D overinvestment is negatively moderated by executive equity-based compensation. Accordingly, executive equity-based compensation may be somewhat effective in mitigating agency problems driven by R&D capitalization. In additional analyses, we conduct several tests to ensure that our empirical results are robust to potential endogeneity concerns and competing explanations.

This study contributes to related literature on R&D capitalization as well as on executive equity-based compensation. Many prior studies focus on benefits of R&D capitalization from the aspect of value relevance. This study complements prior research by examining the potential costs of R&D capitalization-related agency problems. One agency problem that has been examined in prior research is opportunistic accounting choices for capitalizing or expensing R&D expenditures to meet specific earnings goals. This study examines the other potential agency problem associated with R&D overinvestment. With an archival dataset covering a longer period, we offer evidence of R&D overinvestment driven by R&D capitalization for the U.S. software industry, which can help remind regulators and investors to notice the potential adverse effect of corporate R&D capitalization decisions. Moreover, to the extent that contracting and control systems can mitigate such overinvestment behavior, we examine the role of executive equity-based compensation based on agency theory. Despite the negative impacts on financial reporting quality, as evidenced in prior studies, our finding supports the positive role of executive equity-based compensation in mitigating R&D overinvestment driven by R&D capitalization. This evidence helps us better understand the potential benefits of equity-based incentives in terms of suppressing opportunistic investment behavior. Therefore, such evidence is of value to firms' compensation committees in designing executive equity compensation to motivate managers' R&D investment decisions from a long-term perspective.

This study presents several limitations. First, as it examines the effect of incentive intensity arising from equity-based compensation, we restrict the sample used to test H2 to observations granted with executive equity-based compensation. In turn, due to the absence or unavailability of executive equity compensation data in the database, the number of observations may have been compromised when testing the effect of executive equity-based compensation. Furthermore, our sample is limited to observations of the U.S. software industry and thus the generalization of our empirical results to other industries is limited to a certain degree. Overall, we remind readers to view our results with caution due to our research scope and data limitations.

The concept of applying accounting requirements for capitalizing R&D expenditures associated with software costs is similar to concepts employed by IFRSs requiring that research costs are expensed while development costs can be capitalized when specific criteria are met (IASB 2004). Given this, we encourage future studies to examine this issue by focusing on an international setting in which IFRSs allow for the capitalization of R&D expenditures when specific criteria are met.

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