The Hong Kong Polytechnic University

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Corporate Governance and the Valuation of R&D

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CERTIFICATE OF ORIGINALITY

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ABSTRACT

The dissertation studies how corporate governance mechanisms influence the valuation of corporate research and development (R&D) investment.

First, I examine how internal and external corporate governance affect the equity holders' valuation of R&D. Using a sample of U.S. firms from 1998 to 2006, I find that: (1) boards that are more independent and whose independent directors have more outside directorships are associated with higher R&D valuation; (2) less anti-takeover provisions (market control mechanism) are also associated with higher R&D valuation; and (3) effective board governance (market control mechanism) is associated with higher R&D valuation only in the presence of weak market control mechanism (board governance). My results provide evidence indicating that both internal and external governance enhance R&D valuation, but they substitute in doing so.

Next, I focus on the effect of corporate board to enhance the R&D valuation. Effective corporate governance can enhance the market valuation of R&D either by increasing the expected future cash flows (numerator effect), by decreasing the cost of equity (denominator effect), or by both. Examining a sample of U.S. firms, I provide evidence suggesting that: (1) R&D expenditures are positively associated with expected future cash flows, and this positive association is higher with more effective corporate boards; and (2) firms with more R&D expenditures enjoy a lower cost of equity, and this relationship is stronger when corporate boards are more effective. My findings suggest that boards enhance R&D valuation through both increasing R&D-induced expected future cash flows and decreasing R&D-related cost of equity.

Finally, I turn my focus from equity holders to debt holders. I first examine the relationship between R&D investments and cost of debt and then further explore boards' potential influence on it. I find that firms with more R&D expenditures are associated with lower credit ratings (a higher cost of debt), and further, boards that are more independent and whose independent directors have more outside directorships are associated with a less pronounced negative relationship between R&D expenditures and credit ratings.

Keywords: Research and Development (R&D), Corporate Governance, Valuation, Expected Future Cash flows, Cost of Equity, Cost of Debt

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CHAPTER ONE

INTRODUCTION

1.1 Motivation and Objectives

In modern society, innovation is becoming increasingly important for companies to achieve and maintain competitive advantage. This is particularly true for U.S. as it is known as the powerhouse for innovation in technology and organization structure. For example, according to the 2007 R&D Scoreboard published by the U.K. government, the world's most comprehensive R&D ranking, U.S. continued to pull away from Europe and the rest of the world since its largest companies boosted their R&D investment by 13.4 percent to £98.6 billion, 40 percent of the global total (Willman Nov. 11, 2007). The rewards of innovative activities to the companies originate from the monopoly power that the sole ownership of the innovation bestows (Morck and Yeung 1999). Among the innovation activities, R&D investments are regarded as the ultimate source of technological changes and the major driver of the productivity growth (Guellec and Potterie 2004). R&D investments could bring firms a degree of monopoly power either by exploiting cheaper ways of producing existing goods and thus lower the costs, or developing new and better products which enable firms to earn excess profits (Morck and Yeung 1999). Using the monopoly power created by R&D investment, a firm could acquire market share from its non-innovative competitors yet still earn profits above the input costs, and thus manage to increase profits.

Assuming efficient capital markets, the incremental expected value created by R&D investment should be reflected as part of the current firm value. In particular, the valuation reflects the net present value of expected returns from the R&D projects undertaken as part of the investment. Using the market value[1] as an indicator of the firm's expected economic outcome from R&D investment, several empirical studies find that companies that invest more in R&D enjoy higher valuation by investors (Hirschey, and Weygandt 1985; Hall 1993; Sougiannis 1994; Aboody, and Lev 1998; Chan, Lakonishok, and Sougiannis 2001; Chambers, Jennings, and Thompson 2002).

However, R&D investments are discretionary and suffer from severe agency problems (Jensen 1993) because they are subject to high information asymmetry (Aboody and Lev 2000). The agency conflicts between managers and shareholders could be assuaged by corporate governance, which is designed to align the interests of managers and shareholders and protect investors against expropriation by insiders (Jensen and Meckling 1976). On the one hand, R&D investments of firms with better corporate governance are expected to have less agency costs and be associated with higher market valuation. On the other hand, monitoring of boards might stifle innovation and destroy the value created by R&D, leading to a lower market valuation of R&D (Baysinger, Kosnik and Turk 1991; Burkart, Gromb and Panunzi 1997; Stein 1988; Sundaramurthy 2000). As far as I am aware, few studies examine which one of these governance factors might prevail. The first part of my thesis

[1] Economics literature has argued that the market value of the firm will reflect both tangible and intangible factors which have systematic influences on future profitability. Thus, a market-value-based approach is recommended as an attractive means for determining the asset-like characteristics of advertising, R&D, and other such expenditures (Hirschey and Weygandt 1985).

(detailed in chapter two) examines how corporate governance influences the relationship between R&D investment and firm value.

Corporate governance can be broadly classified into internal and external governance mechanisms. Following prior literature, I focus on corporate boards as the internal corporate governance and the market for corporate control (antitakeover provisions, ATPs) as the external corporate governance. Since the impacts of internal/external corporate governance on R&D valuation[2] are two-sided, my research questions examined in chapter two are: (1) Do effective boards and strong corporate control markets enhance or depress the market valuation of R&D? (2) How do effective boards and strong corporate control markets interact in enhancing or depressing the market valuation of R&D?

The results indicate that both internal and external corporate governance enhance the market valuation of R&D, and further, the two mechanisms substitute each other in increasing R&D valuation.

Based on the above findings, I focus on board-based governance in chapter three and explore the sources of the increased R&D valuation accompanying effective corporate boards. Before doing so, I also examine the sources of R&D's value-enhancing effect. Specifically, I separate the effect of R&D on expected future cash flows that constitutes the numerator of the valuation model from the effect on the discount rate (i.e., the cost of equity) which constitutes denominator, and then further examine the effect of corporate boards on the above relations. The underlying assumption is that the increased

[2] I refer to the equity holder's valuation (market valuation) of R&D when I use the term "R&D valuation".

market valuation could stem from higher R&D-induced future cash flows, from lower R&D-related risk premiums, or from both of them. In sum, I investigate the following research questions: (1) Are R&D investments positively related to the expected future cash flows, and do effective boards strengthen the positive relationship between R&D and cash flows? (2) What is the relationship between R&D investments and the cost of equity, and how is this relationship affected by corporate boards?

Finally in chapter four, I turn my focus from equity holders to debt holders and extend prior studies by examining how corporate boards affect the association between R&D investments and cost of debt. Prior literature has studied in depth the benefit and riskiness of R&D outlays (Chan, Martin and Kensinger 1990; Kothari, Laguerre and Leone 2002a; Lakonishok and Sougiannis 2001). However, most of the previous studies focus on shareholder wealth effects. While recently, scholars have begun to pay attention to the impact of R&D investments on cost of debt (Eberhart, Maxwell and Siddique 2007; Shi 2003). Whether R&D investments are beneficial to debt holders depends on whether mean effect or variance effect dominates. Empirically, how corporate boards affect mean effects and variance effects and thus the association between R&D investments and cost of debt remain unexplored. Thus, in chapter four I first examine the relationship between R&D investments and cost of debt and then further explore boards' potential influence on the relationship.

1.2 Research Findings

In chapter two, I use a sample of U.S. firms from 1998 to 2006 and find that: (1) effective board governance (measured as having more independent directors and more outside directorships hold by independent directors) is associated with higher market valuation of R&D; (2) strong market control mechanism (measured as less ATPs) is also associated with higher R&D valuation; and (3) effective board governance (market control mechanism) is associated with higher R&D valuation only in the presence of weak market control mechanism (board governance). The results provide evidence that both internal and external governance mechanisms enhance the market valuation of R&D, and that they act as substitutes in doing so.

Based on a sample of U.S. firms, chapter three provides evidence suggesting that: (1) more R&D expenditures are associated with higher expected future cash flows, and this positive association is higher when corporate boards are more effective; and (2) firms with more R&D expenditures enjoy a lower cost of equity, and this favorable impact could be stronger when corporate boards are more effective. My findings suggest that boards could enhance the market valuation of R&D through both increasing R&D-induced expected future cash flows and decreasing R&D-related cost of equity.

Chapter four finds that firms with more R&D expenditures are associated with lower credit ratings (a higher cost of debt), and further, boards that are more independent and whose independent directors have more outside directorships are associated with a less pronounced negative relationship between R&D expenditures and credit ratings. The results are generally consistent with Shi's (2003) argument that the adverse effect of R&D investment on cost of debt caused by the highly risky R&D investments outweighs the favorable impact. Moreover, my results support the view that boards help lower default risk and assuage agency problems, leading to a less pronounced negative association between R&D investment and cost of debt. All of the above results appear to be robust in the sensitivity checks.[3]

1.3 Contribution

My thesis contributes to the existing literature in several ways.

First, the thesis adds to the literature on the market valuation of corporate R&D. The value-enhancing nature of R&D investment has been widely recognized by both academics and practitioners, and prior literature (Baysinger, Kosnik and Turk 1991; Burkart, Gromb and Panunzi 1997; Jensen 1993; Morck and Yeung 1999) argues that monitoring mechanisms might affect the returns from R&D investments either positively or negatively; My study is the first empirical study to provide evidence that effective monitoring mechanism enhances R&D valuation. It suggests that effective governance mechanism is a potential candidate in causing the variation across firms in the outcome of R&D investment (Pandit, Wasley and Zach 2009).

[3] The results of chapter three and chapter four indicate asymmetric impacts of R&D investments on cost of equity and cost of debt. However, such asymmetric effects of R&D investments are generally consistent with the fact that firms with more (less) R&D investments choose less debt (equity) financing.

In addition, the mechanisms underlying the value-enhancing effect of R&D have not been studied in depth. My results in chapter three indicate that R&D could potentially bring higher future cash flows and reduce the cost of equity, both of which contribute to a higher firm value.

Second, my study adds to the literature on the role of corporate governance. Prior research has demonstrated a relationship between corporate governance and several strategic decisions by a firm (Hermalin and Weisbach 2003). My thesis provides complementary evidence by focusing on a specific corporate investment (i.e., R&D) and by suggesting that effective governance can positively affect the outcome of such investment and ultimately firm value. Through this, I reconcile the debate regarding whether oversight and monitoring benefit or stifle innovation, suggesting that the benefit of monitoring on innovation activities outweighs the cost, resulting in higher corporate valuation.

Furthermore, the thesis also explores the sources of the increased R&D valuation accompanying effective board governance, which is novel in both governance and R&D valuation studies, by investigating whether the valuation increase comes from higher expected future cash flows, from lower risk, or from both of them. Thus, my study extends previous literature in exploring the mechanisms through which corporate governance influences firm value.

Third, my thesis contributes to the literature on the determinants of firm value. There are many studies examining the determinants of firm value in economics, finance and accounting areas, however, such a dichotomous analysis of the two major valuation sources, cash flows and risk premium (cost of equity) is sparse. By examining both the cash flows and risk premium, my study manages to identify the specific ways through which R&D creates firm value as well as effective boards enhance the R&D valuation, and thereby fill the niche.

Last but not least, the thesis adds to the literature on the interplay between internal and external corporate governance in value creation. Some previous studies support substitution among governance mechanisms (Agrawal and Knoeber 2001; Baber and Liang 2008; Denis and Kruse 2000; Huson, Parrino and Starks 2001) while others suggest that governance mechanisms are complementary (Cremers and Nair 2005). Adopting R&D valuation as a test setting, chapter two provides evidence of the substitution effects of the two governance mechanisms.

1.4 Thesis Structure

The rest of the thesis is structured as follows: chapter two examines the effect of corporate governance (corporate boards and corporate control markets) on the market valuation of R&D. Based on the results of chapter two, chapter three further investigates the cash flows and cost of equity effects of corporate boards on R&D valuation. Chapter four examines how corporate boards affect the association between R&D investments and cost of debt. Chapter five concludes the study.

CHAPTER TWO

CORPORATE BOARDS, CORPORATE CONTROL MARKETS, AND THE MARKET VALUATION OF R&D

2.1 Introduction

In modern society, innovations are becoming increasingly important for companies to achieve and maintain competitive advantages (Franko 1989). This is particularly true for U.S. as it is known as the powerhouse for innovation in new technology and organization structure. For example, according to the 2007 R&D Scoreboard published by the UK government, the world's most comprehensive R&D ranking, U.S. continued to pull away from Europe and the rest of the world since its largest companies boosted their R&D investment by 13.4 percent to £98.6 billion, 40 percent of the global total (Willman Nov. 11, 2007). In addition, according to the National Science Foundation's (NSF's) Survey of Industrial Research and Development, U.S. companies spend on R&D rises from 164,476 million dollars in 1998 to 213,342 million dollars in 2006 (constant dollars in 1996)[4]. Figure 1 shows the trend of the total industry R&D in recent years in U.S.

(Insert Figure 1 here)

The rewards of innovative activities to the companies originate from the

[4] Information source: http://www.nsf.gov/statistics/industry/.

monopoly power that the sole ownership of the innovation bestows (Morck and Yeung 1999). Extensively used as a measure of firm investment in innovation (Morck and Yeung 1999), R&D investments are regarded as the ultimate source of technological changes and the major driver of the productivity growth (Guellec and Potterie 2004).

The value created by R&D investment is reflected in the firm value. Such valuation recognition need not occur only after the long lag of converting an invention into the actual productivity. Instead, the firm valuation reflects the net present value of expected returns, including those from R&D projects. Using the market value as an indicator of a firm's expected economic outcome from R&D investment, a number of empirical studies document that companies that invest more in R&D enjoy higher valuation by investors (Aboody and Lev 1998; Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001; Hall 1993; Hirschey and Weygandt 1985; Sougiannis 1994).

Although the importance of innovation and corporate R&D investments in the future growth of the economy is uncontroversial, there is increasing societal and regulatory concern about the discretion accorded to managers on firm-level investments including R&D. Agency problems in R&D investments arise because managers make R&D investment decisions whereas it is the investors who reap the benefits of such investments in the long run. Managers may not always act in the best interests of investors and investors cannot perfectly monitor managerial decisions and actions regarding R&D projects (Baber, Fairfield and Haggard 1991; Bushee 1998; Hill and Snell 1988; Hillier et al. 2008). As a result, R&D investment is exposed to severe agency problems.

Partly resulting from the above reasons, in the past decades, firms' R&D performance suffered largely (Hall 1993; Jensen 1993).

Corporate governance is designed to discipline managerial behavior and reduce agency problems. Accordingly, it could affect the productivity and performance of R&D investments, and thus the market valuation of such investments. Corporate governance can be broadly classified into internal and external governance mechanisms. Following prior literature, I focus on corporate board as the internal corporate governance and market for corporate control (ATPs) as the external corporate governance; thereby investigate the relationship between firm-level corporate governance [5] and the market valuation of R&D.

The impact of board monitoring on R&D valuation can be two-sided. On the one hand, effective boards might increase R&D valuation because boards would attend to setting a suitable R&D budget, constraining managers' underinvestment or overinvestment behavior, and controlling the quality of R&D projects. By these monitoring and oversight actions by the board on R&D at the firm-level they could reduce wasteful investments on potentially unsuccessful projects and encourage investments on valuable projects, thereby improving the productivity and valuation of R&D (Jensen 1993; Morck and Yeung 1999). On the other hand, the control and oversight from the board on R&D investment might stifle innovation by overly restricting managers from developing innovative products or services (Baysinger, Kosnik and Turk 1991;

[5] In this thesis, I always refer to the firm-level governance mechanism when I use the word "corporate governance" or "governance mechanism".

Burkart, Gromb and Panunzi 1997). The lower managerial enthusiasm and lack of innovation in R&D investment would do harm to the productivity and performance of R&D projects and thus lower the R&D valuation.

The impact of market control mechanism on R&D valuation is also two-sided. On the one hand, corporate control market provides incentives for managers to use corporate resources efficiently in investors' interest (Bøhren, Cooper and Priestley 2008; Dittmar and Mahrt-Smith 2007; Meulbroek et al. 1990). Thus, the threat of being taken over would compel managers not to abuse R&D budget for their own benefits but to select most valuable R&D projects. However, on the other hand, managers of firms without ATPs may be induced to increase short-term performance at the expense of long-term profitability to signal the firm value. As a result, managers might myopically forgo valuable R&D projects in the face of strong takeover threat (Stein 1988; Sundaramurthy 2000). In sum, the relation between corporate governance, both internal and external governance, and R&D valuation is an empirical question as it depends on which one of those two opposing effects prevails. In this chapter, I investigate the effect of governance mechanisms on the market valuation of R&D.

Using a sample of U.S. firms from 1998 to 2006, this study shows that boards that are more independent and whose independent directors have more outside directorships are associated with higher R&D market valuation. Also, it provides evidence that firms with less ATPs are associated with higher R&D valuations. These results suggest that both internal and external monitoring mechanisms enhance R&D valuation. Further, I find that the positive association between internal (external) governance effectiveness and R&D valuation only exists when external (internal) governance is less effective, which implies that the internal and external governance work as substitutes in enhancing R&D valuation. My results are robust to the use of capitalized R&D instead of R&D expenses, the use of continuous/dichotomous instead of ranked test variables, the use of intrinsic value instead of the contemporaneous market value, the industry-median adjustment, and the use of lagged instead of contemporaneous corporate governance variables as our attempt to address the concern of endogeneity. Additional analysis shows that effective internal (external) governance is also associated with higher R&D levels. Taken together, these results are consistent with the interpretation that effective governance mechanisms increase R&D valuation by shifting R&D valuation curve upward.

This study contributes to the literature in several ways. First, it adds to the literature on the relation between R&D investment and firm value. Although prior literature (Jensen 1993; Morck and Yeung 1999) argues that monitoring mechanisms might affect the results of R&D investments, my study provide empirical evidence that effective monitoring mechanism enhances R&D valuation. Importantly, it contributes to the debate regarding whether oversight and monitoring benefit or stifle innovation. The empirical analysis suggests that the benefit of monitoring on innovation activities outweigh the cost, resulting in higher firm values. Second, although prior studies imply that variation across firms in the marginal productivity of R&D investment affects the outcome of R&D investment (Pandit, Wasley and Zach 2009), this is the first to suggest that effective governance mechanism is a potential factor explaining such variation. Third, this study adds to the literature on the interplay between internal and external corporate governance in value creation. Some previous studies support substitution among governance mechanisms (Agrawal and Knoeber 2001; Baber and Liang 2008; Denis and Kruse 2000; Huson, Parrino and Starks 2001) while others suggest that governance mechanisms are complementary (Cremers and Nair 2005). Adopting R&D valuation as a test setting, the current study provides evidence of the substitution effect of the two. Finally, this study confirms previous literature regarding the impact of corporate governance on R&D intensity (Hill and Snell 1988; Hillier et al. 2008; Meulbroek et al. 1990). Together with the valuation result, I reconcile the role of corporate governance in reducing R&D underinvestment with the valuation consequence.

The remainder of this chapter is organized as follows: Section 2.2 reviews previous literature and proposes the research question by discussing the link between corporate governance and the market valuation of R&D investment. Section 2.3 describes the empirical analysis. Section 2.4 provides concluding remarks of this chapter.

2.2 Literature Review and Research Question

R&D investments could endow firms a degree of monopoly power either by exploiting cheaper ways of producing existing goods and thus lower the costs, or developing new and better products which enable firms to earn excess profits (Morck and Yeung 1999). Exploiting the monopoly power created by R&D investment, firms could acquire market share from its non-innovative competitors yet still earn profits above the input costs, and thus manage to increase profits and further dominate the market.

Consistent with the arguments, empirical studies provide evidence supporting a positive relationship between corporate R&D investments and firm performance/firm value. Those studies contribute the literature in different ways. For example, Hirschey et al (1985) conduct a market-value-based investigation of advertising and R&D as intangible capital and find that both advertising and R&D expenditures have systematic influence on the market value of the firm that persist over time. Given their estimate of the average size of market value effects, they further derive tentative estimates of economic amortization rates, suggesting a one- to five-year life for advertising and a five- to ten-year life for R&D. By comparing market reaction to advertising and R&D change, Bublitz, and Ettredge (1989) provide evidence that market assesses advertising short-lived while R&D long-lived. Based on Tobin's Q theory, in which the long-run equilibrium market value of the bundle of assets which compose a firm is equal to the book value of those assets if properly measured, Hall (1993) reports that the stock market's valuation of the intangible capital created by R&D investment in the manufacturing sector has fallen precipitously during the 1980's. By estimating a recursive system of earnings and valuation equation, Sougiannis (1994) find that reported earnings (after adjusting for the expensing of R&D) could reflect realized benefits from R&D, and investors place high value on R&D investments. Further, the author separates the effects of R&D on firm value into direct and indirect effect, with the former referring the new R&D information conveyed directly by R&D variables and the latter suggesting the capitalized value of R&D benefits reflected in earnings and expected to persist, and argues that the indirect effect is larger. That is, the R&D information conveyed by earnings numbers is more valued than that by R&D variables themselves. Aboody et al (1998) examine the special case of software capitalization (development component of R&D), the only exception in the U.S. to the full expensing rule of R&D, and indicate that capitalization-related variables (annual amount capitalized and the value of the software asset and its amortization) are significantly associated with stock price, return and future earnings. Their results suggest that software capitalization summarizes information relevant to investors.

Some other scholars adopt event study to investigate the value of R&D. For example, Chan et al (1990) sample firms that announce an increase of R&D spending and find that such announcements experience significantly positive share-price responses even when the announcement occurs in the face of an earnings decline. However, their results show that such positive effects exist only for high-tech firms. Austin (1993) estimates the private values of patents, an important output of R&D investments. Specifically, Austin (1993) uses the capital asset pricing model (CAPM) to estimate the effect of a patent event on the firm value and provides the evidence that patents are valuable.

Since it is widely accepted that R&D is valuable, researchers begin to study whether capitalizing or expensing R&D could provide more relevant information to investors. One notable study is Lev, and Sougiannis (1996). In their paper, the authors estimate the R&D capital of a sample of public companies and find these estimates to be statistically reliable and economically meaningful. Based on the estimates, the authors adjust the reported earnings and book values of sample firms for the R&D capitalization and find that such adjustments are value-relevant to investors. Moreover, they document a significant intertemporal association between R&D capital and future stock returns. Similarly, Loudder, and Behn (1995) examine whether accounting method choice can affect earnings usefulness for firms engaged in R&D activities. They find that there is statistically significant decline in earnings usefulness for firms enforced to switch from capitalizing to expensing R&D outlays, and that the decline appears to persist over time. Moreover, their results indicate that capitalizing firms has significantly higher earnings usefulness than expensing firms.

The above studies generally fall into three categories. One strand of literature uses the long window approach and documents a positive relationship between firm performance and R&D outlays (Bublitz and Ettredge 1989; Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001; Hall 1993; Hirschey and Weygandt 1985; Sougiannis 1994) or R&D capital (Aboody and Lev 1998). A second strand of literature adopts the event study approach and shows that the market reacts positively to R&D announcement (Austin 1993; Chan, J. Martin and Kensinger 1990). The third strand capitalizes and amortizes R&D on a *pro forma* basis and finds that such adjustments are more value relevant than those based on expensing R&D costs when incurred (Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001; Lev and Sougiannis 1996; Loudder and Behn 1995).

Although R&D is generally valuable for a firm, the fact that R&D investment is subject to the discretion of managers indicates the existence of agency problems. Managers can decide "whether to (continue to) invest", "which to invest", "when to invest", as well as "how much to invest". In light of the different utility functions of managers and shareholders, managers' R&D investment decisions might not always follow the shareholder-value maximization rule.

Agency problems might arise due to the following reasons. First, R&D investments have uncertain outcomes and are often subject to failure. Unlike investors who can diversify risks and hedge the consequences of such failure, managers have invested human capital in the company thus are unable to do so (Hill and Snell 1988). Therefore, managers may de-emphasize innovation strategy and thus underinvest (compared to the "optimum" level)[6] in shareholder-value-maximizing R&D projects (Baber, Fairfield and Haggard 1991; Bushee 1998; Dechow and Sloan 1991). Second, typical managerial decision making might be inimical to investment in innovation because many of the classical capital budgeting tools used by corporate managers work poorly in assessing the returns to innovation (Morck and Yeung 1999). As a result, managers might choose R&D projects that provide self-gratification but add little investor value. Third, managers have incentive to overinvest (compared to the "optimum" level) in short-term R&D projects that yield more immediate

[6] Under the normal assumption of a concave relationship between R&D investment level and incremental benefits of such investment (in other words, increased benefit at a diminishing rate), there exists an "optimum" level of R&D in each firm.

benefits during their tenure even if such projects might not be value-maximizing in the long run (Jensen 1993).

Further, agency costs of R&D investment is exacerbated due to higher information asymmetry in the case of R&D investments compared to other capital and financial inputs (Aboody and Lev 2000). R&D projects are often firm-specific, which makes it less reliable to assess their value based on the performance of comparable firms in the same industry. The absence of organized markets in R&D also prevents asset prices from being informative about R&D valuation. In addition, Generally Accepted Accounting Principles (GAAP) requires R&D expenditures to be expensed immediately when incurred, potentially exacerbating the opacity of R&D investments because firms have no obligation to report any details about on-going R&D projects.

The severity of agency problems associated with R&D investment is reflected in the fall of market valuation of R&D investment in the manufacturing sector in the 1980's compared with intangible assets or capital expenditures (Hall 1993). Similarly, Jensen (1993) documents that during the 1980's, excessive R&D and capital investment destroyed at least $10 billion each at companies including General Motors, Ford, British Petroleum, Chevron, and DuPont.

Jensen (1993) suggests that the failure of internal monitoring mechanisms could be the most important reason for the low productivity of the R&D investment. Similarly, Hillier et al. (2008) suggest that corporate governance plays a key role in R&D investment. Morck and Yeung (1999) imply that corporate governance matters for R&D investment. These arguments suggest a link between corporate governance mechanisms and R&D valuation. However, to my knowledge there is little empirical evidence in this regard so far. In this chapter, I would investigate the impact of corporate governance on the market valuation of R&D investments.

Managers might make non-value-maximizing R&D investment decision because of moral hazard or opportunism. Due to agency problems, managers who have information advantage about their own actions may shirk by not carefully attending to the details of R&D projects. The reduced R&D valuation arising from this case could be addressed by strengthening the monitoring. On the other hand, managers are likely under- or over-invest in R&D opportunistically. R&D will reduce net returns on the current balance sheet. Further, payoffs from R&D are neither certain nor immediate, boosting employment risk for managers. Thus, risk-averse managers are less likely to invest in R&D in some situations than shareholders. For example, managers would cut R&D myopically in their final years of office (Dechow, Sloan, 1991) or when spending jeopardizes the ability to report positive/increasing income in the current period (Baber et al 1991; Bushee 1998). By contrast, overinvestment will occur because the market could observe the level of R&D investment but not R&D productivity. In this case, managers who have incentives to send signals that the firm's present value is high would make excessive investments (Bebchuk, Stole, 1993).

The above arguments suggest corporate governance should be directed at different managerial incentives in enhancing R&D valuation. However, a detailed investigation of these issues detracts from the main purpose of the thesis and is therefore not taken up here.

Two types of governance mechanisms could affect R&D valuation: an independent and well-connected corporate board and a well-developed market for corporate control (less ATPs). Below I develop the links between R&D valuation and these two types of corporate governance.

2.2.1 Internal corporate governance – corporate board

Board monitoring is one of the most important corporate governance mechanisms to address agency problems (Birman 2005; Cai, Garner and Walkling 2009). The directors are responsible for overseeing managers' strategic decisions with the objective of representing and protecting the interests of shareholders. Prior study suggests that independent directors are in a better position to monitor managers because their independence from the CEOs enables them to object to managers' inappropriate decisions (Fama 1980; Fama and Jensen 1983; Jensen 1993). Furthermore, independent directors are usually outsiders who have incentives to build reputations as expert monitors because the market for directors punishes those who are involved in corporate disasters or perform poorly (Fama 1980; Fama and Jensen 1983). For directors with multiple directorships, some scholars claim that such directors own more expertise and more capability in monitoring (Ashbaugh-Skaife, Collins and LaFond 2006; Carcello et al. 2002), because the service on multiple boards could provide the directors with a greater diversity of experience or knowledge and the market for outside directorships serves as an important source of incentives for the directors to develop reputation[7]. In addition to the monitoring role, those directors also contribute to investor value in an advisory role by bringing expertise and experience to supplement and if necessary, modify managerial decisions (Linck, Netter and Yang 2008). Further, they add value by networking and bringing in other resources through their exposure to other firms and organizations (Hillman, Cannella and Paetzold 2000). Even so, the effect of these board and director characteristics on R&D valuation is ambiguous.

On one hand, board monitoring might enhance R&D valuation through the following ways:

First, boards would attend to setting a suitable R&D budget, which serves as an important start point for R&D investment. Unsuitable R&D budget is detrimental to R&D investment because it directly influences the amount as well as the capital allocation of the R&D projects. Boards usually evaluate the macro- and industrial-level economic situation and decide whether the R&D budget for a particular year is appropriate. There is anecdotal evidence that boards pay attention to R&D budget. For example, the board of UCB approved a R&D budget of €480 million for year 2005, an actual increase of 8.1 percent

[7] It is also argued in the literature that multiple directorships capture the busyness of the directors, which reduces the effectiveness of their monitoring (see Fich and Shivdasani 2006, Jiraporn et al, 2008). In my sample, the proportion of the busy directors, defined as outside directors holding three or more directorships (Fich and Shivdasani 2006), accounts for only 25% (median) of the independent directors. Further, I get similar results after excluding the observations where the busy directors are prevalent, that is, if 50% or more of the board's independent directors are busy, according to Fich and Shivdasani (2006). As such, it is unlikely that busyness of the board drives my results.

on 2004's budget, and decided on the allocation of its 2005 R&D budget[8]. Similarly, Bristol-Myers Squibb Co approved its pharmaceuticals R&D budget by "increasing over 20 percent" in 1999 to $1.5 billion[9]. And Microsoft planed to boost its R&D spending by more than 20% in 2001[10].

Second, boards would prevent managers from underinvesting or overinvesting in R&D projects. Shareholders aim to maximize long-term profitability while managers also seek personal wealth, job security and prestige. Normally, the payoff of R&D investment can only realize in the long run. As a result, managers would be reluctant to invest in R&D projects, leading to an underinvestment problem. This potential agency problem may be mitigated by board monitoring (Osma 2008). Overinvestment in R&D projects might also occur in the presence of imperfect information and short-term managerial objectives (Bebchuk and Stole 1993). Boards might mitigate overinvestment problem by reducing information asymmetry or constrain managerial myopic behavior.

Third, besides R&D investment amount, boards can also affect the R&D investment decisions regarding the profitability of the projects. Boards are expected to help managers to make optimal decisions on firm strategy and actions (Linck, Netter and Yang 2008). Effective boards can provide advice on R&D projects, participate in design reviews and strategic planning positioning meetings, and guide project team on a specific technical objective/schedule. By

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[8] Information source: http://www.drugresearcher.com/Research-management/UCB-hikes-R-D-budget-for-2005.

[9] Information source: http://www.aegis.com/news/re/1999/RE990503.html

[10] Information source: http://www.informationweek.com/news/showArticle.jhtml?articleID=6505875

doing so, they are able to turn down the value-destroying R&D projects or approve the value-generating ones, or help managers to better identify valuable R&D projects.

However, the effect of these board and director characteristics on R&D valuation could also be negative if a board with strong monitoring and oversight capability stifles innovation by overly scrutinizing R&D investments.

It is usually the managers who take initiatives in proposing creative ideas in developing R&D projects at board meetings. To encourage managers' enthusiasm, boards need to cede discretion to those executives and not to engage in intensive monitoring. In particular, managers should be endowed with enough freedom and support to try new approaches, which are necessary for developing innovative products or services. Successful innovative companies like 3M, GE, and Citibank have entrepreneurial incentive structures that give employees such freedom (Morck and Yeung 1999). In contrast, an emphasis on scrutiny and monitoring could re-orient managerial priorities from bold and valuable innovation to less risky incremental projects. Burkart et al. (1997) point out that it could be optimal to reduce monitoring and cede discretion to management in firms where managerial initiatives lead to higher value. Managerial initiatives are likely to be a critical determinant of firm value in R&D-intensive firms. Similarly, Baysinger et al. (1991) suggest that managers are more likely to invest in value-enhancing R&D projects when they are well-represented on boards and suffer less from the intensive board monitoring in the form of judgment or evaluation.

2.2.2 External corporate governance – corporate control market (ATPs)

Being the primary external mechanism to discipline managers, takeover threats are the source of external governance considered in this study. Similar to board monitoring, there are also two-sides regarding the role of the monitoring from takeover markets on R&D valuation.

On the one hand, a strong takeover market makes it possible for the shareholders to pressure managers to efficiently use corporate resource so as to reduce the possibility for incumbent managers to be taken over. Consequently, takeover threats are related to lower managerial entrenchment, less managerial discretion and the ensued agency problem. Previous literature also documents that the monitoring from takeover markets has significant impact on decision-making as well as decision efficiency. For example, Dittmar and Mahrt-Smith (2007) show that firms with more ATPs dissipate excess cash more quickly and have lower market value of excess cash. Bøhren et al. (2008) show that firms with less ATPs have lower underinvestment and higher investment efficiency. Along with this logic, with more discipline and monitoring of takeover market, managers would be less likely to abuse the R&D budget. When managers choose among R&D projects, they would also try to ensure that the selected project could bring higher future cash flows, thus reducing their risk of being taken over. As a result, managers' concern of being punished by the takeover market would potentially increase the value of the firm's R&D investment. Consistent with this argument, there is empirical evidence that R&D intensity declines after the adoption of ATPs (Meulbroek et al. 1990).

On the other hand, it is usually hard to manage firms for long-term competitiveness under the constant threat of a takeover. Due to asymmetric information, competitors might have better information than shareholders on a firm's true value, and will attempt to take the firm over when the share price falls below the true value of the firm. Therefore, managers would be forced to signal the firm value by raising short-term earnings (either by choosing less profitable short-term projects or by reducing investments in R&D) to support high share price. Therefore, takeover threats could divert managers' focus towards short-term performance (Stein 1988; Sundaramurthy 2000) and away from R&D projects that add value in the long run. On the contrary, when faced with less takeover threats, managers are more likely to concentrate on profitable, long-term investment (Stein 1988). The focus of managers on short-term earnings at the cost of long-term investments would lead to sub-optimal R&D investments, which potentially destroy firm value.

The above arguments suggest that internal and external governance mechanisms could either increase or decrease R&D valuation. It is an empirical question as to which of these two effects ultimately prevail.

2.2.3 Interplay between internal and external governance

Researchers often focus on a particular corporate governance mechanism and its effect on firm performance or managerial decisions. However, the effectiveness of the governance system is determined not only by specific governance attributes, but also by how these mechanisms interact (Cremers and

Nair 2005; Huson, Parrino and Starks 2001; Jensen 1993; Shleifer and Vishny 1997). Therefore, I examine the interaction between the two governance mechanisms.

Although the associations between internal and external governance are not obvious *ex ante*, there exist two theoretical viewpoints guiding the researchers in exploring how the two mechanisms interact. On the one hand, internal and external governance might be substitutes to each other if strong (weak) external governance reduces the demand of the firms to implement strong internal governance mechanisms (Cremers and Nair 2005); on the other hand, the internal and external governance might be complements if they act as a portfolio of governance procedures that minimizes combined agency costs (Agrawal and Knoeber 1996). Prior research examining this relation in other contexts provides mixed results. In studying the role of governance in CEO turnover, some studies suggest that internal and external corporate governance complement (Mikkelson and Partch 1997) whereas others present evidence suggesting a substitute between the two (Denis and Kruse 2000; Huson, Parrino and Starks 2001). Cremers and Nair (2005) use shareholder rights in the corporate law and charter and shareholder activism to proxy for external and internal governance respectively, and find that these two forms of governance mechanisms act as complements in their effect on long-term abnormal returns.

As such, R&D valuation would be better captured by the interplay of corporate boards and takeover threats, and further it is not clear *ex ante* whether the two act as substitutes or complements in influencing the market valuation of R&D investment.

Although some corporate governance mechanisms such as managerial ownership include an incentive role and may influence R&D valuation as well, in the above analysis I concentrated on the mechanisms mainly playing monitoring roles. The reason is that the impact of monitoring mechanisms on R&D valuation is two-fold, making the empirical examination on this issue more interesting. On the contrary, incentive structures' potential impact on R&D valuation is relatively certain. The monitoring and incentive mechanisms might work together to influence the market valuation of R&D. Thus, an investigation on how the relationship between the monitoring mechanisms and R&D valuation varies with different level of incentive structures would be insightful. In this study, however, my focus is on the monitoring mechanisms of corporate governance.

In summary, I examine the following research questions in this chapter: (1) Do effective boards and strong corporate control markets enhance or depress the market valuation of R&D? (2) Do effective boards and strong corporate control markets act as complements or substitutes in enhancing or depressing the market valuation of R&D?

2.3 Measurement of Governance Variables

Based on previous literature (Agrawal and Knoeber 1996; Carcello et al. 2002; Coles, Daniel and Naveen 2008), I characterize internal governance by two board effectiveness variables: the proportion of independent directors on the board (labeled as "independence"); and the average number of outside directorships in other firms held by independent directors (labeled as "exposure" hereafter)[11]. Extensive prior literature suggests that independent directors are in a better position to monitor managers because their independence enables them to challenge the proposals of managers that the directors deem inappropriate. Furthermore, independent directors are usually outsiders who have their own reputations as expert monitors that could be sullied by their involvement in firms that perform poorly (Fama 1980; Fama and Jensen 1983). For directors with multiple directorships, serving on multiple boards provides them with a greater exposure to social network (Booth and Deli 1996; Ferris, Jagannathan and Pritchard 2003) and the market for outside directorship serves as an important mechanism for the directors to develop reputation (Fama and Jensen 1983; Gilson 1990). In order to facilitate a succinct presentation of my results as well as to be comparable with external governance, I use an aggregate internal governance variable (*IGR*), which is computed by summing up the independence and exposure, both of which are partitioned into seven ranks[12], and then scaled into a range of 0 and 1.

My proxy for external governance is the absence of ATPs adopted by the firm. Specifically, I use the entrenchment index which consists of six ATPs: classified boards, poison pills, golden parachutes, limit to amend bylaws, and

[11] I label multiple directorship as 'exposure' based on the premise that with multiple directorships the independent directors are exposed to a social network by sitting on other corporate boards. Prior studies use the multiple directorships to proxy for the board expertise. Although the expert board is also viewed as effective board, I don't label it that way because it is not a direct measure of board expertise.

[12] The seven-rank partition is for convenience of interpreting the relative effect of internal governance versus external governance since the external governance variable has a value between 0 and 6. The results are qualitatively similar when I use dichotomous variable or continuous variable.

supermajority requirements for mergers and charter amendments[13] (Bebchuk, Cohen and Ferrell 2009). The larger the index, the more entrenched the managers are, or alternatively, the less effective the external governance. Therefore, my external governance measure (*Eindex*) is the negative of the entrenchment index. Similarly to internal governance, I construct external governance variable (*EGR*) by scaling *Eindex* into a range of 0 and 1.

2.4 Sample and Data

My initial sample has 19,374 firms and 129,087 firm-year observations in *Compustat Industrial Annual File* (FTP Version) from 1996 to 2006. Deleting negative values of sales (data 12), assets (data 6), book value (data 60), market value (data 199 * data 25) and capital expenditure data (data128) results in a reduced sample of 75,998 firm-years. A further deletion of observations with missing control variables results in 56,850 observations from 1998 to 2006. Data for years 1996 and 1997 are used to compute two year lagged return on assets (ROA). The sample is then merged with RiskMetrics[14] for board variables (12,334 observations left) and with entrenchment index data (11,119

[13] Gompers et al (2003) introduces an index (Gindex), which is constructed by 24 ATPs published by the Investor Responsibility Research Center (IRRC) and documents that Gindex is negatively related to firm value and stock return. Recently, Bebchuk et al (2009) argues that not all 24 provisions contribute equally to the negative correlation between ATPs and firm value. Instead, they identify 6 provisions among the 24 and construct an entrenchment index based on these 6 provisions. They further show that the 6 provisions have negative valuation consequences in firms, both individually and at the aggregate level, and that the other 18 provisions are not significantly negatively related to firm value.

[14] RiskMetrics (formerly Investor Responsibility Research Center, IRRC) covers directors of S&P500, S&P MidCaps, S&P SmallCaps firms starting in 1996. However, the data needed to compute board exposure start from 1998. In detail, RiskMetrics provides non-missing board data on 2,772 firms (14,381 firm-year observations) to calculate board independence and board exposure.

observations left, the preliminary sample)[15]. My final sample (5,952 observations) is obtained by deleting all firm-years with missing R&D expenditures (data 46). The starting year in my sample is chosen to be 1998 because RiskMetrics provides available data to calculate board exposure only from 1998. The sample selection details are given in Panel A of Table 2.1.

(Insert Table 2.1 here)

Panel B shows summary statistics on financial and corporate governance variables for the final sample. The mean and median values of Tobin's Q are 2.238 and 1.750 respectively. R&D expenditure scaled by total assets has a mean of 4.9% (median of 2.7%). Similar to prior literature (Cheng 2008; Fich and Shivdasani 2006), the average proportion of independent directors is 67% (median of 70%). Board exposure has a mean of 0.992 (median of 0.909), which is consistent with some of the prior literature (Jiraporn, Kim and Davidson-III 2008) though lower than other previous studies (Carcello et al. 2002; Fich and Shivdasani 2006). *Eindex* varies between -6 and 0, with a mean of -2.39 (median of -2).

Capital expenditure accounts for about 5.2% (median of 4%) of the total assets. Firm size has a mean (median) of 7.298 (7.118). On average annual sales grow at a rate of 10.9%. Return on assets in the current and past two years is around 0.08. In sum, the descriptive statistics of these control variables are consistent with prior literature (Bebchuk, Cohen and Ferrell 2009; Faleye 2007; Villalonga and Amit 2006).

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[15] I also estimate the effect of IGR/EGR on R&D valuation using the larger samples (6645/7059 observations.) without requiring EGR/IGR measure and obtain qualitatively similar results.

Since the observations with missing-R&D value account for 46.47% (5, 167 over 11,119) of the preliminary sample, to ensure that the sample firms included within my final sample is representative of the broader sample, I also present the descriptive statistics of firms with missing R&D values in Panel C. Separate descriptive statistics are also presented for zero R&D and positive R&D to facilitate comparison of firm characteristics, although the final sample groups them together[16]. The positive-R&D group has the highest Q ratio, lowest leverage, lowest growth opportunity and the best profitability, and more importantly, the most effective internal monitoring mechanism. The three groups show little difference in external governance.

Table 2.2 presents the results of Pearson and Spearman correlations. Both *RD* and *Capx* are positively related to *Q* (with p-value less than 0.01) although the correlation coefficient of *Capx* with *Q* is lower than that of *RD* with *Q*. These correlations indicate that both R&D and capital expenditures might be valuable, though a final determination of this result can only be made after controlling for other factors. Interestingly, *IGR* itself is not correlated with *Q*. Consistent with previous literature (Bebchuk, Cohen and Ferrell 2009), *EGR* is positively related to *Q* (p-value less than 0.01). *IGR* is positively correlated with *RD* in Spearman correlation only, while *EGR* and *RD* are positively correlated in both Pearson and Spearman correlations, indicating that the monitoring effectiveness might be positively associated with R&D. Further, *IGR* is negatively associated with *EGR*, suggesting that in the face of weak

[16] The (untabulated) results are similar if I just include the positive R&D firm-years in my sample.

external governance, there might be a greater demand for internal governance. However, an evaluation of their interactive role on R&D valuation is possible only in multivariate tests. Consistent with previous studies (Bebchuk, Cohen and Ferrell 2009; Faleye 2007; Villalonga and Amit 2006), leverage is negatively correlated with Tobin's Q, while *Size*, *Growth* and *ROA* are positively related to Tobin's Q.

(Insert Table 2.2 here)

2.5 Empirical Analysis and Results

My multivariate tests are estimated using ordinary lest squares (OLS). To address the influences of outliers, I winsorize all the variables (except external governance variables) at the 1st and 99th percentile.

2.5.1 Corporate governance and the valuation of R&D

I estimate the following model to test the relations between internal/external corporate governance and the market valuation of R&D.

$$Q_{i,t}=\beta_0+\beta_1 RDDummy_{i,t}+\beta_2(IGR/EGR_{i,t}*RDDummy_{i,t})+\beta_3 IGR/EGR_{i,t}+\beta_4 CapxDummy_{i,t}+\beta_5 Lev_{i,t}+\beta_6 Size_{i,t}+\beta_7 Growth_{i,t}+\beta_8 ROA_{i,t}+\beta_9 ROA_{i,(t-1)}+\beta_{10} ROA_{i,(t-2)}+\varepsilon \quad (2.1)$$

where:

Q	=	Tobin's Q; the book value of assets minus the book value of equity, plus the market value of equity, scaled by the book value of assets at year *t*;

IGR = Internal governance, which is computed by first summing up board independence and board exposure, both of which are partitioned into 7 ranks, and then scaled into a range of 0 and 1. The higher the value of *IGR*, the stronger is the internal monitoring mechanism.

EGR = External governance, which is computed by scaling *Eindex* into a range of 0 and 1. *Eindex* is minus 1 times the IRRC entrenchment index with 7 ranks[17]. The higher the value of *EGR*, the stronger the external monitoring mechanism;

RDDummy = Dummy variable which is equal to one if R&D expenditure scaled by the book value of assets at year *t* is above the 75th percentile for that year, and zero otherwise;

CapxDummy = Dummy variable which is equal to one if capital expenditure scaled by the book value of assets at year *t* is above median for that year, and zero otherwise;

Lev = Total debt divided by total assets;

Size = Firm size measured by the natural logarithm of total assets;

Growth = Annual growth rate of sales;

ROA = Net income before R&D expenditures (adjusted for the tax saving of R&D expenditure) scaled by total assets[18].

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[17] Based on the data from IRRC, the entrenchment index is provided in year 1990, 1993, 1995, 1998, 2000, 2002, 2004 and 2006. Following Gompers et al (2003) and Bebchuk et al (2009), I compute *Eindex* for each year by assuming that firms' governance provisions as reported in a given IRRC volume remain in place from the publication date of an IRRC volume until the next publication date. The results remain similar if I only use the data in the publication years.

[18] I also use sales of year *t* as deflator in Q, R&D, Capx, Leverage, and ROA, and results are qualitative similar.

In the above regressions, the dependent variable Tobin's Q and the measurement are frequently used in previous literature to proxy for firm value (Bebchuk, Cohen and Ferrell 2009; Cheng 2008; Coles, Daniel and Naveen 2008; Faleye 2007; Gompers, Ishii and Metrick 2003). Here β_1 captures R&D valuation and I predict β_1 to be positive and significant since more R&D expenditures are supposed to be related to a higher firm value. Due to the skewness of the R&D distribution[19], I measure R&D intensity at its 75th percentile, which is consistent with previous literature such as Coles et al (2008). In the sensitivity section, I also measure R&D in its continuous form and the results are the same.

The variable of my interest is the interaction term between corporate governance and R&D: $IGR_{i,t}*RDDummy_{i,t}$ or $EGR_{i,t}*RDDummy_{i,t}$, which measures the R&D valuation effects of internal or external governance. If more monitoring could enhance R&D valuation by mitigating agency problem, I expect β_2 to be positive. In contrast, if more monitoring would stifle innovation and thus hurt the R&D valuation, I expect β_2 to be negative.

Following the large literature on the determinants of firm value (Agrawal and Knoeber 1996; Bebchuk, Cohen and Ferrell 2009; Coles, Daniel and Naveen 2008; Faleye 2007; Yermack 1996), I control the following variables: First, I control capital expenditures because Bebchuk et al (2009) find that capital expenditure is positively related to firm value. Second, I control

[19] The skewness of R&D expense is 1.698. In robustness checks, I also measure R&D intensity by its continuous value and the inference is unchanged.

financial leverage because debt changes a firm's contracting environment through debt covenants (Faleye 2007) and thereby influences its ability to create value. Third, I control firm size to reduce heteroscedascity. Next, I include the annual growth rate of sales, *Growth*, to control for the effect of future investment opportunities on firm value (Yermack 1996). Lastly, the *ROA* at times *t*, *t-1* and *t-2* are include to control for the effect of contemporaneous and past performance on firm value (Coles, Daniel and Naveen 2008). In the regression analysis, I also control the year and industry fixed effect.

The results of the test are shown in Table 2.3. Columns (1) and (3) give the results for pooled regressions that include both fixed industry and year effects. Columns (2) and (4) present the results of Fama-Macbeth estimates in which the annual regression includes only fixed industry effect.

(Insert Table 2.3 here)

Consistent with prior literature (Bublitz and Ettredge 1989; Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001; Hall 1993; Hirschey and Weygandt 1985; Sougiannis 1994), I find that the coefficients of *RD Dummy* are positive and significant (p-value less than 0.01) in all columns, supporting that firms with higher level of R&D expenditures are valued higher by the market. This evidence also implies that on average firms underinvest in R&D.

The coefficients of *IGR*RD Dummy* are positive and significant (p-value less than 0.01) in all regressions, indicating that firms with more effective internal governance have higher market valuation of R&D. Similarly, the coefficients of *EGR*RD Dummy* are positive and significant (p-value less than

0.1) in the pooled regressions, which is supportive of effective external governance enhancing R&D valuation. These results suggest that corporate governance's impact on mitigating R&D-related agency problems prevails the effect on stifling innovation, leading to a positive association between governance effectiveness and the market valuation of R&D. In sum, the main results shown on Table 2.3 are consistent with my expectation as discussed in Section 2.2 and suggest that effective corporate governance mechanisms enhance R&D valuation.

The coefficients of *IGR* are positive though insignificant, and the coefficients of *EGR* are significantly positive, suggesting that more effective monitoring mechanisms may increase firm value irrespective of R&D intensity. The parameter estimates of control variables are generally consistent with prior literature (Bebchuk, Cohen and Ferrell 2009; Faleye 2007; Villalonga and Amit 2006). I show a positive and significant relation between capital expenditures and firm value in most of the specifications, indicating that capital expenditures are valued by the market. The coefficients of *Lev* are negative and significant, implying that the market disfavors risks and thus charges a discount on the firm value if the leverage ratio is high. The significantly positive coefficients of *Size* imply that larger firms have higher firm value. The coefficients estimates of *Growth* are significantly positive, suggesting that growth opportunity captures the development potential of firms and thus enhance the firm value. The coefficients of $ROA_{i,t}$, $ROA_{i,(t-1)}$ and $ROA_{i,(t-2)}$ are positive, suggesting that the more profitable firms are attached with higher value by the market.

2.5.2 Interactive effects of internal and external governance

In equation (2.1) I test the internal and external governance independently, and both are shown to be associated with higher market valuation of R&D. In this section, I examine the interactive effects of the two. Specifically, I augment equation (2.1) by including both *IGR*RD Dummy* and *EGR*RD Dummy* as well as *IGR*EGR*RD Dummy* to test their interactive effects on R&D valuation. *IGR*EGR* is also included for econometric reason. The model used is shown below:

$$Q_{i,t}=\beta_0+\beta_1 RDDummy_{i,t}+\beta_2(IGR_{i,t}*RDDummy_{i,t})+\beta_3(EGR_{i,t}*RDDummy_{i,t})+\beta_4(IGR_{i,t}*EGR_{i,t}*RDDummy_{i,t})+\beta_5(IGR_{i,t}*EGR_{i,t})+\beta_6 IGR_{i,t}+\beta_7 EGR_{i,t}+\beta_8 CapxDummy_{i,t}+\beta_9 Leverage_{i,t}+\beta_{10} Size_{i,t}+\beta_{11} Growth_{i,t}+\beta_{11} ROA_{i,t}+\beta_{12} ROA_{i,(t-1)}+\beta_{13} ROA_{i,(t-2)}+\varepsilon \tag{2.2}$$

The estimates on the 3-way-interaction term: $IGR_{i,t}*EGR_{i,t}*RDDummy_{i,t}$ helps to address my third research question. This variable is included to examine the interactive effect of internal and external corporate governance on R&D valuation. If they are substitutes, I expect the 3-way-interaction coefficient to be negative; if they are complements, I expect this coefficient to be positive.

Columns (5) and (6) of Table 2.3 present the pooled and Fama-MacBeth estimates of this regression. Both *IGR*RD Dummy* and *EGR*RD Dummy* have significantly positive signs except for *EGR*RD Dummy* in column (6), suggesting both internal and external governance are relatively or incrementally R&D value-enhancing. The coefficients of *IGR*EGR*RD Dummy* are negative and significant in Fama-Macbeth approach (in Pool regression the coefficient is negative with p-value being 0.117, which is close to conventional significance level), suggesting that the positive association between internal governance (external governance) and R&D valuation will be stronger when external governance (internal governance) is weaker. The results indicate that the internal and external governance work as substitutes to each other in influencing the market valuation of R&D. All other estimates are similar to those reported in column (1) to (4).

Interestingly, the coefficients of *IGR* are not significant in column (1) and (2) while the coefficients of *IGR*RD* are always significant; the coefficients of *EGR* are significant while those of *EGR*RD* are less significant. There are different explanations to it. It's likely that directors are more involved in strategic decisions and thus boards affect firm value through R&D investment while takeover market influence R&D valuation via its impact on overall firm value[20]. It's also possible that internal governance is effective in reducing information asymmetry but not moral hazard while external governance is more effective in reducing moral hazard but not necessarily information asymmetry. In firms without R&D investment, little information asymmetry leads to neglectable demand for internal governance. For firms with high R&D, however, high information asymmetry suggests that more internal governance is demanded and valued by the market. But in both cases, there is moral hazard and therefore, external governance will help in increasing the value. The

[20] If takeover market indeed influences R&D valuation via its impact on overall firm value, RD as dependent variable should be associated with firm value as the independent variable with EG controlled. However, further simultaneous equations to test it are needed.

interpretation and further analysis of this result potentially provide some further research opportunities.

Alternatively, I also conduct sub-sample regressions and compare the difference between the effect of internal (external) governance on R&D valuation in face of strong and weak external (internal) governance. I expect that, if internal and external governance mechanisms function as substitutes, then internal (external) governance's influence on R&D valuation would be mitigated in the case of strong external (internal) governance and *vice versa*. In contrast, if internal and external governance are complementary to each other, then internal (external) governance's influence on R&D valuation would be stronger in the case of strong external (internal) governance and *vice versa*.

Specifically, I estimate equation (2.1) with *IGR* and *IGR*RD Dummy* in the strong/weak external governance subgroups and equation (2.1) with *EGR* and *EGR*RD Dummy* in the strong/weak internal governance subgroups respectively. I first partition my sample into high-EG and low-EG sub-samples. The high-EG (low-EG) sample consists of firm-years whose *EGR* is higher (lower) than the median in year *t*, thus representing the observations whose external corporate governance is stronger (weaker). Second, I partition my final sample into high-IG and low-IG sub-samples. The high-IG (low-IG) sample consists of firm-years whose *IGR* is higher (lower) than the median in year *t*, thus representing the observations whose internal corporate governance is stronger (weaker).

Panel A of Table 2.4 shows the descriptive statistics of the dependent variable, control variables and governance variables of these sub-samples. The high-EG sub-sample firms present higher market value and more R&D expenditures than the low-EG sub-sample firms. Consistent with the correlation result of Table 2.2, the boards of the high-EG sub-sample firms are less independent and have lower exposure than those of the low-EG sub-sample firms. The Tobin's Q and R&D expenditures of the high-IG sub-sample firms are lower than those of the low-IG sub-sample firms. The external governance of the high-IG sub-sample firms is weaker than that of the low-IG sub-sample firms, confirming my substitution demand arguments when interpreting the correlation coefficients.

About 26.11% (1,554 out of 5,952) of observations are at the median level of *EGR*. I include those observations in both the high-EG and low-EG sub-samples and the results of estimating equation (2.1) for the two sub-samples are reported in Panel B of Table 2.4. The results (untabulated) are similar when I exclude those observations from both sub-samples. The coefficients of *IGR* RD Dummy* are significantly positive in the low-EG sub-sample but not significant in the pool regression in the high-EG sub-sample. This suggests that internal governance's impact on R&D valuation is weaker and even only exists when external corporate governance is weak, supporting the substitution role between the two forms of governance mechanisms. In both sub-samples, the coefficients of *RD Dummy* are positive and significant. The coefficients of *IGR* are negative in the low-EG sample but positive in the high-EG sample. The coefficients of other control variables are the same in both sub-samples.

The low-IG (high-IG) sample consists of those firm-years whose *IGR* is lower (higher) than the median in year *t*, representing less (more) effective boards. There are 741 observations at the median level of *IGR*. I include these observations in both high-IG and low-IG sub-samples. The regression results are tabulated in Panel C. Excluding the at-median observations from both sub-samples does not change my results (untabulated). In the low-IG sub-sample where internal governance is weak, the coefficients of *EGR * RD Dummy* are positive and significant; while in the high-IG sample where internal governance is strong, the coefficients of *EGR * RD Dummy* is not significant for the pooled regression and even negative for the Fama-MacBeth method. These results indicate that the effective external monitoring is valuable for the market valuation of R&D only when the internal governance is weak, also supporting the substitution effects of the two. Other control variables present similar results as before.

(Insert Table 2.4 here)

2.5.3 Sensitivity tests

I perform several tests to ascertain whether my results are sensitive to research design choices or variable measurements. In this section, I discuss results from several additional robustness checks.

2.5.3.1 Using lag values to address endogeneity problem

In my regressions of Tobin's Q, I use current-year value of corporate governance as independent variables. Prior literature suggests that board variables can be determined by Tobin's Q (Bizjak, Brickley and Coles 1993;

Coles, Daniel and Naveen 2008; Demsetz and Lehn 1985; Denis and Sarin 1999; Hermalin and Weisbach 1988; Smith and Watts 1992). Further, it is plausible that R&D intensive firms or firms with high R&D valuation endogeneously choose certain board characteristics and bylaws relating to ATPs. In addition, managers might learn from the market valuation to make R&D investment. To address these endogeneity problems, following Hermalin and Weisbach (1991), I use lagged (instead of contemporaneous) values of internal and external governance and their corresponding interaction terms as well as lagged R&D investment in the regression of Tobin's Q. The results are reported in Table 2.5. It is shown that the coefficients of $IGR_{(t-1)}*RD\ Dummy_{(t-1)}$ are positive and significant in three out of four regressions. However, external governance is not significantly associated with R&D valuation using either the pooled regression or the Fama-MacBeth method. The parameter estimates of the three-way-interaction term, $IGR_{(t-1)}*EGR_{(t-1)}*RD\ Dummy_{(t-1)}$ are significantly negative. The control variables present qualitatively the same result as as they are shown in Table 2.3. In sum, all my results remain similar except that the effect of external governance is not significant here.

(Insert Table 2.5 here)

2.5.3.2 Using intrinsic value to proxy for firm value

Tobin's Q is extensively used to measure the market value. However, prior literature suggests that R&D investment is mispriced by investors (Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001; Lev and Sougiannis 1996). Therefore, to rule out the possibility that my results are driven by the systematic difference in the level of R&D mispricing in the presence of different corporate governance, I replace Tobin's Q by a measure of firms' intrinsic value, which is less likely to suffer from mispricing issue. Following Subramanyam and Venkatachalam (2007), I develop an *ex post* intrinsic value (IV) based on the dividend discount model. Particularly, based on a three-year horizon, a firm's IV is calculated as following:

$$IV_t = \sum_{i=1}^{3} \rho^{-i}(d_{t+i}) + \rho^{-3}(P_{t+3}) \tag{2.3}$$

where:

d_t = dividend at fiscal year t is computed as dividends which are defined as the sum of common dividends (*Compustat* data item 21) and cash distributions from stock repurchases (changes in *Compustat* data item 226);

P_t = stock price at fiscal year t, measured as the stock price (*Compustat* data item 199) times outstanding shares (*Compustat* data item 25) at fiscal year t ;

ρ = the discount rate is estimated as the following model(Francis, Olsson and Oswald 2000): $\rho - 1 = r_f + \beta[E(r_m) - r_f]$;

r_f = one-month treasury bill rate;

β = systematic risk for the industry to which a firm belongs. I compute industry betas by averaging firm-specific betas for all sample firms in each two-digit SIC codes. Firm-specific betas are calculated using daily returns data over fiscal year *t-1*; and

$E(r_m) - r_f$ = market risk premium. Following Subramanyam and Venkatachalam (2007), I use 6 percent as the market risk premium.

The three-year-horizon could effectively reduce the measurement errors in terminal value due to R&D mispricing. Subramanyam and Venkatachalam (2007) also argue that this measure "provides a more accurate measure of the users' (investors') future cash flows realization than a finite horizon of future operating cash flows…*ex post* market values accurately portray the future payoffs to an investor" (p.462).

Similar to R&D expenditures, the intrinsic value is scaled by total assets. The results of this regression (2.3) are reported in Table 2.6. The coefficients of *IGR*RD Dummy* are positive though insignificant in the Fama-Macbeth regressions. Similar to Table 2.5, the coefficients of *EGR*RD Dummy* are insignificant in either approach. Consistent with Table 2.3, the coefficients of *IGR*EGR*RD Dummy* remain significantly negative in both the pool and the Fama-Macbeth specifications. For the control variables, capital expenditure is no longer significant here. Interestingly, the coefficients of *Size* are negative and significant, which is different from the above.

(Insert Table 2.6 here)

2.5.3.3 Using industry-median adjusted values

Following Gompers et al (2003), I use an alternative measure of my dependent variable, namely industry-adjusted Tobin's Q. This is computed as Tobin's Q net of its industry (one-digit SIC) median for that year. I also adjust all the explanatory variables themselves by industry medians. As before, I use *IGR* and *EGR*, but they are based on the industry-adjusted IG and EG values. R&D here is the industry-adjusted continuous value. All my results are presented in Table 2.7. It is shown that both internal and external corporate governance are positively related to the market valuation of R&D. Similar to Table 2.3, the coefficients of *EGR*RD* are positive though insignificant in Fama-Macbeth specifications. Also, the three-way-interaction term IGR*EGR*RD is close to the conventional significance level (p-value is 0.168) in the pool regression. Other control variables remain the same.

(Insert Table 2.7 here)

2.5.3.4 Other robustness tests

Besides the above tests, I also do the following robustness checks. The results are tabulated in Table 2.8.

(Insert Table 2.8 here)

First, in the main test, R&D investment is measured as the reported R&D expenses of the year, which does not reflect the stock of the R&D investment that is captured in the firm value. As a sensitivity test, I compute a stock measure of R&D investment to test its valuation and the impact of governance on its valuation. Following previous literature (Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001), I capitalize and amortize R&D on a *pro forma* basis by assuming that R&D investments are depreciated by the straight-line method over five years. The estimated net R&D assets are calculated based on the following formula:

$$RDasset_t = RDexp_t + 0.8(RDexp_{t-1}) + 0.6(RDexp_{t-2}) + 0.4(RDexp_{t-3}) + 0.2(RDexp_{t-4}) \quad (2.4)$$

where

RDasset = Estimated net R&D assets;

RDexpt = R&D expenditures occurred at year *t*;

I recompute R&D dummy by using the estimated net R&D assets and repeat the regressions.[21] As Panel A of Table 2.8 shows, the results of *IGR*RD Dummy* and *IGR*EGR*RD Dummy* are qualitatively the same to those in Table 2.3. But the coefficients of *EGR*RD Dummy* are negative though insignificant, suggesting that external governance is not associated with R&D valuation in either method. The results again support my argument that external governance's impact on R&D valuation is less compared with internal governance.

Second, since R&D expenditure intensity is measured dichotomously in my reported regression analyses. I repeat the analyses using R&D value in its continuous form, computed as R&D expenditures deflated by total assets at the end of year *t*. The results of the analyses (presented in Panel B of Table 2.8) are consistent with the earlier results obtained using the dummy variable. Specifically, the coefficients of *IGR*RD Dummy* are significantly positive and the coefficients of *IGR*EGR*RD Dummy* are significantly negative. The

[21] Other variables computed based on book value of assets are adjusted accordingly by using adjusted book value of assets, which are equal to book value of assets plus estimated net R&D assets.

parameter estimates of *EGR*RD Dummy* are positive but insignificant in either pool or Fama-Macbeth regressions.

Third, the results reported in Table 2.3 use an aggregate measure of *IGR* that combines board independence and exposure into one variable and a ranked measure of external governance. As a sensitivity test, I repeat the analysis by using board independence and exposure separately in their continuous forms and external governance in its discrete form (*Eindex*). The results are shown in Panel C of Table 2.8.

The coefficients of *Independence*RD Dummy* are positive though insignificant in the pooled regression; but the coefficients of *Exposure*RD Dummy* are significantly positive in both the pooled and Fama-Macbeth specifications. The impact of external governance is similar to the results reported in Table 2.3. The coefficients of *Eindex*RD Dummy* are positive and significant in the pooled regressions but not significant in the Fama-Macbeth regressions. The joint effects of internal and external governance on R&D valuation are now captured by two coefficients, *Independence*Eindex*RD Dummy* and *Exposure*Eindex*RD Dummy*. The parameter estimates of *Independence*Eindex*RD Dummy* are significantly negative in both the pooled and Fama-Macbeth regressions. While the coefficients of *Exposure*Eindex*RD Dummy* are negative but significantly only in the Fama-MacBeth regression. Overall, the (untabulated) results are consistent those reported earlier although there is a loss of significance.

Next, since *Gindex* is also extensively used as a proxy for external governance (Cremers and Nair 2005; Dittmar and Mahrt-Smith 2007), I replace

Eindex with *Gindex* and repeat the analyses. *Gindex* differs from *Eindex* in that it includes additional 18 provisions, extending to other provisions in the corporate law and charters. The results presented in Panel D of Table 2.8 remain qualitatively unchanged except that external governance's impact is not significant in both pool and Fama-Macbeth specifications.

Finally, I further control size effect on R&D valuation. Prior studies[22] find that firm size enhances the effect of R&D on firm value. To ensure that my result is not driven by the omitted effect of size on R&D valuation, I further control the interaction term between size and R&D in the model. The results are tabulated in Panel E of Table 2.8. Consistent with previous findings, the coefficients of *Size*RD Dummy* are positive and significant in five out of six regressions, suggesting that lagers firms have positive impact on the market valuation of R&D. Similar to the results presented above, the coefficients of *IGR*RD Dummy* are significantly positive and the coefficients of *IGR*EGR*RD Dummy* are significantly negative. The parameter estimates of *EGR*RD Dummy* are positive but insignificant in either pool or Fama-Macbeth regressions.

2.5.4 Additional analysis I: corporate governance and R&D level

From a theoretical perspective, there should be an optimal level of R&D intensity for each firm. In this case, R&D in any firm is likely to increase firm value at a diminishing rate. Thus, the R&D value function can be expressed as a parabolic curve, which I call R&D value curve, as Figure 2 shows. The slope

[22] See Morck and Yeung (1999) for a comprehensive review.

on the R&D value curve represents the R&D valuation. The figure clearly shows that R&D valuation (the slope) is decreasing with the increase of R&D investment.

(Insert Figure 2 here)

This suggests an optimal level of R&D in each firm. For underinvesting firms whose R&D investments are below the optimal level, increasing R&D could enhance the firm value; while for overinvesting firms whose R&D investments are above the optimal level, increasing R&D could destroy the firm value. If firms mostly achieve this optimum level (point A, where the slope is zero), there should be no significant average cross-sectional relationship between R&D level and firm value. As such, finding a positive/negative relationship between R&D level and firm value is consistent with the view that on average firms underinvest/overinvest in R&D. In terms of this, prior studies on corporate governance and R&D level (Hill and Snell 1988; Hillier et al. 2008; Meulbroek et al. 1990) are incomplete with respect to firm value enhancing. Although they find that effective governance mechanisms generally increase R&D level, these papers do not examine whether the consequently higher or lower R&D investment amount is valued by the investors. Only examining the R&D investment level might lead to misguiding results because whether the R&D level is deviate from optimal could be partly explained by how the market evaluates the firms' R&D investment.

However, a study of R&D valuation without a concurrent study of the R&D levels is also incomplete because an increase (decrease) in R&D valuation might either imply more (less) underinvestment or less (more) overinvestment in firms or just a shift in the R&D value curve. Therefore, without concurrently examining the corporate governance's effects on the R&D investment level, one cannot draw conclusion on the ultimate effect of governance on firm value via its effects on R&D investment. This motivates me to examine the effect of both internal and external governance variables on the level of R&D expenditure in this section. In doing so, I will be able to not only complement the earlier R&D valuation results of the effect of corporate governance, but also extend and reconcile with prior studies on the governance's effects on R&D intensity (Hill and Snell 1988; Hillier et al. 2008; Meulbroek et al. 1990).

I examine the effect of both internal and external governance variables on the level of R&D expenditure by estimating the following model.

$$\begin{aligned} RD_{i,t} &= \alpha_0 + \alpha_1 IGR_{i,t} + \alpha_2 EGR_{i,t} + \alpha_3 OCF_{i,t-1} + \alpha_4 Ltd_{i,t-1} + \alpha_5 Size_{i,t-1} \\ &+ \alpha_6 MS_{i,t-1} + \alpha_7 TAN_{i,t-1} + a_8 Div_{i,t-1} + a_9 Tax_{i,t-1} + a_{10} Growth_{i,t-1} + u_{i,t} \end{aligned} \tag{2.5}$$

In equation (2.5), variable *IGR* and *EGR* are defined the same as in equation (2.1). Other variables are defined below.

RD = Research and development expenditures to total assets;

OCF = Operating cash flows deflated by total assets, lagged one year;

Ltd = Long-term debt and debt in current liabilities deflated by total assets, lagged one year;

Size = Natural log of total assets, lagged one year;

MS = Market share (a firm's total sales as a proportion of sales by all other firms in the same industry) lagged one year;

TAN = PPE deflated by total assets, lagged one year;

Div = Total dividends deflated by total assets, lagged one year;

Tax = Income taxes deflated by total assets, lagged one year.

Growth = Annual growth rate of sales, lagged one year.

The model and control variables in equation (2.5) are based on Bhagat et al (1995) and Hillier et al (2008). The results of this analysis are given in Table 2.9. Columns (1) and (2) include only *IGR*, columns (3) and (4) include only *EGR*, whereas columns (5) and (6) include both *IGR* and *EGR*. Columns (1), (3) and (5) are the results of pool regressions that include both the fixed industry and year effects. Columns (2), (4) and (6) give the averages of Fama-Macbeth analysis conducted on an annual basis and therefore include only industry fixed effects. I find that the level of R&D is significantly positively associated with internal and external governance both independently and incrementally. The results are consistent with the earlier studies on the role of corporate governance played in determining the level of firm R&D investment.

The coefficients of control variables are in general consistent with prior studies. Although the negative relationship between cash flows and R&D is counter-intuitive, the result is consistent with Bhagat et al (1995). The negative coefficients of *Ltd*, *Tan*, *Div* and *Tax* are all consistent with the results of Bhagat et al (1995) and Hillier et al (2008). Contrary to Hillier et al (2008), I find *Size* to be negatively related to R&D. In view of the diverse results on the relationship between firm size and R&D (Hillier et al. 2008), my result is not surprising. Consistent with the arguments of Blundell, Griffith, and Reenen (1999), I show a positive association between market share and R&D. The coefficients of *Growth* are not significant.

(Insert Table 2.9 here)

Also to address the possible endogenous problem, I repeat the regression of (2.5) but with *IGR* and *EGR* lagged one year. The results are shown on Table 2.10. The coefficients of $IGR_{i,(t-1)}$ and $EGR_{i,(t-1)}$ are positive and significant, confirming that better corporate governance will lead to higher level of R&D investments. The results of the control variables are similar to Table 2.9.

(Insert Table 2.10 here)

In the untabulated analysis, I separate the board variables and find that R&D is positively associated with both the independence and exposure variables. R&D is also positively associated with *Eindex* as well as the indicator variable of external corporate governance which is computed by annual median cutoff.

(Insert Figure 3 here)

Specifically, increasing R&D level will reduce the R&D valuation because the slope decreases. As Figure 3 shows, with more effective corporate governance, a firm increases its R&D investment from point A to point C. This action leads to the decline in the slope (R&D valuation) though still an increase in the firm value. However, my earlier empirical evidence suggests that effective governance mechanisms enhance R&D valuation (the slope), which is only possible when the R&D value curve is shifted upward. For example, at point C on the new R&D value curve, the slope (R&D valuation) is larger than that at point A on the old R&D value curve.

The above analysis suggests that, in conjunction with an increase in the level of R&D, an increase in its valuation with better governance mechanisms implies that it should be the results of an upward-shift in the R&D value function (curve)[23].

2.5.5 Additional analysis II: characteristics of outside directorship

Directors serving on multiple boards are assumed to play a better monitoring role because their exposure to other companies may help these directors in networking. Further, sitting on other boards could help directors obtain expertise or knowledge in making R&D decision. However, spending more time at board meetings in unrelated industries would not necessarily improve their decision about the R&D expenditures for the sample company. In terms of these, investigating the characteristics of the outside directorships hold by the directors would facilitate the understanding of how board exposure could enhance the market valuation of R&D investments.

However, I am not aware of any established public data providing the detailed information of the outside directorship a director holds. Even so, I can hand-collect the relevant data from the website of Forbes. Due to the great workload in hand collecting, in this study, I pick the ten firms with the highest R&D valuation to examine whether their directors hold outside directorships from related industries (labeled as "outside related directorships" hereafter, meaning that directorship is from the same or the related industries such as up or down stream industries). I use all the available data from Compustat and run

[23] Previous cross-sectional analysis shows that firms with more R&D have higher value, suggesting that on average firms underinvest in R&D. The one-firm analysis here is based on this argument.

the equation (2.1) without board variables. The coefficient of *RD* is defined as a firm's R&D valuation. The reason that I exclude board variables in the regression is because that would reduce my sample period to 9 years, making the calculation of a firm's R&D valuation inappropriate. I obtained the information of each firm's directors by typing the ten firms' ticker name on the webpage: http://people.forbes.com/search. The detailed information is presented on Table 2.11.

Two measurements are used. One is the ratio of the number of directors with outside related directorship to the number of directors with outside directorship, and the other is the ratio of the number of outside related directorships to the number of outside directorship. Table 2.11 shows that most of the firms have high percentages. Specifically, the average ratio of the number of directors with outside related directorship to the number of directors with outside directorship is 61.05% and the average ratio of the number of outside related directorships to the number of outside directorship is 48.04%. The result suggests that the directors of the ten firms generally hold related outside directorship, enabling them to enhance the market valuation of R&D. Admittedly, however, the ten selected firms are not random and might not generalizable to the population. Therefore, the result should be interpreted with caution.

2.6 Concluding Remarks

Using U.S. data from 1998 to 2006, this chapter presents the results of the investigation of the relation between corporate governance and the market valuation of R&D investments. I find that both internal and external governance, proxied respectively by board independence and exposure for internal governance and the lack of ATPs for external governance are associated with higher market valuation of R&D investment. Further, I show that the association between internal (external) governance effectiveness and R&D valuation is significant only when the external (internal) governance is weak, suggesting that internal and external governance act as substitutes in influencing the market valuation of R&D. I also confirm earlier studies that the level of R&D investment is significantly influenced by both internal and external governance. These results combined suggest that corporate governance guides the selection of R&D projects at the corporate level in a way that shift R&D value function upward and enhances the economic benefits of R&D investment. Further, I also provide evidence of a substitutive relation between internal and external monitoring mechanisms regarding R&D valuation.

CHAPTER THREE

CASH FLOWS AND COST OF EQUITY EFFECTS OF R&D INVESTMENT AND CORPORATE BOARDS

3.1 Introduction

R&D investments are regarded as the ultimate source of technological changes and the major driver of the productivity growth (Guellec and Potterie 2004). However, R&D investments suffer from severe agency problems (Jensen 1993) because they are subject to the managerial discretion and featured as high information asymmetry (Aboody and Lev 2000). The agency conflicts between managers and shareholders are expected to be assuaged by corporate governance, which is designed to align the interests of both sides and protect investors against expropriation by insiders (Jensen and Meckling 1976). In this vein, chapter two suggests that R&D investments of the firms with better corporate governance should endure less agency costs, leading to a positive association between board effectiveness and the R&D valuation[24].

However, the sources of the increased valuation are not yet well understood. Firm value is a function of expected future cash flows and discount

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[24] Although corporate control market also plays a positive role for enhancing R&D valuation, the effect is much less significant and stable compared with that of corporate boards due to the indirect involvement of corporate control market in R&D investment. Resulting from this, chapter three only focuses on corporate boards to explore the cash flows and cost of equity effects.

rates. Therefore, the increased R&D valuation could stem from effective boards' impact on higher R&D-induced future cash flows expectation, or lower R&D-related cost of equity, or both. This chapter is aimed at exploring the sources of the increased R&D valuation accompanying effective corporate boards, thereby provide evidence on the channels through which corporate boards shape R&D valuation. Before doing so, an examination on the sources of R&D's value-enhancing effects is necessary.

Specifically, I examine the following research questions in this chapter: (1) Are R&D investments positively related to the expected future cash flows, and do effective boards strengthen the positive relationship between R&D and cash flows? (2) What is the relationship between R&D investments and the cost of equity, and how is this relationship affected by corporate boards?

I predict that R&D investments are positively associated with expected net future cash flows for at least three reasons. First, R&D investments have knowledge spillovers effect (Klette 1996), which enables firms to better exploit externally-generated knowledge than firms with low R&D investments and thereby create profit margin (Cohen and Levinthal 1989). Second, R&D investments could provide firms with competitive and differentiated outputs and thus contribute to the differentiation-related strategies, which play an important role in sustaining profit differentials (Cohen, and Levin 1989; Morck, and Yeung 1999; Caves, and Ghemawat 1992). Third, knowledge obtained in R&D investment process could help lower the costs of other products in the same firm (Cardinal and Opler 1995; Helfat 1997). All these imply that R&D investments are beneficial to a firm's ability to generate future cash flows.

Although R&D investments result in cash outflows, I predict a positive relationship between R&D investments and the expected net future cash inflow.

Managers' discretionary decisions on R&D projects and amount could alter cash flows (Baber, Fairfield and Haggard 1991) due to their self-interest behavior. Effective boards may mitigate managers' opportunistic activities by actively monitoring the R&D projects selection and reducing the potential expropriation during the investment process. Boards might also impose the expertise of board members on R&D decision-making, increasing the likelihood for managers to make optimal decisions on innovation strategy and actions, and thus enhancing the potential future cash flows of R&D. Additionally, the expertise of board members helps improve the ability of managers to exploit growth opportunities during R&D investments. Based on the above arguments, I expect the positive relationship between R&D investments and the expected future cash flows to be more pronounced with more effective boards. However, it is possible that boards with strong monitoring and oversight capability stifle innovation by overly scrutinizing R&D investments. Another possibility is that boards push managers to choose less risky projects that are likely to have lower future cash flows, a behavior that might be good for investors if the benefits from reduction in risk dominate the loss from decrease in future cash flows. Both of the above cases could lead to a less pronounced positive association between R&D investments and the expected future cash flows when boards are more effective. Therefore, how corporate boards affect the association between R&D investments and the expected future cash flows is an open question.

There are two competing views on the relationship between R&D investments and the cost of equity. On the one hand, R&D investments are typically characterized by high specificity (Aboody and Lev 2000) and thus generate firm-specific risks which could be diversified away. Accordingly, the R&D risks might not be a determinant of the cost of equity. Given a constant budget, an increase in R&D investment will lead to a decrease in other investment, including risky investment that is not firm-specific and would generate systematic risk. As a result, R&D investment could help reduce systematic risk of the equity holders.. From this aspect, firms with more R&D investments would enjoy a lower cost of equity. On the other hand, the high information asymmetry of R&D investments leads to higher agency risks for investors, and these increase the cost of equity. Thus, whether more R&D investments are associated with a higher or lower cost of equity is an open question.

Since strong boards would help increase the level of R&D investment, therefore, in firms with stronger boards, other projects/investments, whose risk is non-diversifiable will be replaced more by R&D investment, risk of which could be diversified away. Moreover, by fostering greater oversight on managerial opportunism, effective board monitoring could reduce firms' exposure to non-diversifiable risk of managers' expropriation, resulting in a lower cost of equity. In sum, better boards are expected to be associated with more negative or less positive relationship between R&D and the cost of equity.

Using a sample of U.S. firms, I find that firms with more R&D expenditures have higher analyst earnings forecasts (my proxy for expected future cash flows) and enjoy a lower cost of equity, and further, these relations are more pronounced when boards are more independent or boards' independent directors have more outside directorships. The results are generally consistent with my arguments and appear to be robust.

This study contributes to the literature in three ways. First, it adds to the literature on the R&D valuation. Several empirical studies find that companies that invest more in R&D enjoy higher market valuation (Aboody and Lev 1998; Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001; Hall 1993; Hirschey and Weygandt 1985; Sougiannis 1994). However, the sources of the higher market valuation associated with R&D investments are relatively unexplored. My results indicate that R&D investments potentially bring higher future cash flows and reduce the cost of equity, both of which contribute to a higher firm value.

Second, this study adds to the literature on the role of corporate governance. It identifies the sources of increased R&D valuation associated with better boards by separating the effect of boards on expected future cash flows in the numerator of the valuation model from the effect on the cost of equity in the denominator. Being the first empirical paper on the channels through which effective monitoring mechanism enhances R&D valuation, this study presents evidence suggesting that the increased R&D valuation associated with more effective boards stems from both higher R&D-induced expected future cash flows and lower risk premium of R&D.

Third, this study contributes to the literature on the exploration of valuation sources. There are many studies examining the determinants of firm value in economics, finance and accounting areas, but an analysis on the two major sources, cash flows and risk premium (cost of equity), is sparse. By examining both the cash flows and risk premium, this study is able to identify the specific channels by which R&D creates firm value as well as effective boards enhance the R&D valuation.

This chapter is organized as follows: the next section reviews previous literature and presents the research questions. Section 3.3 describes the empirical analysis, including the models, the samples, the descriptive statistics, the empirical results, and the sensitivity tests for the analysis of expected future cash flows and the cost of equity. Section 3.4 provides concluding remarks.

3.2 Literature Review and Research Question

3.2.1 R&D, expected future cash flows and corporate boards

3.2.1.1 Relationship between R&D and expected future cash flows

A number of empirical studies present a positive relationship between R&D investments and firm value (Aboody and Lev 1998; Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001; Hall 1993; Hirschey and Weygandt 1985; Sougiannis 1994). However, these valuation results provide no direct evidence that R&D affects firms' valuation through changing the expectations of future cash flows. For example, while the total market value of equity of the publicly traded cellular phone companies examined in Amir, and Lev (1996) was $34 billion in May 1993, the median cash flows of these companies were consistently negative since mid-1980s.

Spending on R&D can be viewed as a form of investment in intangible assets with predictably positive effects on a firm's ability to generate future cash flows (Chauvin and Hirschey 1993; Lev and Sougiannis 1996). R&D investments could bring future cash flows through a combination of (a) knowledge spillovers, (b) provision of differentiated products, and (c) economies of scope (Lev, Radhakrishnan and Ciftci 2006).

First, R&D could have lasting benefits to firms due to knowledge spillovers effect (Klette 1996). Firms investing more in R&D are better capable of exploiting externally-generated knowledge than firms with low R&D investments (Cohen and Levinthal 1989). This specific knowledge spillover effect brought by R&D investments could enhance firms' learning or absorptive capacity, which facilitate firms to take advantage of and benefit from the innovative activities of other firms, leading to a higher profit margin (Cohen and Levinthal 1989)[25]. Second, by generating new knowledge or developing new and better products (Cohen and Levin 1989; Morck and Yeung 1999), R&D could be a main contributor to differentiation-related strategies. Economics literature shows that differentiation-related strategies tend to bring higher profit margin and larger market shares than cost-related strategies, and

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[25] For example, Tilton Tilton, J. E., 1971, "International diffusion of technology: the case of semiconductor," *Washington: Brookings Institution*. states that one of the main reasons firms invested in R&D in the semiconductor industry was that, "R&D effort provided an in-house technical capability that could keep these firms abreast of the latest semi-conductor developments and facilitate the assimilation of new technology developed elsewhere"'. Evenson, and Kislev Evenson, R. E., and Y. Kislev, 1973, "Research and productivity in wheat and maize," *The Journal of Political Economy* 81, 1309-1329. make a similar point when they observe that the international transfer of agricultural technology depends, in part, upon the recipients' own research efforts.

thus play a more important role in sustaining profit differentials (Caves and Ghemawat 1992). Thus, R&D could bring firms higher earnings by providing competitive and differentiated outputs. Third, R&D investment could bring economics of scope, which occur when knowledge obtained in the innovation process to develop one category of goods is transferred to lower the cost of developing another category of goods (Cardinal and Opler 1995). Researchers have conducted empirical research to estimate the extent of internal economies of scope in R&D. For example, Helfat (1997) shows that petroleum firms' capabilities to develop new coal gasification/liquefaction knowledge via R&D depends on their knowledge accumulated through R&D in technologically related businesses. Therefore, with the benefits of economics of scope, R&D investments would lead to higher firm profits and efficiency (Cardinal and Opler 1995).

3.2.1.2 Boards' role in influencing the relationship between R&D and expected future cash flows

Corporate boards could affect the relationship between R&D investments and the expected future cash flows in the following ways.

First, boards' monitoring and advisory actions could motivate managers to choose R&D projects that could bring higher future cash flows. Managers' R&D investment decisions might deviate from the optimal (from investors' viewpoint) due to the agency conflicts between managers and shareholders. It has long been recognized that managers have incentives to take up short-term R&D projects due to their short tenure, or invest a sub-optimal amount of R&D

projects for their own benefits while sacrificing the expected future cash flows at the costs of shareholders (Baber, Fairfield and Haggard 1991; Bushee 1998; Dechow and Sloan 1991). Managers' decisions on adjusting the R&D expenditures do alter cash flows (Baber, Fairfield and Haggard 1991). Since effective boards may actively review managers' R&D investment decisions and approve appropriate R&D projects or reject the inappropriate ones, I expect effective board monitoring to reduce managers' opportunistic behavior. Besides the monitoring role, board directors also work as advisors who guide managers in making better R&D decisions. R&D is comprised of creative work which is the main contributor to the provision of differentiated products. However, managers might be incompetent because many of the classical capital budgeting tools used by managers work poorly in assessing the returns to innovation (Morck and Yeung 1999). Effective boards could help managers in this regard. For example, directors could identify new opportunities in R&D that the managers might not have thought of and screen projects with negative NPV. Moreover, their expertise could suggest some of the projects that were supposed to be positive NPV projects are in fact, negative NPV projects and vice versa. Since boards are expected to help managers to make optimal decisions on firm strategy and actions (Linck, Netter and Yang 2008), I perceive efficient boards to impose the expertise of directors for assisting managers in differentiating good R&D projects from bad ones, and thus increase the potential future cash flows.

Second, boards might enhance the expected future cash flows of R&D investments by monitoring the R&D enforcement process. The R&D spending is usually devoted in the early stage. After the initial investment, firms need to further spend on development, marketing and distribution before the new product starts to generate cash flows. Due to the interest conflicts between managers and shareholders, managers might expropriate investors in every step of R&D enforcement by shirking, overcompensation, empire building and/or seeking other personal benefits. For example, managers may undermine the innovation process due to their disincentives to invest in risky, long-term R&D projects (Hayes and Abernathy 1980). Managers might also inappropriately increase R&D investments for personal benefits (Jensen 1993). With effective board monitoring which prevents managers from abusing R&D expenditures during the implementation stage, managers are less likely to expropriate the cash flows of R&D. Besides, boards could help to stop bad R&D projects, reducing the potential loss in future periods. The less managerial expropriation induced by better board monitoring is particularly valuable because the high information asymmetry of R&D investments makes outsiders hard to see though the enforcement process and thus provides much room for managerial expropriation.

However, as I have discussed in chapter two, it is also possible that boards with strong monitoring and oversight capability stifle innovation by overly scrutinizing R&D investments. Moreover, boards may push managers to choose less risky projects that are likely to have lower future cash flows, a behavior that could be good for investors if the benefits from reduction in risk dominate the loss from decrease in future cash flows. From this aspect, more effective boards could be related to a less pronounced positive association between R&D

investments and the expected future cash flows.

Therefore, how corporate boards affect the association between R&D investments and the expected future cash flows is an open question. This chapter attempts to empirically investigate this issue.

3.2.2 R&D, the cost of equity and corporate boards

3.2.2.1 Relationship between R&D and the cost of equity

Although the higher expected future cash flows as well as uncertainty of future cash flows associated with R&D investments are favorable for enhancing equity valuation, the relationship between R&D and the cost of equity is more complicated than just considering the change in the mean and variance of the future cash flows distribution.

On the one hand, R&D investment could help lower the cost of equity. R&D investments exhibit high specificity (Aboody and Lev 2000) and thus will generate idiosyncratic risks which could be diversified away. By balancing high-risk stocks against low-risk stocks in their portfolio by switching out of a high-risk stock if the R&D performance of the firm starts to slip, equity holders could diversify away the firm-specific risks induced by R&D (Hill and Snell 1988). Therefore, with a constant budget, an increase in R&D investment leads to decreases in other investments, including risky investment that is not firm-specific. To the extent that other investments that might have resulted in systematic risk are diverted to R&D investments that result in diversifiable idiosyncratic risk, there could be an overall reduction in the cost of equity. Following this logic, firms with more R&D investments would enjoy a lower cost of equity.

However, on the other hand, it is also possible that R&D investment leads to higher cost of equity. R&D information asymmetry creates agency risks between managers and shareholders. The agency risks associated with managers' decision rights on investments are captured, at least partly, by beta (Ashbaugh, Collins and LaFond 2004). In this vein, firms with more R&D investments might be related to a higher cost of equity. In sum, it is an empirical question regarding the relationship between R&D and the cost of equity.

3.2.3.2 Boards' role in influencing the relationship between R&D and the cost of equity

Corporate boards could affect the relationship between R&D and the cost of equity at least through two ways.

First, since strong boards would help increase the level of R&D investment, therefore, in firms with stronger boards, other projects/investments, whose risk is non-diversifiable will be replaced more by R&D investment, risk of which could be diversified away. Accordingly, corporate boards help strengthen the negative association between R&D investments and cost of equity (or weaken the positive association between R&D investments and cost of equity).

Second, corporate boards might affect the relationship between R&D and the cost of equity by lowering firms' exposure to market risk. Managers' decision rights on R&D investments give rise to potential management misbehavior. The misbehavior together with ineffective corporate governance is demonstrated to increase firms' systematic risk (Garmaise and Liu 2005). With strong board governance, the shareholders' agency risks driven by the agency problems could be reduced (Core, Holthausen and Larcker 1999; Richardson 2006). Thus, effective boards are expected to lower firms' exposure to non-diversifiable risk of managers' expropriation by fostering greater oversight on managerial opportunism, leading to a lower cost of equity on R&D.

Based on the above discussions, I predict that effective boards could facilitate a stronger negative or weaker positive association between R&D and the cost of equity.

3.3 Empirical Analysis

Similar to chapter two, I characterize internal governance (IG) by two board effectiveness variables: the proportion of independent directors on the board (labeled as "independence" hereafter); and the average number of outside directorships in other firms held by independent directors (labeled as "exposure" hereafter) due to their important roles in the board structure. I compute an aggregate internal governance indicator variable (IG) that is set equal to one if the sum of the independence and exposure scores is above the median of that year and zero otherwise[26]. My empirical analysis consists of two parts, the expected future cash flows analysis and the cost of equity analysis.

[26] Here I do not use the ranked board variables as chapter two does since I do not need to compare boards' effect with external governance's effect. However, using the ranked board variables does not change the results.

3.3.1 Expected future cash flows analysis

3.3.1.1 Regression model

In the long-run, cash flows are close to earnings. Therefore, I use the aggregated forecasted EPS (earnings per share) to proxy for the expected future cash flows[27]. I estimate the following cross-sectional model to test the relationship between R&D and the expected future cash flows as well as the boards' influence on the relation:

$$EFC\_dis_{i,t}=\alpha_0+\alpha_1 RDDummy_{i,t}+\alpha_2(IG_{i,t}*RDDummy_{i,t})+\alpha_3 IG_{i,t}+\alpha_4 CapxDummy_{i,t}+\alpha_5 Lev_{i,t}+\alpha_6 Size_{i,t}+\alpha_7 Growth_{i,t}+\varepsilon \quad (3.1)$$

In equation (3.1), the subscripts, *i* and *t*, denote the firm and the year respectively.

The dependent variable *EFC_dis*, is used to proxy for the expected future cash flows. It is the sum of the adjusted analysts' consensus EPS forecast for the 5 years ahead scaled by the book value of assets at year *t*, where the adjusted ESP forecasts are net present value of *t*-year-ahead EPS forecasts computed as EPS forecasts divided by a constant discount rate of 10%. I use 10% as the discount rate to convert the forecasted EPS to net present value at period *t* based on the assumption that the same amount of forecasted EPS in different periods has different net present value. I also ignore the assumption and use *EFC*, which is computed by directly summing up the forecasted EPS

27 Here I focus on the market expectation on future cash flows, therefore, I use analyst forecast data rather than the realized future cash flows or earnings. Moreover, I do not use analyst forecast future cash flows because there are too many missing values. Notably, in the sensitivity checks, I also use realized future cash flows and earnings to proxy for the expected future cash flows and get similar results.

for the 5 years ahead scaled by the book value of assets at year *t*, as the dependent variable, and the results are the same.

Consistent with previous literature (Dhaliwal, Heitzman and Li 2006; Hail and Leuz 2006), I require non-missing data on analyst EPS forecasts for two periods ahead (e_1 and e_2), and either forecasted EPS for period *t+3* (e_3) or an estimate of long-term earnings growth (*ltg*). The data are drawn from the I/B/E/S database. If explicit EPS forecasts for the periods *t+3* through *t+5* are missing, I apply the following relation: $e_{t+1}=e_t*(1+ltg)$. Alternatively, if long-term growth projections are missing, I impute *ltg* from the percentage change in forecasted EPS between periods *t+2* and *t+3*. Analyst forecasts are measured as of 7 months after the fiscal year end (I/B/E/S provides updates as of the third Thursday of each month). This time lag is chosen to avoid analyst sluggishness problem (Guay, Kothari and Shu 2005) by ensuring that financial data are publicly available and impounded into the analyst forecast[28].

Other variables are defined as follows:

RDDummy = Dummy variable which is equal to one if R&D expenditure scaled by the book value of assets[29] at year *t* is above the 75th percentile for that year, and zero otherwise;

IG = Internal governance, measured as a dummy variable that equals one if the sum of board independence and board exposure are above the median for year *t*, and zero otherwise.

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[28] I also use analyst forecasts data as of June or 10 months after the fiscal year end, the results remain the same.
[29] I also use sales as deflator to compute the related variables in the regression and the results remain the same.

The higher the value of *IG*, the stronger is the internal monitoring mechanism. Here the board independence and exposure are in the form of fractional rank. Board independence is the number of independent directors as a percentage of the total number of directors. The definition of independence follows the IRRC definition. Board exposure is the average number of outside directorships held by independent directors. My measurements are based on previous literature (Agrawal and Knoeber 1996; Carcello et al. 2002; Coles, Daniel and Naveen 2008);

CapxDummy = Dummy variable which is equal to one if capital expenditure scaled by the book value of assets at year t is above median for that year, and zero otherwise;

Leverage = Total debt divided by total assets;

Size = Firm size measured by the natural logarithm of total assets;

Growth = Annual growth rate of sales;

In model (3.1), α_1 captures the sensitivity of the expected future cash flows to R&D. I expect α_1 to be significantly positive, representing that R&D investments could increase the expected future cash flows for firms. α_2 is also of my interest. A significantly positive coefficient of α_2 indicates that effective boards enhance the expected future cash flows brought by R&D investments and vice versa. I control capital expenditure in the model since capital expenditure is identified to be positively related to firm valuation (Bebchuk, Cohen and Ferrell 2009), therefore it is possible that capital expenditure might affect the expected future cash flows. I control leverage because capital structure with high debt ratio is regarded as risky for firms and thus may have negative impact on firms' ability in generating future cash flows. Growth opportunity is controlled since firms with more growth opportunities have more potential to increase the future cash flows. Finally, firm size is included to control for size effects following prior studies.

3.3.1.2 Sample and data

My initial sample has 17,992 firms and 119,023 firm-year observations in *Compustat Industrial Annual File* (FTP Version) from 1998 to 2006. Excluding wrong data (negative values of sales, assets, book value, market value and capital expenditure data) results in shrinking the sample to 62,564 firm-years. Further deletion of all observations with missing control variables results in 53,739 observations. The sample is then merged with I/B/E/S for forecasted EPS data (29,286 observations left). After deleting the missing value to compute expected future cash flows, the sample reduces to 24,172 observations. Next, I merge the sample with RiskMetrics for board variables and get our preliminary sample (10,383 observations). The final sample (5,871 observations) is obtained by deleting all firm-years with missing R&D expenditures. The sample selection details are given in Panel A of Table 3.1.

(Insert Table 3.1 here)

Panel B of Table 3.1 presents the summary statistics on the expected future cash flows data, financial and board variables for the final sample. The mean and median values of the expected future cash flows are 0.350 and 0.292

respectively. R&D expenditures account for, on average, 4.9% of the total assets (median of 2.7%). Consistent with prior literature (Cheng 2008; Fich and Shivdasani 2006), the average proportion of independent directors is 67% (median of 70%). Board exposure has a mean of 0.997 (median of 1.000), which is similar to Jiraporn et al. (2008). Panel B also shows that the average and median capital expenditures to total assets is 5.2% and 4.0%, while corporate debt averaged 19.7% (median of 18.7%) of total assets. The mean and median of firm size is 7.347 and 7.184 respectively. Between 1998 and 2006, the annual sales grow at an average rate of 13.4% (median of 9.7%). The descriptive statistics of the control variables are consistent with the findings of previous literature (Anderson and Reeb 2003; Faleye 2007; Villalonga and Amit 2006).

Since the observations with missing-R&D value account for 43.46% (4,512 over 10,383) of the preliminary sample, to ensure that the sample firms included within my final sample is representative of the broader sample, I also present the descriptive statistics of firms with missing R&D, zero R&D and positive R&D values in Panel C of Table 3.1 to facilitate comparison of firm characteristics. Consistent with my argument, the positive-R&D group has the highest expected future cash flows. Also, the positive-R&D group is smallest in firm size and shows the lowest capital expenditure, lowest leverage, and the most effective internal monitoring mechanism.

Table 3.2 presents the Pearson and Spearman correlations for the main variables of equation (3.1). *RD Dummy* is positively correlated with *EFC_dis* with the p-value less than 0.01, suggesting a positive impact of R&D

expenditures on the expected future cash flows. Internal corporate governance is not significantly correlated with either the expected future cash flows or R&D expenditures. Capital expenditure is significantly positively related to *EFC_dis*, suggesting that capital expenditure also may increase firms' future cash flows. The table also shows a significant negative (positive) correlation between leverage/size (growth) and the expected future cash flows. However, a more detailed analysis should be conducted in multivariate regressions to facilitate better understating of the variables' relationship.

(Insert Table 3.2 here)

3.3.1.3 Results

My multivariate tests are estimated using ordinary lest squares (OLS). All the variables in equation (3.1) are winsorized at the 1st and 99th percentile values to reduce the influence of outliers.

The results are presented in Table 3.3. Columns (1) and (3) are results of pool regressions that include both the fixed industry and year effects. Columns (2) and (4) give the averages of Fama-Macbeth analysis conducted on an annual basis and therefore include only industry fixed effects. The coefficients of *RD Dummy* are positive and significant in all columns, supporting the documentation that R&D expenditures could bring future cash flows for the invested firms. More importantly, the coefficients of *IG*RD Dummy* are also significantly positive, supporting the view that effective boards can help increase the expected future cash flows brought by R&D investments. The coefficients of *IG* are negative but not significant.

Not surprisingly, the capital expenditure is positively and significantly related to expected future cash flows, indicating that firms' investment in capital expenditure is also favorable for enhancing the future cash flows. The coefficients of *Lev* are negative and significant, implying that high-lever firms are considered risky in operation and detrimental to the future cash flows. Consistent with the view that growth opportunity provides firms potential to increase the future cash flows, the results present positive and significant coefficients on *Growth*. The parameter estimates of *Size*, however, are insignificant though positive in sign.

(Insert Table 3.3 here)

3.3.1.4 Sensitivity tests

I conduct several sensitivity tests to ensure that my results are robust. The results are shown in Table 3.4.

(Insert Table 3.4 here)

First, in the main test, basing on the assumption that the same amount of forecasted EPS in different periods has different net present values, I compute the dependent variable by using 10% as the discount rate to convert the forecasted EPS to net present value at period *t*. As a sensitivity test, I repeat the analysis by alleviating the assumption and use *EFC*, which is computed by directly summing up the forecasted EPS for the 5 years ahead, as the dependent variable. The results are tabulated in Panel A of Table 3.4. It shows that the results are unchanged.

Second, in computing the expected future cash flows, I also follow previous literature in the cost of equity (Dhaliwal, Heitzman and Li 2006; Dhaliwal et al. 2008; Gebhardt, Lee and Swaminathan 2001; Gode and Mohanram 2003) and use the analyst forecast data as of June rather than at different points in the year according to the fiscal year end of each firm. The results are qualitatively the same and presented in Panel B of Table 3.4.

Third, since analyst forecast data might suffer from forecast error, I use realized future earnings to proxy for the expected future cash flows[30]. The realized future earnings are computed as the sum of the 5-year-ahead net income before R&D expenditures (adjusted for the tax saving of R&D expenditures) scaled by the total assets. Again, I try two approaches, one by using 10% as the discount rate to convert the future earnings to net present value and the other by directly summing up the 5 periods of future earnings. The results are shown in Panel C of Table 3.4. The first (last) two columns present the results with (without) 10% discount rate in computing the dependent variable. The same set of control variables are used in the regression analysis. It shows that the coefficients of both *RD Dummy* and *IG*RD Dummy* are still positive and significant, though the control variables *Capx Dummy* and *Growth* lose significance.

Fourth, R&D expenditure intensity is measured dichotomously in my reported regression analyses. Now I repeat the analysis using R&D value, computed as R&D expenditures deflated by total assets at the end of year *t*. The results of this analysis shown on Panel D of Table 3.4 are consistent with the

[30] I also use realized future cash flows to proxy for the expected future cash flows and get similar results.

earlier results obtained using the dummy variable.

Next, I measure R&D investments as the reported R&D expenses of the year in the reported regression analysis. As a sensitivity test, I compute a stock measure of R&D investment to repeat the analysis. Specifically, I follow previous literature (Chambers, Jennings and Thompson 2002; Chan, Lakonishok and Sougiannis 2001), capitalize and amortize R&D on a *pro forma* basis by assuming that R&D investments are depreciated by the straight-line method over five years. The estimated net R&D assets are calculated based on equation (2.3). I recompute R&D dummy by using the estimated net R&D assets and repeat the regressions. Other variables computed based on book value of assets are adjusted accordingly by using adjusted book value of assets, which are equal to book value of assets plus estimated net R&D assets. The results shown in Panel E of Table 3.4 are similar to those in Table 3.3.

Lastly, the results reported in Table 3.3 are based on an aggregate measure of internal governance that combines board independence and exposure into one dummy variable. Now I use the two variables separately in their continuous forms and repeat the regressions. The results are presented in Panel F of Table 3.4. The coefficients of *RD Dummy*, *Independence*RD Dummy* and *Exposure*RD Dummy* are all significantly positive, which is consistent with the results provide in Table 3.3. Results of the control variables also remain similar to the above.

3.3.2 Cost of equity analysis

3.3.2.1 Regression model

To investigate how R&D investments are associated with the cost of equity as well as how the corporate boards affect the association, the following linear equation is examined:

$$rmean_{i,t}=\gamma_0+\gamma_1 RDDummy_{i,t}+\gamma_2(IG_{i,t}*RDDummy_{i,t})+\gamma_3 IG_{i,t}+\gamma_4 Beta_{i,t}+\gamma_5 MV_{i,t} +\gamma_6 BMratio_{i,t}+\gamma_7 EPSVAR_{i,t}+\gamma_8 LTG_{i,t} +\gamma_9 Growth_{i,t} +\varepsilon \quad (3.2)$$

The subscripts, *i* and *t*, denote the firm and the year respectively. The dependent variable, *rmean*, is used to proxy for the cost of equity[31]. *rmean* is calculated as the average of four implied equity premium, *rgls*, *rct*, *roj* and *rpeg*. Specifically, I estimate *rgls* from the methodologies described in Gebhardt, Lee, and Swaminathan (2001), *rct* from Claus, and Thomas (2001), *roj* from Ohlson, and Juettner-Nauroth (2005), which is implemented by Gode and Mohanram (2003) and *rpeg* from Easton (2004). For each method, the implied equity premium is obtained by first solving the equations and then subtracting the current yield on 10-year Treasury bonds. All four of these measures have been used in the literature to estimate a firm's cost of equity, though there is no consensus regarding the dominance of a particular cost of capital estimation approach. Limiting the empirical analysis to just one measure may cause measurement error problem and produce spurious results, therefore, I follow previous studies (Dhaliwal, Heitzman and Li 2006; Dhaliwal et al. 2008; Guay,

[31] Since I test the effects of R&D on expected cash flows and cost of equity separately, I use implied cost of equity rather than expected returns to proxy for cost of equity following Hail and Leuz Hail, L., and C. Leuz, 2008, "Cost of capital effects and changes in growth expectations around U.S. cross-listings," *Working Paper*..

Kothari and Shu 2005; Hail and Leuz 2006) and use the average of the four separate estimates on the cost of equity to minimize the potential problems.

The Appendix describes in detail the four models used to estimate a firm's cost of equity. Following previous literature (Dhaliwal, Heitzman and Li 2006; Dhaliwal et al. 2008; Gebhardt, Lee and Swaminathan 2001; Gode and Mohanram 2003), I estimate the cost of equity at the end of June for each year *t*. The reason for collecting data as of the same month each year for all firms rather than at different points in the year according to the fiscal year end of each firm is to ensure that the risk-free rate is the same across each annual sample (Claus and Thomas 2001). Since a recent paper (Guay, Kothari and Shu 2005) documents predictable error in the implied cost of equity estimates resulting from analysts' forecasts that are sluggish with respect to information in past stock returns, I also adopt the method proposed in their paper and estimate the valuation models using stock prices at January instead of June while continuing to use analysts' forecast data as of June. It is suggested that this method would allow analysts approximately five extra months to resolve the sluggishness in their forecasts with respect to information that is embedded in January stock price (Guay, Kothari and Shu 2005), thereby reduce the measurement error. The results are the same and provided in sensitivity tests section. As an alternative means to avoid analyst sluggishness problem, I also estimate the cost of equity by using 3-month-ahead stock price data and 7-month-ahead analyst forecast data so that both the stock market and analysts have enough time to absorb the financial information. The results (tabulated in sensitivity tests section) remain the same.

For an observation to be included in my sample I require current stock price data (P_t), financial data for the most recent fiscal year ending prior to June, analyst EPS (earnings per share) forecasts for two periods ahead (e_1 and e_2), and either forecasted EPS for period $t+3$ (e_3) or long-term earnings growth forecast (*ltg*). If explicit EPS forecasts for the periods $t+3$ through $t+5$ are missing, I apply the following relation: $e_{(t+1)}=e_t*(1+ltg)$. Alternatively, if long-term growth projections are missing, I impute *ltg* from the percentage change in forecasted EPS between periods $t+2$ and $t+3$.

Estimating *roj* requires $e_{t+1}>0$ and $e_{t+2}>0$ (Gode and Mohanram 2003; Ohlson and Juettner-Nauroth 2005) and estimating *rpeg* requires $e_{t+2}\geqslant e_{t+1}>0$ (Easton 2004). Similar to Dhaliwal et al. (2006), I require sample firms to have all four measures in order to calculate the average equity risk premium, *rmean*.

Consistent with Hail and Leuz (2006), I use an iterative procedure to determine the equity risk premium since most of the valuation models do not have a closed form solution. This numerical approximation identifies the firm-specific discount rate that equates P_t to the right-hand side of the respective equity valuation model. I stop iterating if the imputed price falls within a 0.0001 difference of its actual value. Implied cost of equity capital estimates are restricted to be positive and set to missing otherwise.

RDDummy[32] and *IG* are defined as above. The following control variables are included according to previous literature (Ashbaugh-Skaife et al. 2009; Botosan, Plumlee and Xie 2004; Dhaliwal, Heitzman and Li 2006; Francis et al.

[32] R&D expenditures are scaled by assets in the model. I also use sales as deflator to compute the related variables in the regression and the results remain the same.

2005; Hail and Leuz 2006).

Beta = Market model *Beta* for firm *i*, representing the sensitivity of a firm's return to market returns. I estimate *beta* for each firm year by regressing 60 lagged monthly returns against the corresponding monthly market return, requiring a minimum of 30 months (Botosan, Plumlee and Xie 2004). The Capital Asset Pricing Model (CAPM) suggests that a stock's market beta should be positively correlated with its cost of equity. Several studies also find a positive association between *beta* and the risk premium (Botosan, Plumlee and Xie 2004; Gebhardt, Lee and Swaminathan 2001; Hail and Leuz 2006).

MV = The natural log of the total market value of equity. It is documented that, unless the empirical model for expected returns includes all risk factors, a negative association between firm size and expected returns should be observed as market value is inversely associated with risk in general (Berk 1995).

BMratio = The ratio of the book value of equity to the market value of equity. *BMratio* inversely proxies for firm size (Berk 1995) and, consequently, I expect *BMratio* to be positively related to the cost of equity.

EPSVAR = Earnings variability, computed as the standard deviation of annual EPS over the last five years scaled by total assets per share (Dhaliwal, Heitzman and Li 2006; Hail and Leuz 2006). Following Hail et al. (2006), I require at least three yearly observations to calculate earnings variability. Firms with more volatile earnings are more risky and expected to associate with a higher cost of equity.

LTG = The I/B/E/S estimate of long-term earnings growth. Abnormal earnings streams derived from growth opportunities are more risky because they are subject to greater competitive erosion (Beaver, Kettler and Scholes 1970), suggesting a positive association between the expected long-term earnings growth and the cost of equity capital.

Growth = Growth opportunity, computed as annual growth rate of annual sales. Following Francis et al. (2005), I expect *Growth* to be negatively related to the cost of equity.

3.3.2.2 Sample and data

I obtain financial accounting data from Compustat, stock price and return data from CRSP, analyst forecast data from I/B/E/S and board characteristics data from RiskMetrics. The details of the sample selection procedure are provided in Panel A of Table 3.5. My initial sample consists of 183,006 firm-year observations (20,189 firms) spanning from 1993 to 2006. To compute earnings variability I require at least three yearly observations and non-missing value prior 1998. This reduces the sample to 75,001 observations from 1998 to 2006. After deleting wrong data (sales, asset, book/market value and capital expenditure less than zero) and missing value to compute other financial variables, I obtain 55,077 observations. Next, I merge the sample with CRSP (I require a minimum of 30 months to estimate *Beta* for each firm-year) and

I/B/E/S, leading to a sample of 21,920 observations. I further exclude the data with missing value to estimate the cost of equity; the sample collapses to 15,365 observations. I then merge the sample with RiskMetrics for board data and get the preliminary sample (8,501 observations). Further deleting missing R&D expenditure data leads my final sample to 4,493 observations.

(Insert Table 3.5 here)

The summary statistics of the variables are shown in Panel B of Table 3.5. The results suggest some substantial differences in the cost of equity estimates generated by the four approaches, although the average estimate is significantly and positively correlated with each of the four separate estimates (correlations range from 0.750 to 0.958, shown on Table 6). The magnitudes of the risk premiums are generally consistent with those obtained in prior studies (Guay, Kothari and Shu 2005; Hail and Leuz 2006). The mean (median) risk premium over the sample period is 0.10 (0.096). Consistent with prior research (Dhaliwal, Heitzman and Li 2006; Guay, Kothari and Shu 2005), *roj* and *rpeg* produce the largest equity risk premium estimates. In my sample, *rct* produces the smallest estimate.

R&D expenditures account for, on average, about 4.3% (median of 2.5%) of total assets. The mean and median of independent directors as a percentage of total directors on the board are 67% and 70% respectively. Board exposure has a mean (median) of 0.983 (1.00). The descriptive statistics of the board variables are consistent with previous literature (Cheng 2008; Fich and Shivdasani 2006; Jiraporn, Kim and Davidson-III 2008). The mean (median) level of market model *Beta* is 1.113 (0.943). Firm size measured by market value of equity has a mean (median) level of 7.713 (7.516), and the *BMratio*'s mean (median) is 0.419 (0.357). The mean (median) of *EPSVAR*, *LTG* and *Growth* are 0.047 (0.028), 0.163 (0.150) and 0.085 (0.089) respectively. The descriptive statistics of these control variables are generally consistent with previous literature (Ashbaugh-Skaife et al. 2009; Botosan, Plumlee and Xie 2004; Dhaliwal, Heitzman and Li 2006).

The observations with missing-R&D value account for 47.15% (4,008 over 8,501) of the preliminary sample. Therefore, I provide the descriptive statistics of firms with missing R&D values in Panel C of Table 3.5 to ensure that my final sample is representative of the broader sample. Separate descriptive statistics are also presented for zero-R&D and positive-R&D groups to facilitate comparison of firm characteristics, although the final sample groups them together. The positive-R&D group enjoys the lowest *rmean* and the most effective corporate boards. This group appears to be most risky in that it presents the highest *Beta* and earnings variability.

(Insert Table 3.6 here)

The Pearson and Spearman correlation coefficients between the individual risk premiums and the average measure, *rmean*, are shown in Panel A of Table 3.6. It reveals the expected positive correlations between these measures, with the highest correlation between *roj* and *rpeg*. The correlation coefficients between *rmean* and the individual measures range from 0.750 to 0.958. The results are quite similar to prior studies (Dhaliwal, Heitzman and Li 2006; Guay, Kothari and Shu 2005).

The Pearson and Spearman correlations between variables of equation (3.2) are presented in Panel B of Table 3.6. It is shown that R&D is negatively associated with the cost of equity with p-value less than 0.01, suggesting that firms with more R&D investments enjoy lower risk premium. Board effectiveness is also negatively related to the cost of equity though not significant. Consistent with prior literature (Ashbaugh-Skaife et al. 2009; Botosan, Plumlee and Xie 2004; Dhaliwal, Heitzman and Li 2006), I show a positive and significant association between *Beta* or *BMratio* and the cost of equity, as well as a significantly inverse relation between *MV*, *Growth* and the cost of equity. *LTG* is negatively associated with *rmean* though insignificant in Pearson correlation.

3.3.2.3 Validation of the cost of equity measurement

A variety of implied cost of capital estimates have been proposed in the literature (Botosan and Plumlee 2005). Theoretical and empirical research indicates that a good measure of implied cost of capital is positively related to beta and the book-to-market ratio and negatively related to size (Berk 1995; Black 1972; Botosan and Plumlee 2005; Fama and French 2006; Lintner 1965; Sharpe 1964). Consistent with prior literature (Ashbaugh-Skaife, Collins and LaFond 2006; Hail and Leuz 2006), I validate my estimate of cost of equity capital by documenting the relations between *rmean* and these three risk proxies. Specifically, I estimate the following regression:

$$rmean=\eta_0+\eta_1 Beta+\eta_2 MV+\eta_3 BMratio+\text{fixed effects}+\varepsilon \qquad (3.3)$$

The pool regression results are shown on Table 3.7. The first three columns report the results where *rmean* is regressed independently on *BETA*, *MV* and *BMratio*, respectively, after controlling industry and year fixed effects. The last column reports the results of estimating the model that includes all three risk proxies. Consistent with prior literature, my results indicate a positive relation between *Beta* or *BMratio* and the cost of equity capital whereas *MV* are negatively related to the cost of equity capital. The Fama-Macbeth regression results are qualitatively the same though untabulated. In sum, my measurement of *rmean* serves as a good proxy for the cost of equity capital.

3.3.2.4 Empirical results

Multivariate tests are estimated based on ordinary lest squares (OLS) approach. I winsorize all the variables at the 1st and 99th percentile values. The results are shown in Table 3.8. Columns (1) and (3) give the results for pooled regressions that include both fixed industry and year effects. Columns (2) and (4) present the results of Fama-Macbeth estimates in which the annual regression includes only fixed industry effects.

(Insert Table 3.8 here)

Across all specifications, the coefficients of *RD Dummy* are negative and significant, suggesting that more R&D investments are associated with lower cost of equity. The coefficients of *IG*RD Dummy* are also negative though marginal significant (p-value is 0.110 in Pool regression analysis and 0.058 in Fama-Macbeth specification). The results indicate that the negative relationship between R&D and the cost of equity is more pronounced in firms with more effective board monitoring.

I do not find a negative association between effective boards and the cost of equity as Ashbaugh, Collins, and LaFond (2004) expect. Particularly, the coefficients of *IG* are positive but insignificant. The results of the other control variables are generally similar to prior studies (Ashbaugh-Skaife et al. 2009; Botosan, Plumlee and Xie 2004; Dhaliwal, Heitzman and Li 2006; Francis et al. 2005; Hail and Leuz 2006). CAPM model *Beta* is shown to be significantly and positively related to the cost of equity, suggesting that firms with higher systematic risk suffer higher charge of risk premium from investors. The coefficients of *BMratio* (*MV*) are positive (negative) and significant, supporting the negative association between firm size and expected returns proposed by Berk (1995). The parameter estimates of *EPSVAR* are significantly positive, suggesting that the volatility of earnings would increase the risks investors bear and thus lead to a higher cost of equity. The coefficients of *LTG* are positive and significant, indicating that firms with higher long-term earnings growth forecasts are regarded more risky (Beaver, Kettler and Scholes 1970). The coefficients of *Growth* are positive but insignificant.

3.3.2.5 Sensitivity tests

To ensure the robustness of my results, I conduct several sensitivity tests and report the results in Table 3.9.

(Insert Table 3.9 here)

First, since Guay et al (2005) indicate that the estimated cost of equity might suffer from measurement error because of the sluggishness of financial analysts in updating information to their forecasts. I follow one of their suggested ways, using stock price data as of January while continuing to use forecast data as of June to estimate the implied cost of equity, and repeat the analysis. The results are shown on Panel A of Table 3.9. Consistent with what I report in Table 3.8, the coefficients of *RD Dummy* and *IG*RD Dummy* are still negative and significant.

Second, to avoid using the same month to collect the forecast data as well as address the financial analyst sluggishness issue, I repeat the analysis by using 3-month-ahead CRSP and 7-month-ahead I/B/E/S data to estimate implied cost of equity. The results (shown on Panel B of Table 3.9) present a significantly negative association between *RD Dummy* or *IG*RD Dummy* and the cost of equity, which is consistent with those reported earlier.

Third, I use *rmean* as the dependent variable in the main tests. To further improve the robustness, I use all the four cost of equity measures (e.g. *rgls*, *rct*, *roj*, and *rpeg*) as the dependent variable and replicate the main tests separately. As shown in Panel C of Table 3.9, the results[33] are generally consistent with my conclusions. In three out of four columns, the coefficients on *RD Dummy* are significantly negative and the coefficients on *IG*RD Dummy* are significantly negative.

Fourth, I follow Francis et al (2005) and measure the cost of equity as industry adjusted EP ratio. To calculate industry-adjusted EP ratio, I first compute the median EP ratio for all firms with positive earnings in year *t* in each of the industry groups. I then calculate a firm's industry-adjusted EP ratio,

[33] For brevity, I only report pooled results in Table 3.9. In the untabulated results, the Fama-MacBeth specifications are also consistent with the main results.

IndEP, as the difference between the firm's EP ratio and the median industry EP ratio in year *t* (I draw similar inferences using the ratio of the firm's EP ratio to the median industry EP). In particular, a lower *IndEP* implies a lower cost of equity capital, suggesting that investors are willing to pay more for a given dollar of earnings. I follow Francis et al. (2005) and run the regression below:

$$IndEP_{i,t}=\rho_0+\rho_1 RDDummy_{i,t}+\rho_2(IG_{i,t}*RDDummy_{i,t})_t+\rho_3 IG_{i,t}+\rho_4 Growth_{i,t}+\rho_5 Lev_{i,t}+\rho_6 Beta_{i,t}+\rho_7 Size_{i,t}+\varepsilon \quad (3.4)$$

where the subscripts, *i* and *t*, denote the firm and the year respectively. The independent variables are defined as above.

The results are shown in Panel D of Table 3.9. Consistent with the reported results in Table 3.8, the coefficients of *RD Dummy* are negative and significant (p-value less than 0.01). The parameter estimates of *IG*RD Dummy* are also negative though only significant in Pool regression (p-value is 0.280 in Fama-Macbeth specification). In sum, the results remain qualitatively the same.

Fifth, I repeat the analysis using R&D value, computed as R&D expenditures deflated by total assets at the end of year *t*. The results are presented in Panel E of Table 3.9. The coefficients of *RD* are negative though insignificant in Fama-Macbeth approaches. The coefficients of *IG*RD* are also negative, but just close to significant in Pool regressions. The results are overall consistent with those reported in Table 3.8.

Next, I estimate the stock of R&D capital and then reexamine model (3.3) with R&D expenditures replaced by estimated net R&D assets. Other variables computed based on book value of assets are adjusted accordingly by using adjusted book value of assets, which are equal to book value of assets plus estimated net R&D assets. The results are shown in Panel F of Table 3.9. Similar to Table 3.8, the coefficients of *RD Dummy* and *IG*RD Dummy* are significantly negative in both Pool and Fama-Macbeth specifications. The results of control variables also remain qualitatively the same.

Finally, I use the board independence and exposure separately in their continuous forms to repeat the regressions and present the results in Panel G of Table 3.9. The coefficients of *RD Dummy* are still significantly negative (in one of the four columns, p-value is 0.108). The coefficients of *Independence*RD Dummy* are insignificant but remain negative; the coefficients of *Exposure*RD Dummy* are negative and significant in Fama-Macbeth specification though insignificant in Pool regression (p-value is 0.188). The results remained similar though there is loss of significance.

3.4 Concluding Remarks

Using a sample of U.S. firms, this study investigates the following research questions: (1) Are R&D investments positively related to the expected future cash flows, and do effective boards strengthen the positive relationship between R&D and cash flows? (2) What is the relationship between R&D investments and the cost of equity, and how is this relationship affected by corporate boards?

My empirical findings show that: (1) Firms with more R&D expenditures are associated with higher expected future cash flows, and this positive association is more pronounced in firms with more effective corporate boards; (2) Firms with more R&D expenditures are charged by a lower cost of equity by investor, and this favorable impact could be stronger with more effective corporate boards.

CHAPTER FOUR

CORPORATE BOARDS, R&D INVESTMENTS, AND COST OF DEBT

4.1 Introduction

A voluminous literature has studied in depth the benefit and riskiness of research and development outlays (R&D). Most of the previous studies focus on shareholder wealth effects. While recently, scholars have begun to pay attention to the impact of R&D investments on cost of debt (Eberhart, Maxwell and Siddique 2007; Shi 2003). Whether R&D investments are beneficial to debt holders depends on whether mean effects or variance effects dominate. Moreover, how corporate boards affect mean effects and variance effects and thus affect the association between R&D and cost of debt remains unexplored. This chapter extends prior studies by examining how corporate boards affect the association between R&D investments and cost of debt.

R&D investments could bring more benefits (the mean of the future cash flows distribution) as well as higher risks (the variance of the future cash flows distribution) (Kothari, Laguerre and Leone 2002b). Since higher mean effects would strengthen firms' ability to pay back the debt and reduce default risks while higher variance effects could increase the probability of the financial distress and thereby increase the default risks for debt holders, the relationship between R&D investments and the cost of debt depends on whether mean effects or variance effects dominates.

It has long been accepted in finance and economics literature that debt financing is costly and disadvantageous to R&D-intensive firms. One of the most important reasons is the lack of collateral value for R&D "capital" and firms' need to protect proprietary information even from potential investors (Brown, Fazzari and Petersen 2009; Carpenter and Petersen 2002; Hall 2002). However, empirical evidence in this regard is mixed. Specifically, Shi (2003) shows a positive correlation between R&D and the cost of debt, suggesting that the adverse effect caused by the highly risky R&D investments outweighs the favorable impact; while Eberhart, Maxwell, and Siddique (2007) find that a higher R&D intensity is associated with lower cost of debt by claiming that their measurement of R&D intensity suffers less measurement errors. In this chapter, I first replicate their examined relationship and then further explore boards' potential influence on it.

Corporate boards could alleviate the potential unfavorable effects of R&D on the cost of debt by increasing the expected future cash flows of R&D and reducing the agency costs arising from R&D investments. The two ways are not mutually exclusive, however. Chapter three finds that effective boards could assist to promote the expected future cash flows of R&D, which will lead to lower default risks for debt holders. In addition, managers might engage in self-serving negative NPV R&D investments. This agency risk could be assuaged by effective boards, acting in the interests of shareholders in guarding against the self-interest behavior of managers. Boards' impact on less opportunistic management behavior would increase firm value and benefit all stakeholders including debt holders. The above discussions predict a less positive (or stronger negative) association between R&D and the cost of debt in firms with more effective boards.

Using a sample of U.S. firms, I find that firms with more R&D expenditures are associated with lower credit ratings (higher cost of debt), and further, boards that are more independent and whose independent directors have more outside directorships are associated with a less pronounced negative relationship between R&D expenditures and credit ratings. The results support the viewpoint that corporate boards help increase expected future cash flows from R&D and assuage the agency risk of R&D.

This study contributes to the literature in at least three ways. First, my empirical evidence suggests that firms with more R&D investments suffer higher cost of debt (lower credit ratings), further supporting the findings of Shi (2003). Second, this study adds to the literature on the role of corporate governance. My findings suggest that corporate boards help mitigate the positive association between R&D investments and cost of debt, which will ultimately contribute to the increase of firm value. Finally, this study contributes to the literature on R&D. My findings further justify the view that R&D investments suffer from severe agency problems and that corporate boards could help assuage these agency problems and eventually weaken the positive association between R&D investments and cost of debt.

This chapter is organized as follows: section 4.2 reviews previous literature and brings forward research questions. Section 4.3 describes the empirical analysis, including the models, the samples, the descriptive statistics, the empirical results and the sensitivity tests for three sets of tests: expected future cash flows analysis, the cost of debt analysis and the cost of equity analysis. Section 4.4 provides concluding remarks.

4.2 Literature Review and Research Question

4.2.1 Relationship between R&D and the cost of debt

Though R&D investments are able to bring benefits to shareholders, it is also demonstrated that R&D could lead to a higher future performance volatility due to its high risks (Kothari, Laguerre and Leone 2002b). To the extent that the benefits and risks associated with R&D have different impacts on shareholders versus debt holder, we could not simply interpret the positive association between R&D and firm value as evidence on the net benefits of R&D for debt holders.

The differential influences of a firm's R&D investment on its equity and debt valuation could be elaborated using option pricing theory framework (Shi 2003). Option pricing theory suggests that the higher expected future cash flows as well as uncertainty of future cash flows associated with R&D investments is favorable for enhancing the equity valuation, because shareholders could transfer part of the losses of high risky R&D projects (for example, if the projects turn sour) to debt holders while benefit from a large payoff if the investment pans out (Shi 2003). In contrast, although the higher expected future cash flows of R&D is also beneficial to debt holders, the higher uncertainty of future cash flows arising from R&D investment is detrimental to the debt valuation, because debt holders' default risk would increase with the variance of future cash flows. As a result, shareholders would have incentives to expropriate debt holders by taking riskier R&D projects. Anticipating this, rational debt holders would charge higher premiums for holding the debt of firms with more R&D investments, leading to a higher cost of debt.

In finance and economics literature, it has long been recognized that the debt financing is costly and disadvantageous to R&D-intensive firms or young high-tech firms with high level of risky R&D investments, partly because of the low collateral value of R&D investments and firms' need to protect proprietary information (Brown, Fazzari and Petersen 2009; Carpenter and Petersen 2002; Hall 2002). The costly debt financing problem is especially relevant for R&D investments because "the outputs can never be predicted perfectly from the inputs" (Arrow 1962). For example, due to the various default probabilities of R&D investments across equivalent firms, it is particularly plausible for the banks of high-tech firms to ration credit rather than use interest rates which may force low risk borrowers to exit the application pool (Himmelberg and Petersen 1994). It is suggested that the high cost of debt associated with R&D investments even makes R&D-intensive firms rely less on debt in financing the projects (Harris and Raviv 1991; Jensen and Meckling 1976).

In spite of debt market being a unique setting, empirical studies generally neglect the relationship between R&D and the cost of debt until recently. Based on a sample of R&D-intensive firms that issue new bonds, Shi (2003) shows a positive correlation between R&D and risk premium, suggesting that the adverse effect caused by the high uncertainty of firms' R&D activities outweighs, on average, the favorable impact of the firm value increments from the viewpoint of creditors. However, claiming that assets or sales are better deflators to measure R&D intensity than market value of equity, used by Shi (2003), Eberhart et al. (2007) find that higher R&D intensity is associated with a lower cost of debt.

In view of the mixed results, in this paper I will first examine the relationship between R&D investments and the cost of debt and then investigate how boards impact the relation.

4.2.2 Boards' role in influencing the relationship between R&D and the cost of debt

Empirically, how corporate boards affect the association between R&D investments and cost of debt still remains unexplored. I expect that corporate boards could affect the association between R&D investments and cost of debt at least through the following ways.

First, according to my findings in chapter three, corporate boards could increase the R&D-induced expected future cash flows and so lower the default risk. The cost of debt is essentially determined by the risk that firms would or could not pay back the money (i.e., default risk), which is further determined by financial risk characteristics of the firm (Elton et al. 2001; Fisher 1959). For firms with high level of R&D investments, their financial risk status is affected by the probability distribution of future cash flows to a large extent. If the debt holders consider the firms' future cash flows to be sufficient to cover the total debt, the firms' creditworthiness would be regarded as high. As firms' mean of the future cash flow distribution shifts upward, the default risk and so the firms' cost of debt would decrease. Since effective boards might promote the expected future cash flows of R&D (see Section 3.2.1.2 for details), I expect debt holders to suffer lower default risks from the R&D investments in firms with stronger boards.

In addition, corporate boards' monitoring role on R&D projects provides insurance for debt holders, leading to lower interest expenses born by the firms. Accordingly, the cash flow to equity holder would be higher and thus the default risks would be lower.

Second, managers might expropriate external stakeholders, including debt holders, by engaging in value-destroying R&D investment. Self-interested managerial behavior would increase the agency risks faced by all stakeholders. Boards could address the R&D-related agency conflicts between managers and all stakeholders. As the most important line of defense for the shareholders to guard against the self-interest behavior of managers, boards could facilitate efficient R&D decision making by providing effective and independent monitoring on managers. In this vein, debt holders of firms with effective board governance would face less agency risks vis-a-vis management. Thus, the above discussions indicate that debt holders of firms with strong boards would face lower R&D-induced default risks.

Boards' influence on the relationship between R&D and cost of debt might show variances across firms. For example, some R&D-intensive firms might be high levered while others low. For those firms with high level of debt, debt holder would play an active monitoring role. In this case, the boards' impact would be relatively weak. However, for the firms with low level of debt, boards' impact would be stronger since these firms would subject to less or no monitoring from debt holders. Since this relationship is relatively complicated, I leave it to future tests.

Basing on the above arguments, I predict that boards are expected to relate to a less pronounced positive association (or more pronounced negative association) between R&D investment and cost of debt.

4.3 Empirical Analysis

Similar to chapter two and three, I characterize internal governance (IG) by two board effectiveness variables: the proportion of independent directors on the board (labeled as "independence" hereafter); and the average number of outside directorships in other firms held by independent directors (labeled as "exposure" hereafter) due to their important roles in the board structure. I compute an aggregate internal governance indicator variable (IG) that is set equal to one if the sum of the independence and exposure scores is above the median of that year and zero otherwise.

4.3.1 Regression model

Following prior literature (Ashbaugh-Skaife, Collins and LaFond 2006; Bhojraj and Sengupta 2003; Eberhart, Maxwell and Siddique 2007; Shi 2003), I estimate the following model to test the relationship between R&D and the cost of debt as well as the boards' influence on the relation:

$$Rating_{i,t+1}=\beta_0+\beta_1 RDDummy_{i,t}+\beta_2(IG_{i,t}*RDDummy_{i,t})+\beta_3 IG_{i,t}+\beta_4 DE_{i,t}+\beta_5 Times_{i,t}+\beta_6 ROA_{i,t}+\beta_7 Size_{i,t}+\beta_8 Sub_{i,t}+\beta_9 PPE_{i,t}+\varepsilon \quad (4.1)$$

where the subscripts, *i* and *t*, denote the firm and the year respectively. The dependent variable takes values which are one year ahead of those of independent variables in case credit ratings are more affected by past information rather than by current information (Shi 2003). I also run contemporaneous regression and find the results the same (see section 3.3.2.4 for details).

The dependent variable, *Rating*, proxies for the cost of debt. Consistent with previous literature (Ashbaugh-Skaife, Collins and LaFond 2006; Francis et al. 2005), *Rating* is measured as the long-term issuer credit ratings compiled by Standard & Poor's and reported on Compustat (data item 280). Following Ashbaugh-Skaife et al. (2006), I collapse the multiple ratings into seven categories according to the schedule provided in Table 4.1.

(Insert Table 4.1 here)

I use firm-level credit ratings as the measure of the cost of debt because firm-level credit ratings are less likely to capture issue specific characteristics that protect lenders (Weber 2006). R&D is invested from firms' perspective. It is more related to the overall default risk of the company rather than the default risk associated with a single bond issue. Therefore, it should be more appropriate to employ firm-level rather than issue-level credit ratings to capture the cost of debt related to R&D investments.

IG, *RD Dummy* and *Size* are defined the same as their definition in equation (3.1). Other variables are defined as follows:

DE = Ratio of long-term debt to book value of equity. This ratio is frequently used to proxy for default risk. The higher this ratio, the higher the default risk and the lower the credit ratings;

Times = Income before interest expenses divided by interest expenses. Firms with higher this ratio are associated with lower default risk. I thus expect it to be positively associated with credit ratings;

ROA = Net income before R&D expenditures (adjusted for the tax saving of R&D expenditures) scaled by total assets. Firms with higher profitability are expected to be less risky and thus enjoy higher credit ratings;

Sub = Dummy variable that is coded as one if the firm has subordinated debt, zero otherwise. The debt structure of a firm with subordinated debt is considered to be more risky due to the differential claims to assets by debt providers. I expect it to be associated with lower credit ratings;

PPE = Gross PPE divided by total assets. I include it in the model to control for differences in firms' asset structure, where firms with greater PPE present lower risk to debt providers, and thus are expected to have higher credit ratings.

Firm size, *SIZE*, is also controlled because larger firms face lower risk, and thus should have higher credit ratings (Ashbaugh-Skaife, Collins and LaFond 2006; Shi 2003).

4.3.2 Sample and data

The initial sample consists of 119,023 firm-year observations (17,992 firms) available on the Compustat Industrial Annual data (FTP Version), dating from 1998 to 2006. Then, wrong data (Observations with sales, asset, book value, market value and capital expenditure data less than zero) and missing value to compute dependent and control variables are deleted, leading to 10,296 firm-year observations spanning from 1998 to 2005. Next, I merge the sample with RiskMetrics data set for board variables. The sample reduces to 5,747 observations (preliminary sample). Finally, I exclude missing R&D expenditure data and obtain the final sample (2,812 observations). The sample selection procedure is presented on Panel A of Table 4.2.

(Insert Table 4.2 here)

Panel B of Table 4.2 shows the descriptive statistics of the variables used in equation (3.2). The median (mean) credit ratings is 4.0 (3.901), implying a debt rating in the BBB+ to BBB- range. The result is the same to previous literature such as Ashbaugh-Skaife et al. (2006). Consistent with prior studies (Ashbaugh-Skaife, Collins and LaFond 2006; Cheng 2008; Fich and Shivdasani 2006), the average percentage of independent directors on the board is 69.3% (median of 72.7%). Similar to Jiraporn et al. (2008), the average (median) number of outside directorships held by independent directors is 1.255 (1.200).

R&D expenditure accounts for about 3.1% (median of 1.7%) of total assets, which is lower than that in Shi (2003) since Shi (2003) focuses on R&D intensive firms. Similar to Shi (2003), the mean (median) of long-term debt to book value of equity is 0.979 (0.594). Consistent with Ashbaugh-Skaife et al. (2006), the mean (median) values of *ROA*, *Size* and *PPE* are 0.063 (0.062), 8.223 (8.013) and 0.533 (0.470) respectively. *Times* has a mean (median) of 7.801 (3.567), which is higher than Shi (2003). Consistent with Shi (2003) and Ashbaugh-Skaife et al. (2006), about 15.6% of the firms have subordinated debt.

About 51.07% of the observations of the preliminary sample are missing in R&D expenditure data. Thus, I present the descriptive statistics of three groups (missing-R&D group, zero-R&D group and positive-R&D group) in Panel C of Table 4.2, though my final sample includes both zero-R&D and positive-R&D groups. Firms in the missing-R&D and positive-R&D groups have similar credit ratings and firm size. Positive-R&D group is less risky than missing-R&D group, showing lower *DE* and *Sub*, higher *ROA* and *Times*. Positive-R&D group also enjoys the most effective corporate board governance. Missing-R&D group has highest *PPE*, suggesting low default risk. Interestingly, zero-R&D group is rated lowest, has lowest *DE*, *ROA*, *Times*, *Size*, *Sub* and *PPE* and the least effective corporate board governance. The results, however, should be noted with caution since zero-R&D group consists of only 566 observations and may not be representative.

(Insert Table 4.3 here)

Table 4.3 presents the univariate correlation of the variables used in the cost of debt analysis. It is shown that R&D is negatively and significantly related to credit ratings, suggesting that firms with more R&D are subject to higher default risk and thus unfavorable for debt holders, though a final determination of this result can only be made after controlling for other factors. *IG* is positively and significantly correlated with *Rating*, consistent with the view of Ashbaugh-Skaife et al. (2006) that more efficient monitoring mechanism helps increase rating level. Similar to prior literature (Ashbaugh-Skaife, Collins and LaFond 2006; Shi 2003), the table presents a significantly negative correlation between *DE* or *Sub* and *Rating* as well as a significantly positive relation between *Times* or *ROA* or *Size* or *PPE* and *Rating*. *IG* and *RD Dummy* are positively related, suggesting that better internal corporate governance increases R&D level. This result is consistent with the R&D level analysis conducted in chapter two (see the details in section 2.5.4).

4.3.3 Empirical results

My multivariate tests results are tabulated in Table 4.4 based on ordinary lest squares (OLS) regressions. Ordered logit regressions also lead to the same results (untabulated). Since Eberhart et al. (2007) claim that assets or sales are better scalar than market value of equity in measuring R&D intensity, I scale R&D and other related variables by assets. However, I find similar results by using sales or market value of equity as the deflator[34]. The details could be found in sensitivity test results. All variables, except *Rating* and *Sub*, are winsorized at the 1st and 99th percentile values.

[34] Different from Eberhart et al. (2007), my empirical results indicate that the relationship between R&D expenditure and credit rating is not sensitive to the scaling variable used in the measurement of R&D intensity. Specifically, R&D expenditure scaled by assets, sales and market value of equity consistently present a significantly negative association with credit rating. The results should be more convincing because they are consistent with not only the empirical findings of Shi (2003) but also the theoretical predictions made by prior economics and finance literature (Arrow 1962; Brown et al. 2009; Hall 2002; Carpenter et al. 2002; Himmelberg et al. 1994; Harris et al. 1991; Jensen et al. 1976).

(Insert Table 4.4 here)

Column (1) and (3) are results for pool regressions and column (2) and (4) are results for Fama-Macbeth specifications. In all specifications, the coefficients of *RD Dummy* are negative and significant, with p-value less than 0.01, indicating that firms with more R&D expenditures experience lower credit ratings. The results are similar to Shi (2003), in supportive of the argument that R&D expenditures capture less asset-like characteristics but more risk attributes for creditors because the adverse effect of R&D risks on the probability of default (the variance effect) outweighs, on average, the favorable impact of R&D benefits (mean effects). The coefficients of the interaction term *IG*RD Dummy* are significantly positive, supporting the view that effective corporate boards could mitigate the adverse effect of R&D on credit ratings.

The results on control variables are similar to previous literature (Ashbaugh-Skaife, Collins and LaFond 2006; Bhojraj and Sengupta 2003; Eberhart, Maxwell and Siddique 2007; Shi 2003). Consistent with the theory proposed by Ashbaugh-Skaife et al. (2006), I find a significantly positive relationship between *IG* and *Rating*, suggesting that firms possessing strong corporate governance benefit from higher credit ratings relative to firms with weak governance. The coefficients of the four variables proxying for default risk, *DE*, *ROA*, *Times*, and *PPE*, have the expected signs. *Size* is significantly and negatively correlated with *Rating*, suggesting that larger firms typically have lower default risk and higher ratings. The coefficients of *Sub* are negative and significant, indicating that firms with subordinated debt are relatively risky and thus related to lower credit ratings.

4.3.4 Sensitivity tests

I perform several robustness tests and report the results in Table 4.5.

(Insert Table 4.5 here)

First, Eberhart et al. (2007) state that the ratio of R&D to sales or R&D to assets is a better measure of R&D intensity than R&D to the market value of equity because the market value of equity incorporates the market's expectations of the R&D value, and that using the market value of equity as the scalor might invert the true relation between R&D intensity and credit ratings. In this logic, by adopting R&D to sales or R&D to assets to measure R&D intensity, Eberhart et al. (2007) present a positive relationship between R&D expenditures and credit ratings, which is opposite to Shi (2003) and my findings shown in Table 4.4. Therefore, to reconcile the scaling problems, I also employ sales and market value of equity as scalars to repeat the regressions to see whether there are any differences on the results. The results are shown in Panel A and B of Table 4.5. Contrary to Eberhart et al. (2007), I find that both scaling methods result in a negative and significant association between R&D expenditures and credit ratings. Further, the coefficients of *IG*RD Dummy* are significantly positive when R&D expenditures are deflated by sales, and are positive though just close to significant (p-value is 0.112 and 0.136 in pool and Fama-Macbeth regression respectively) when market value of equity is used as the deflator. It appears that my results are not sensitive to different scalars. I interpret this robust result more convincing than that of Eberhart et al. (2007) because it is consistent with not only the empirical findings of Shi (2003) but also the theoretical predictions, debt financing is costly for firms with high level of R&D, made by prior economics and finance literature (Arrow 1962; Brown et al. 2009; Hall 2002; Carpenter et al. 2002; Himmelberg et al. 1994; Harris et al. 1991; Jensen et al. 1976).

Second, in the main test, the dependent variable, *Rating*, takes values which are one year ahead of those of independent variables in case credit ratings are more affected by past information rather than by current information (Shi 2003). Some scholars, however, use contemporaneous regression in similar models (Ashbaugh-Skaife et al, 2006; Bhojraj et al, 2003). As a sensitivity test, I repeat the analysis by running contemporaneous regression and report the results on Panel C of Table 4.5. The results are similar to what I present in Table 4.4.

Third, I repeat the regression using R&D expenditures deflated by total assets to replace the R&D dummy variable. The results (shown in Panel D of Table 4.5) are unchanged though less significant for *IG*RD*.

Next, I also estimate R&D capital and repeat the regression. Other variables computed based on book value of assets are adjusted by using adjusted book value of assets, which are equal to book value of assets plus estimated net R&D assets. The results of this analysis shown in Panel E of Table 4.5 are consistent with the earlier results obtained by using the R&D expenditures.

Finally, I use board independence and exposure separately in their continuous forms and repeat the regressions. The results are presented in Panel

F of Table 4.5. The coefficients of *Independence*RD Dummy* are positive but not significant; and the coefficients of *Exposure*RD Dummy* are significantly positive in both the pooled and Fama-Macbeth specifications. The coefficients of *Exposure* are significantly positive but the coefficients of *Independence* are insignificantly positive. The results are overall consistent with those reported earlier although there is loss of significance.

4.4 Concluding Remarks

Using a sample of U.S. firms, this study investigates two research questions: What is the relationship between R&D investments and the cost of debt, and do effective corporate boards facilitate a less positive (or stronger negative) association between R&D and the cost of debt? Using credit rating to proxy for cost of debt, my empirical findings suggest that firms with more R&D expenditures are related to higher cost of debt, and this positive relationship could be mitigated if firms have more effective corporate boards.

This study contributes to the literature in three ways. First, my empirical evidence suggests that firms with more R&D investments suffer higher cost of debt (lower credit ratings), further supporting the findings of Shi (2003). Second, this study adds to the literature on the role of corporate governance. My findings suggest that corporate boards help mitigate the positive association between R&D investments and cost of debt, and thus ultimately contribute to the increase of firm value. Finally, this study contributes to the literature on R&D. My findings further justify the view that R&D investments suffer from severe agency problems and that corporate boards could help assuage these agency problems and eventually weaken the positive association between R&D investments and cost of debt.

CHAPTER FIVE

CONCLUSION

This chapter concludes the thesis. Section 5.1 briefly summarizes the thesis. Section 5.2 points out the research limitations and section 5.3 provides an insight into the future research opportunities.

5.1 Summary

This dissertation studies how the corporate governance mechanism influences the market valuation of corporate R&D investment. Specifically, in chapter two I examine whether boards and corporate control markets enhance or depress the market valuation of R&D, and whether boards and corporate control markets substitute each other in affecting the R&D valuation. Using U.S. data from 1998 to 2006, the study suggests that both internal and external governance are associated with higher market valuation of R&D investment. Further, the results show that the association between internal (external) governance effectiveness and the R&D valuation is significant only when the external (internal) governance is weak, suggesting that internal and external governance act as substitutes in influencing the market valuation of R&D.

Based on chapter two's results, I further explore the sources of the R&D valuation and the increased R&D valuation accompanied by effective boards.

By separating the effect of R&D/boards on expected future cash flows in the numerator of the valuation model from the effect on the cost of equity in the denominator, the third chapter examines two types of relations: (1) Are R&D investments positively related to the expected future cash flows, and do effective boards strengthen the positive relationship between R&D and cash flows? (2) What is the relationship between R&D investments and the cost of equity, and how is this relationship affected by corporate boards? Using a sample of U.S. firms, I find that: (1) more R&D expenditures are associated with higher expected future cash flows, and this positive association is higher with more effective corporate boards; and (2) firms with more R&D expenditures are charged by a lower cost of equity by investors, and this favorable impact could be stronger with more effective corporate boards.

Finally, I turn my focus from equity holders to debt holders. In chapter four, I first examine the relationship between R&D investments and cost of debt and then further explore boards' potential influence on it. My empirical results indicate that firms with more R&D expenditures are associated with lower credit ratings (higher cost of debt), and further, boards that are more independent and whose independent directors have more outside directorships are associated with a less pronounced negative relationship between R&D expenditures and credit ratings.

Not only is corporate R&D investment critical to long-run competitiveness and profitability at the firm level but is also a critical driving force in the evolving knowledge-based economy at the country level. At the same time, given the frequency and magnitude of recent accounting scandals, corporate governance is emerging as an important regulatory mechanism to manage the economy by altering the incentives for risky investments at the corporate level. It is therefore important to understand how these altered incentives at the corporate level affect the selection of R&D projects, the resulting value of R&D investments as well as the mechanisms through which the altered incentives enhance the R&D valuation. My study addresses these issues and provides evidence suggesting that corporate governance is an important *positive* factor affecting R&D investments for both equity holders and debt holders and that boards could enhance the equity holders' valuation on R&D through both increasing R&D-induced future cash flows and decreasing R&D-related cost of equity.

5.2 Limitations

This dissertation is subject to some limitations:

First, it is important to recognize that R&D inputs represent only one of the components of the innovation process, and firms are likely to vary in their abilities to convert R&D inputs into future outputs. By focusing on R&D inputs alone, this study does not provide insights into the governance's influence on R&D outputs.

Second, my study attempt to separate the effect of R&D/boards on expected future cash flows from the effect on the cost of capital. However, it might hard to completely disentangle the two effects. Future studies on the dichotomy analysis on the two major sources, cash flow and risk premium (cost of capital), of firm value is wanted to facilitate the research.

5.3 Future Research Opportunities

This dissertation, together with some previous research, studies research questions on the valuation of R&D for both equity holders and debt holders. However, there is still some room for further study. For example, my study addresses the issue at the overall investment level. More detailed studies of how it affects the number and nature of patents, publications and other dimensions of innovation need to be investigated to gain a full understanding of the effect of corporate governance mechanisms. On another level, discretionary expenditures other than R&D such as advertising and training expenditures are also affected by the altered managerial incentives resulting from governance regulations. Examining the relationship between corporate governance and other discretionary expenditures will complement the understanding of the role of corporate governance in affecting the market valuation of firms. Further, follow-up studies could investigate whether the market valuation of R&D will be hurt when R&D is used as a tool for the managers to manage earnings. I hope to see more future research on this interesting topic.

REFERENCES

Aboody, D., and B. Lev, 1998, "The value relevance of intangibles: the case of software capitalization," *Journal of Accounting Research* 36, 161-191.

—, 2000, "Information asymmetry, R&D, and insider gains," *Journal of Finance* 55, 2747-2766.

Agrawal, A., and C. R. Knoeber, 1996, "Firm performance and mechanisms to control agency problems between managers and shareholders," *Journal of Financial and Quantitative Analysis* 31, 377-397.

—, 2001, "Do some outside directors play a political role?," *The Journal of Law and Economics* 44, 179-198.

Amir, E., and B. Lev, 1996, "Value-relevance of nonfinancial information: the wireless communications industry," *Journal of Accounting and Economics* 22, 3-30.

Anderson, R. C., and D. M. Reeb, 2003, "Founding-family ownership and firm performance: Evidence from the S&P 500," *The Journal of Finance* 58, 1301-1328.

Arrow, K. J., 1962, "Economic welfare and the allocation of resources for invention," *in R. R. Nelson (ed.), The rate and direction of inventive activity: Economic and social factors (Princeton: Princeton University Press)* 609-625.

Ashbaugh-Skaife, H., D. W. Collins, W. R. K. JR., and R. Lafond, 2009, "The effect of SOX internal control deficiencies on firm risk and cost of equity," *Journal of Accounting Research* 47, 1-43.

Ashbaugh-Skaife, H., D. W. Collins, and R. LaFond, 2006, "The effects of corporate governance on firms' credit ratings," *Journal of Accounting and Economics* 42, 203-243
Ashbaugh, H., D. W. Collins, and R. LaFond, 2004, "Corporate governance and the cost of equity capital," *Working Paper*.

Austin, D. H., 1993, "An event-study approach to measuring innovative output: the case of biotechnology," *The American Economic Review* 83, 253-258.

Bøhren, Ø., I. Cooper, and R. Priestley, 2008, "Real Investment, Q and corporate governance quality," *Working Paper*.

Baber, W. R., P. M. Fairfield, and J. A. Haggard, 1991, "The effect of concern about reported income on discretionary spending decisions: the case of research and development," *The Accounting Review* 66, 818-829.

Baber, W. R., and L. Liang, 2008, "Associations between internal and external corporate governance characteristics and the consequences of regulating governance practices " *Working Paper*.

Baysinger, B., R. Kosnik, and T. Turk, 1991, "Effects of board and ownership structure on corporate R&D strategy," *Academy of Management Journal* 34, 205-214.

Beaver, W., P. Kettler, and M. Scholes, 1970, "The association between market determined and accounting determined risk measures," *The Accounting Review* 45, 654-682.

Bebchuk, L., A. Cohen, and A. Ferrell, 2009, "What matters in corporate governance?," *The Review of Financial Studies* 22, 783-827.

Bebchuk, L. A., and L. A. Stole, 1993, "Do short-Term objectives lead to under- or overinvestment in long-term projects?," *Journal of Finance* 48, 719-729.

Berk, J. B., 1995, "A critique of size-related anomalies," *The Review of Financial Studies* 8, 275-286.

Bhagat, S., and I. Welch, 1995, "Corporate research & development investments international comparisons " *Journal of Accounting and Economics* 19, 443-470.

Bhojraj, s., and P. Sengupta, 2003, "Effect of Corporate Governance on Bond Ratings and Yields: The Role of Institutional Investor and Outside Directors," *Journal of Business* 76, 455-475.

Birman, S. V., 2005, "Managerial entrenchment or efficient monitoring? The effect of antitakeover provisions and board structure on CEO turnover " *Working paper*.

Bizjak, J. M., J. Brickley, and J. Coles, 1993, "Stock-based incentive compensation and investment behavior," *Journal of Accounting and Economics* 16, 349-372.

Black, F., 1972, "Capital market equilibrium with restricted borrowing," *The Journal of Business* 45, 444-455.

Blundell, R., R. Griffith, and J. V. Reenen, 1999, "Market Share, market value and innovation in a panel of British manufacturing firms," *Review of Economic Studies* 66, 529-554.

Booth, J. R., and D. N. Deli, 1996, "Factors affecting the number of outside directorships held by CEOs," *Journal of Financial Economics* 40, 81-104.

Botosan, C., and M. Plumlee, 2005, "Assessing alternative proxies for the expected risk premium," *Accounting Review* 80, 21-53.

Botosan, C., M. Plumlee, and Y. Xie, 2004, "The role of private information precision in determining cost of equity capital," *Review of Accounting Studies* 9, 233-259.

Brown, J., S. Fazzari, and B. Petersen, 2009, "Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom," *Journal of Finance* 64, 151 - 185.

Bublitz, B., and M. Ettredge, 1989, "The information in discretionary outlays: advertising, research and development," *The Accounting Review* 64, 108-124.

Burkart, M., D. Gromb, and F. Panunzi, 1997, "Large shareholders, monitoring, and the value of the firm," *Quarterly Journal of Economics* 112, 693-728.

Bushee, B., 1998, "The Influence of Institutional Investors on Myopic R&D Investment Behavior " *The Accounting Review* 73, 305-333.

Cai, J., J. L. Garner, and R. A. Walkling, 2009, "Electing Directors" *Journal of Finance* forthcoming.

Carcello, J. V., D. R. Hermanson, T. L. Neal, and R. A. Riley Jr, 2002, "Board characteristics and audit fees," *Contemporary Accounting Research* 19, 365-384.

Cardinal, L. B., and T. C. Opler, 1995, "Corporate diversification and innovative efficiency an empirical study," *Journal of Accounting and Economics* 19, 365-381.

Carpenter, R. E., and B. C. Petersen, 2002, "Capital market imperfections, high-tech investment, and new equity financing," *Economic Journal* 112, 54-72.

Caves, R. E., and P. Ghemawat, 1992, "Identifying mobility barriers," *Strategic Management Journal* 13, 1-12.

Chambers, D., R. Jennings, and R. B. Thompson, 2002, "Excess returns to R&D-intensive firms," *Review of Accounting Studies* 7, 133-158.

Chan, L. K. C., J. Lakonishok, and T. Sougiannis, 2001, "The stock market valuation of research and development expenditures," *The Journal of Finance* 56, 2431-2456.

Chan, S., J. Martin, and J. Kensinger, 1990, "Corporate research and development expenditures and share value," *Journal of Financial Economics* 26, 255-276.

Chan, S. H., J. Martin, and J. Kensinger, 1990, "Corporate research and development expenditures and share value," *Journal of Financial Economics* 26, 255-276.

Chauvin, K. W., and M. Hirschey, 1993, "Advertising, R&D expenditures and the market value of the firm," *Financial Management* 22, 128-140.

Cheng, S., 2008, "Board size and the variability of corporate performance," *Journal of Financial Economics* 87, 157-176.

Claus, J., and J. Thomas, 2001, "Equity premia as low as three percent? Evidence from analysts' earnings forecasts for domestic and international stock markets," *The Journal of Finance* 56, 1629-1666.

Cohen, W., and R. Levin, 1989, "Empirical studies of innovation and market structure," *in: R. Schmalensee and R. Willig, eds., Handbook of industrial organization, Vol. II (Elsevier Science B.V., Amsterdam).* .

Cohen, W. M., and D. A. Levinthal, 1989, "Innovation and learning: the two faces of R&D," *The Economic Journal*.

Coles, J. L., N. D. Daniel, and L. Naveen, 2008, "Boards: does one size fit all?," *Journal of Financial Economics* 87, 329-356
Core, J. E., R. W. Holthausen, and D. F. Larcker, 1999, "Corporate governance, chief executive officer compensation, and firm performance," *Journal of Financial Economics* 51, 371-406.

Cremers, K. J. M., and V. B. Nair, 2005, "Governance mechanisms and equity prices," *Journal of Finance* 60, 2859-2894.

Dechow, P., and R. Sloan, 1991, "Executive incentives and the horizon problem: an empirical investigation," *Journal of Accounting and Economics* 14, 51-89.

Demsetz, H., and K. Lehn, 1985, "The structure of corporate ownership: causes and consequences," *The Journal of Political Economy* 93, 1155-1177.

Denis, D. J., and T. A. Kruse, 2000, "Managerial discipline and corporate restructuring following performance declines," *Journal of Financial Economics* 55, 391-424.

Denis, D. J., and A. Sarin, 1999, "Ownership and board structures in publicly traded corporations," *Journal of Financial Economics* 52, 187-223.

Dhaliwal, D., S. Heitzman, and O. Z. Li, 2006, "Taxes, leverage, and the cost of equity capital " *Journal of Accounting Research* 44, 691-723(33).

Dhaliwal, D. S., R. E. Huber, H. S. G. Lee, and M. Pincus, 2008, "Variability of book-tax differences, information uncertainty, and implied cost of capital " *Working Paper*.

Dittmar, A., and J. Mahrt-Smith, 2007, "Corporate governance and the value of cash holding," *Journal of Financial Economics* 83, 599-634

Easton, P., 2004, "PE ratios, PEG ratios, and estimating the implied expected rate of return on equity capital," *Accounting Review* 79, 73-95.

Eberhart, A. C., W. F. Maxwell, and A. R. Siddique, 2007, "A reexamination of the tradeoff between the future benefit and riskiness of R&D " *Journal of Accounting Research* 46, 27 - 52.

Elton, E. J., M. J. Gruber, D. Agrawal, and C. Mann, 2001, "Explaining the Rate Spread on Corporate Bonds," *The Journal of Finance* 56, 247-277.

Evenson, R. E., and Y. Kislev, 1973, "Research and productivity in wheat and maize," *The Journal of Political Economy* 81, 1309-1329.

Faleye, O., 2007, "Classified boards, firm value, and managerial entrenchment," *Journal of Financial Economics* 83, 501-529.

Fama, E. F., 1980, "Agency problems and the theory of the firm," *The Journal of Political Economy* 88, 288.

Fama, E. F., and K. R. French, 2006, "Profitability, investment and average returns," *Journal of Financial Economics* 82, 491-518.

Fama, E. F., and M. C. Jensen, 1983, "Separation of ownership and control," *The Journal of Law and Economics* 26, 301.

Ferris, S. P., M. Jagannathan, and A. C. Pritchard, 2003, "Too busy to mind the business? Monitoring by directors with multiple board appointments," *The Journal of Finance* 58, 1087-1112.

Fich, E. M., and A. Shivdasani, 2006, "Are busy boards effective monitors?," *The Journal of Finance* 61, 689-724.

Fisher, L., 1959, "Determinants of Risk Premiums on Corporate Bonds," *The Journal of Political Economy* 67, 217-237.

Francis, J., R. LaFond, P. Olsson, and K. Schipper, 2005, "The market pricing of accruals quality," *Journal of Accounting and Economics* 39, 295-327.

Francis, J., P. Olsson, and D. R. Oswald, 2000, "Comparing the accuracy and explainability of dividend, free cash flow, and abnormal earnings equity value estimates," *Journal of Accounting Research* 38, 45-70.

Franko, L. G., 1989, "Global corporate competition: Who's winning, who's losing, and the R&D factor as one reason why," *Strategic Management Journal* 10, 449-474.

Garmaise, M. J., and J. Liu, 2005, "Corruption, firm governance, and the cost of capital," *Working Paper*.

Gebhardt, W. R., C. M. C. Lee, and B. Swaminathan, 2001, "Toward an implied cost of capital," *Journal of Accounting Research* 39, 135-176.

Gilson, S. C., 1990, "Bankruptcy, boards, banks, and blockholders: evidence on changes in corporate ownership and control when firms default," *Journal of Financial Economics* 27, 355-387.

Gode, D., and P. Mohanram, 2003, "Inferring the cost of capital using the Ohlson-Juettner model," *Review of Accounting Studies* 8, 399-431.

Gompers, P., J. Ishii, and A. Metrick, 2003, Corporate governance and equity prices, The Quarterly Journal of Economics.
Guay, W., S. P. Kothari, and S. Shu, 2005, "Properties of implied cost of capital using analysts' forecasts," *Working Paper: MIT Sloan School of Management*.

Guellec, D., and B. V. P. d. l. Potterie, 2004, "From R&D to productivity growth: Do the institutional settings and the source of funds of R&D matter?," *Oxford Bulletin of Economics and Statistics* 66, 353-378.

Hail, L., and C. Leuz, 2006, "International differences in the cost of equity capital: Do legal institutions and securities regulation matter?," *Journal of Accounting Research* 44, 485.

—, 2008, "Cost of capital effects and changes in growth expectations around U.S. cross-listings," *Working Paper*.

Hall, B. H., 1993, "The stock market's valuation of R&D investment during the 1980's," *The American Economic Review* 83, 259-264.

—, 2002, "The financing of research and development," *Oxford Bulletin o Economics and Statistics* 18, 35-51.

Harris, M., and A. Raviv, 1991, "The theory of capital structure," *Journal of Finance* 46, 297-355.

Hayes, R. H., and W. J. Abernathy, 1980, "Managing our way to economic decline," *Harvard Business Review* 58, 67-77.

Helfat, C. E., 1997, "Know-how and asset complementarity and dynamic capability accumulation: the case of R&D," *Strategic Management Journal* 18, 339 - 360.

Hermalin, B., and M. Weisbach, 1988, "The determinants of board composition," *The RAND Journal of Economics* 19, 589-606.

—, 1991, "The effects of board composition and direct incentives on firm performance," *Financial Management* 20, 101-112.

Hermalin, B. E., and M. S. Weisbach, 2003, "Boards of directors as an endogenously determined institution: A survey of the economic literature," *Economic Policy Review* 9, 7-26.

Hill, C. W. L., and S. A. Snell, 1988, "External control, corporate strategy, and firm performance in research-intensive industries," *Strategic Management Journal* 9, 577-590.

Hillier, D., J. Pindado, V. d. Queiroz, and C. d. l. Torre, 2008, "The impact of corporate governance on research and development " *Working Paper*.

Hillman, A. J., A. A. Cannella, and R. L. Paetzold, 2000, "The resource dependence role of corporate directors: Strategic adaptation of board composition in response to environmental change," *Journal of Management Studies2000* 37, 235-255.

Himmelberg, C. P., and B. C. Petersen, 1994, "R&D and internal finance: A panel study of small firms in high-tech industries," *The Review of Economics and Statistics* 76, 38-51.

Hirschey, M., and J. J. Weygandt, 1985, "Amortization policy for advertising and research and development expenditures," *Journal of Accounting Research* 23, 326-335.

Huson, M. R., R. Parrino, and L. T. Starks, 2001, "Internal monitoring mechanisms and CEO turnover: A long-term perspective," *Journal of Finance* 56, 2265-2297.

Jensen, M., 1993, "The modern industrial revolution: exit and the failure of internal control systems," *Journal of Finance* 48, 831-880.

Jensen, M. C., and W. H. Meckling, 1976, "Theory of the firm: Managerial behavior, agency costs and ownership structure," *Journal of Financial Economics* 3, 305-360.

Jiraporn, P., Y. Kim, and W. Davidson-III, 2008, "Multiple directorships and corporate diversification," *Journal of Empirical Finance* 15, 418– 435.

Klette, T. J., 1996, "R&D, scope economies, and plant performance," *RAND Journal of Economics* 27, 502-522.

Kothari, S., T. Laguerre, and A. Leone, 2002a, "Capitalization versus expensing: Evidence on the uncertainty of future earnings from capital expenditures versus R&D outlays," *Review of Accounting Studies* 7, 355-382.

Kothari, S. P., T. E. Laguerre, and A. J. Leone, 2002b, "Capitalization versus expensing: evidence on the uncertainty of future earnings from capital expenditures versus R&D outlays," *Review of Accounting Studies* 7, 355-382.

Lakonishok, J., and T. Sougiannis, 2001, "The stock market valuation of research and development expenditures," *Journal of Finance* 2431-2456.

Lev, B., S. Radhakrishnan, and M. Ciftci, 2006, "The stock market valuation of R&D Leaders," *Working Paper*.

Lev, B., and T. Sougiannis, 1996, "The capitalization, amortization, and value-relevance of R&D," *Journal of Accounting and Economics* 21, 107-138.

Linck, J. S., J. M. Netter, and T. Yang, 2008, "The determinants of board structure," *Journal of Financial Economics* 87, 308-328.

Lintner, J., 1965, "The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets," *The Review of Economics and Statistics* 47, 13-37.

Loudder, M. L., and B. K. Behn, 1995, "Alternative income determination rules and earnings usefulness: the case of R&D costs," *Contemporary Accounting Research* 12, 185-205.

Meulbroek, L. K., M. L. Mitchell, J. H. Mulherin, J. M. Netter, and A. B. Poulsen, 1990, "Shark repellents and managerial myopia: an empirical test," *The Journal of Political Economy* 98, 1108-1117.

Mikkelson, W. H., and M. M. Partch, 1997, "The decline of takeovers and disciplinary managerial turnover," *Journal of Financial Economics* 44, 205-228.

Morck, R., and B. Yeung, 1999, "The economic determinants of innovation," *Working Paper*.

Ohlson, J. A., and B. E. Juettner-Nauroth, 2005, "Expected EPS and EPS growth as determinants of value," *Review of Accounting Studies* 10, 349-365.

Osma, B. G., 2008, "Board independence and real earnings management: The case of R&D expenditure," *Corporate Governance: An International Review* 16, 116-131.

Pandit, S., C. E. Wasley, and T. Zach, 2009, "Further evidence on the relation between the uncertainty of future operating performance and R&D expenditures: The role of R&D inputs and outputs " *Working Paper*.

Richardson, S., 2006, "Over-investment of free cash flow," *Review of Accounting Studies* 11, 159-189.

Sharpe, W. F., 1964, "Capital asset prices: A theory of market equilibrium under conditions of risk," *The Journal of Finance* 19, 425-442.

Shi, C., 2003, "On the trade-off between the future benefits and riskiness of R&D: a bondholders' perspective," *Journal of Accounting and Economics* 35, 227-254.

Shleifer, A., and R. W. Vishny, 1997, "A survey of corporate governance," *The Journal of Finance* 52, 737-783.

Smith, C., and R. Watts, 1992, "The investment opportunity set and corporate financing, dividend, and compensation policies," *Journal of Financial Economics* 32, 263-292.

Sougiannis, T., 1994, "The accounting based valuation of corporate R&D," *The Accounting Review* 69, 44-68.

Stein, J. C., 1988, "Takeover threats and managerial myopia," *The Journal of Political Economy* 96, 61-80.

Subramanyam, K. R., and M. Venkatachalam, 2007, "Earnings, cash flows, and ex post intrinsic value of equity," *The Accounting Review* 82, 457-481.

Sundaramurthy, C., 2000, "Antitakeover provisions and shareholder value implications: A review and a contingency framework," *Journal of Management* 26, 1005-1030.

Tilton, J. E., 1971, "International diffusion of technology: the case of semiconductor," *Washington: Brookings Institution*.

Villalonga, B., and R. Amit, 2006, "How do family ownership, control and management affect firm value?," *Journal of Financial Economics* 80, 385-417.

Weber, J., 2006, "Discussion of the effects of corporate governance on firms' credit ratings," *Journal of Accounting and Economics* 42, 245-254.

Willman, J., Nov. 11, 2007, "US ahead as global R&D spending up 10%," *Financial Times*.

Yermack, D., 1996, "Higher market valuation of companies with a small board of directors," *Journal of Financial Economics* 40, 185-211.

APPENDIX: IMPLIED COST OF EQUITY CAPITAL MODELS

The following definitions are common to the four models. Specific assumptions and modifications to these variables are described with the model.

P_t = Market price of a firm's stock at year *t*.

BV_t = Book value per share at the beginning of the year.

BV_{t+i} = Expected future book value per share at yeat *t+i*. $BV_{t+i} = BV_{t+i-1} + E_{t+i}(1-k)$.

DPS_0 = Dividends per share paid during year *t-1*.

DPS_{t+i} = Expected future net dividends per share for period (*t+i–1, t+i*), derived from the dividend payout ratio times the earnings per share forecast E_{t+i}.

EPS_0 = Actual earnings per share for year *t-1*.

LTG = Consensus long-term growth forecast reported in year *t*.

E_{t+i} = Forecasted earnings per share for year *t+1*. E_1 and E_2 are equal to the one and two year-ahead consensus EPS forecasts. E_3 is equal to the three year-ahead consensus EPS forecast when available, and E_2 (1 + LTG) when not available.

k = Expected dividend payout ratio, calculated as DPS_0/EPS_0. If $EPS_0 \leqslant 0$, then k is equal to six percent of total assets at the beginning of year *t*. k is winsorized to be between 0 and 1.

r_j = Implied cost of equity estimate for each of the four models.

r_{rf} = Risk-free rate equal to the yield on a 10-year Treasury note in year *t*.

Claus and Thomas (2001):

$$P_t = BV_t + \sum_{i=1}^{5} \frac{(E_{t+i} - rct * BV_{t+i-1})}{(1+rct)^i} + \frac{(E_5 - rct * BV_4)(1+g_{ae})}{(rct - gae)(1+rct)^5}$$

Model-specific assumptions:

This is a special case of the residual income valuation model. It uses actual book values per share and forecasted earnings per share up to five years ahead to derive the expected future residual income series. I assume clean surplus, that is, future book values are imputed from current book values, forecasted earnings and dividends. Dividends are set equal to a constant fraction of forecasted earnings. g_{ae} is growth in abnormal earnings, calculated as r_{rf}–0.03.

Gebhardt, Lee, and Swaminathan [2001]:

$$P_t = BV_t + \frac{FROE_{t+1} - rgls}{(1+gls)} * BV_t + \frac{FROE_{t+2} - rgls}{(1+rgls)^2} * B_{t+1} + TV$$

$$TV = \sum_{i=3}^{T-1} \frac{FROE_{t+i} - rgls}{(1+rgls)^i} * BV_{t+i-1} + \frac{FROE_{t+T} - rgls}{rgls(1+rgls)^{T-1}} * BV_{t+T-1}$$

Model-specific assumptions:

This is a special case of the residual income valuation model. It uses actual book values per share and forecasted ROE up to three years ahead to impute future expected residual income for an initial three-year period. I assume clean surplus, that is, future book values are imputed from current book values, forecasted earnings and dividends. Dividends are set equal to a constant fraction of forecasted earnings. For years one through three, $FROE_{t+i}$ is equal to $FROE_{t+i}$/BV_{t+i-1}. After the explicit forecast period of three years, the residual income series is derived by linearly fading the forecasted ROE to the third year industry-specific median return. Industries are defined as 2-dig SIC code. Negative industry-specific target returns are excluded from the computation. T is the forecast horizon and set to be 12.

Ohlson and Juettner-Nauroth [2005]:

$$P_t = (E_{t+1}/roj)*(gst + roj*DPS_{t+1}/E_{t+1} - glt)/(roj - glt)$$

Model-specific assumptions:

This is a special case of the abnormal earnings growth valuation model developed by Ohlson and Juettner-Nauroth [2005]. It uses one-year-ahead forecasted earnings and dividends per share as well as forecasts of short-term and long-term abnormal earnings growth. Dividends are set equal to a constant fraction of forecasted earnings. Following Gode and Mohanram [2003], the short-term growth rate *gst* is estimated as the average between the forecasted percentage change in earnings from year *t+1* to *t+2* and the five-year growth forecast provided by financial analysts on I/B/E/S. The model requires a positive forecasted earnings to yield a numerical solution, that is $E_{t+1}>0$ and $E_{t+2}>0$. *glt* is equal to (r_{rf}–0.03). Note that *glt* sets a lower bound to the cost of capital estimates.

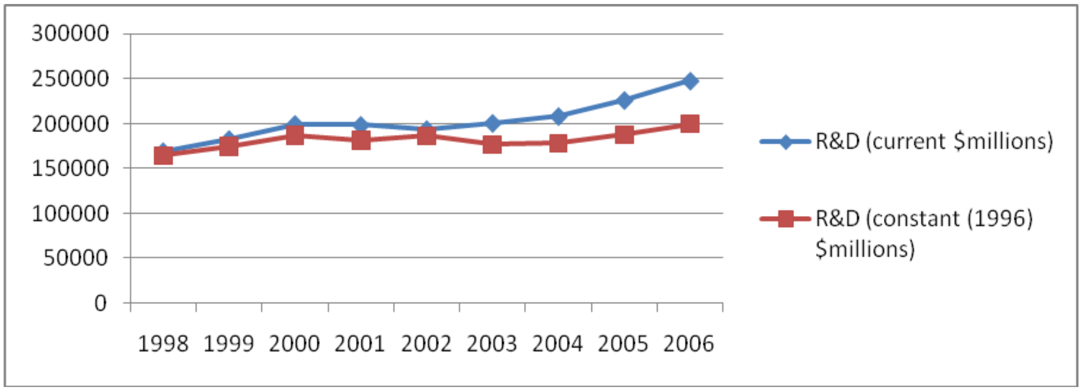
Easton [2004]:

$$P_t = \left(\frac{E_{t+2} + rpeg*DPS_{t+1} - E_{t+1}}{rpeg^2}\right)$$

Model-specific assumptions:

This is a special case of the abnormal earnings growth valuation model developed by Ohlson and Juettner-Nauroth [2005]. It uses one-year-ahead and two-year-ahead earnings per share forecasts as well as expected dividends per share in period *t+1* to derive a measure of abnormal earnings growth. Dividends are set equal to a constant fraction of forecasted earnings. The model embeds the assumption that growth in abnormal earnings persists in perpetuity after the initial period. Note that it requires positive changes in forecasted earnings (including reinvested dividends) to yield a numerical solution, that is $E_{t+2} \geqslant E_{t+1} > 0$.

Figure 1



300000
250000
200000
150000
100000
50000
0
1998 1999 2000 2001 2002 2003 2004 2005 2006
R&D (current $millions)
R&D (constant (1996) $millions)

Figure 2

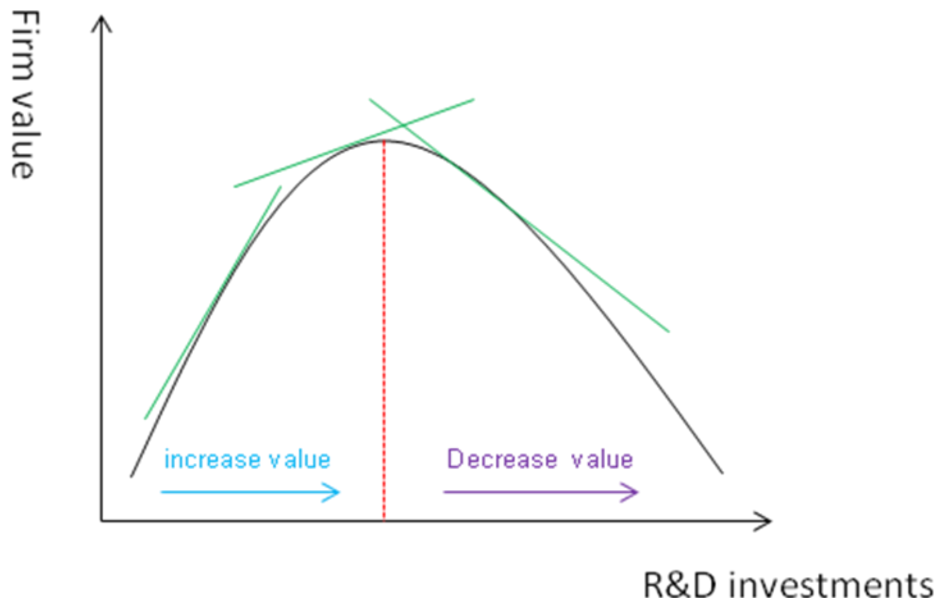


Figure 3

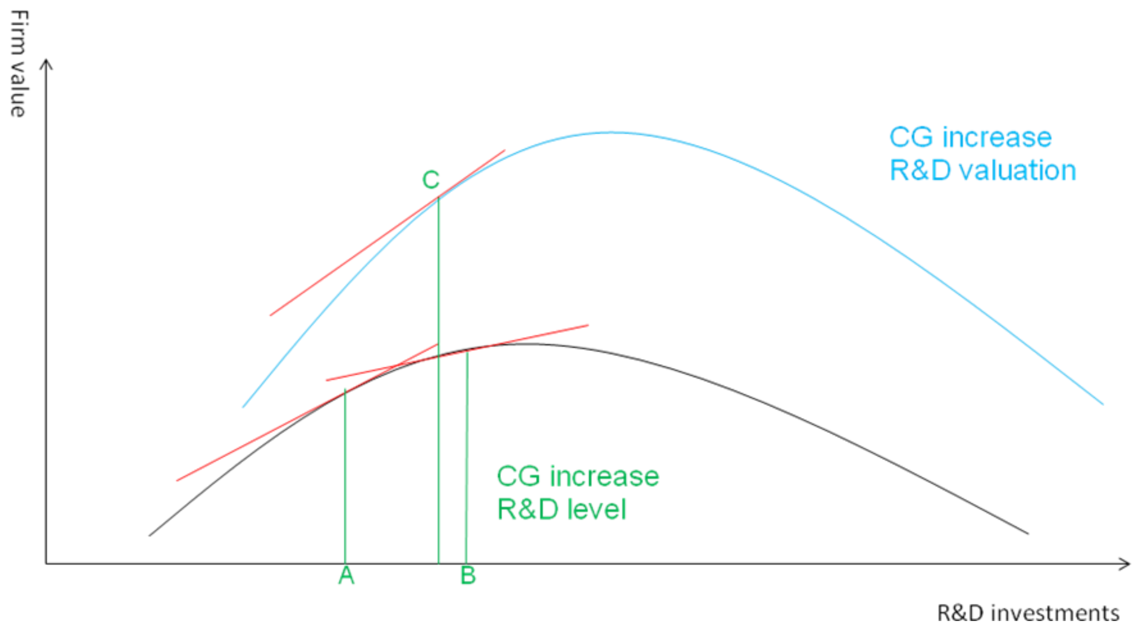

Firm value
CG increase
R&D valuation
C
CG increase
R&D level
A
B
R&D investments

Table 2.1 Sample Selection Procedure and Descriptive Statistics

Panel A presents the selection procedure of the sample. The sample consists of 5,952 firm-year observations covering from 1998 to 2006. Data on financial items are from Compustat. Data on board items are from RiskMetrics. Data on entrenchment index are from Lucian Bebchuk's home page (http://www.law.harvard.edu/faculty/bebchuk/data.shtml). Panel B presents the summary statistics of the data used in equation (2.1). All variables except entrenchment index are winsorized at the 1st and 99th percentile values. Panel C presents the summary statistics comparison between three types of data. They are data where R&D is missing, R&D is zero and R&D is positive, respectively.

ROA(n) is missing in R&D missing group because ROA is computed as net income before R&D expenditures (nonmissing) scaled by total assets. Tobq is the ratio of market value of assets to book value of assets, calculated as the book value of assets minus the book value of equity, plus the market value of equity, scaled by the book value of assets at year t. RD is research and development expenditure (nonmissing), scaled by the book value of assets at year t. RD Dummy is equal to one if RD is above 75th percentile for that year, and zero otherwise. IGR is to scale the sum of Independence and Exposure into a range of 0 and 1; both Independence and Exposure are partitioned into 7 ranks. Independence is the number of independent directors as a percentage of the total number of directors. The definition of independence follows the IRRC definition. Exposure is the average number of outside directorships in other firms held by independent directors. Eindex is minus one multiplies with Entrenchment index, a discrete measure ranging in value from zero to six representing the presence of staggered boards, limits to shareholder bylaw amendments, supermajority requirements for mergers, supermajority requirements for charter amendments, poison pills and golden parachutes. EGR is to scale Eindex into a range of 0 and 1. Capx is capital expenditure, scaled by the book value of assets at year t. Capx Dummy is equal to one if Capx is above median for that year, and zero otherwise. Lev is total debt divided by total assets. Size is firm size, measured as the natural logarithm of total assets; Growth is annual growth rate of annual sales; ROA_t is net income (before R&D expenditures) on total assets, after adjusting the tax influenced by R&D expenditure, at year *t*; $ROA_{(t-1)}$ is ROA at year *t-1*; $ROA_{(t-2)}$ is ROA at year *t-2*.

Panel A. Sample selection procedure

Criteria	N
Compustat Industrial Annual data (FTP Version), 1996-2006	129, 087
Less: Observations with sales, asset, book/market value and capital expenditure less than zero	(53, 089)
Missing value to compute other financial variables, 1998-2006	(19, 148)
Subtotal	56, 850
Merge with RiskMetrics data set on directors	12, 334
Merge with entrenchment index data	11, 119
Less: Missing R&D expenditure data	(5, 167)
Final Sample	5, 952

Table 2.1 – Continued

Panel B. Descriptive statistics of the data used in the regression (n=5952)

VARIABLE	MEAN	STD	P25	MEDIAN	P75
Tobq	2.238	1.484	1.309	1.750	2.598
RD	0.049	0.058	0.005	0.027	0.074
RD Dummy	0.251	0.433	0.000	0.000	1.000
Independence	0.672	0.170	0.571	0.700	0.800
Exposure	0.992	0.706	0.500	0.909	1.400
Eindex	-2.390	-1.283	-3.000	-2.000	-1.000
Capx	0.052	0.039	0.024	0.040	0.067
Capx Dummy	0.501	0.500	0.000	1.000	1.000
Lev	0.197	0.161	0.036	0.191	0.310
Size	7.298	1.469	6.238	7.118	8.172
Growth	0.109	0.224	0.005	0.087	0.184
ROA	0.078	0.102	0.036	0.078	0.127
$ROA_{(t-1)}$	0.082	0.100	0.038	0.080	0.131
$ROA_{(t-2)}$	0.086	0.099	0.040	0.082	0.134

Panel C. Descriptive statistics comparison: missing-RD data, zero-RD data and positive-RD data

VARIABLE	RD is missing (n=5,167)		RD is zero (n=1,143)		RD is nonmissing/nonzero (n=4,809)	
	mean	median	mean	median	mean	median
Tobq	1.613	1.295	1.984	1.650	2.301	1.777
RD	-	-	0.000	0.000	0.060	0.039
RD Dummy	-	-	-	-	0.251	0.000
Independence	0.646	0.667	0.613	0.625	0.686	0.714
Exposure	0.883	0.750	0.848	0.750	1.026	1.000
Eindex	-2.430	-2.000	-2.346	-2.000	-2.401	-2.000
Capx	0.057	0.042	0.079	0.068	0.046	0.037
Capx Dummy	0.500	1.000	0.502	1.000	0.500	1.000
Lev	0.267	0.273	0.204	0.179	0.195	0.192
Size	7.852	7.641	7.196	7.048	7.322	7.159
Growth	0.121	0.081	0.128	0.109	0.104	0.080
ROA	-	-	0.062	0.061	0.082	0.083
$ROA_{(t-1)}$	-	-	0.065	0.061	0.086	0.085
$ROA_{(t-2)}$	-	-	0.066	0.060	0.091	0.088

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Table 2.2 Univariate Correlation

This table provides the Pearson and Spearman correlation of the variables used in the main regression model. The Pearson (Spearman) correlation coefficients are presented above (below) the diagonal. *, **, *** denoting two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively. All variables follow the definitions in Table 2.1.

Variable	Tobq	RD	IGR	EGR	Capx	Lev	Size	Growth	ROA	$ROA_{(t-1)}$	$ROA_{(t-2)}$
Tobq	-	0.326***	-0.033	0.181***	0.119***	-0.291***	0.003	0.301***	0.470***	0.416***	0.363***
RD	0.279***	-	-0.028	0.132***	-0.118***	-0.276***	-0.234***	0.021	0.188***	0.230***	0.263***
IGR	0.000	0.027**	-	-0.164***	-0.089***	0.159***	0.423***	-0.070***	-0.013	-0.024*	-0.051
EGR	0.176***	0.096***	-0.167***	-	0.079***	-0.124***	0.023*	0.080***	0.059***	0.076***	0.083***
Capx	0.130***	-0.215***	-0.044*	0.054***	-	-0.044***	-0.038***	0.070***	0.069***	0.117***	0.078***
Lev	-0.352***	-0.273***	0.186***	-0.151***	-0.002	-	0.293***	-0.034***	-0.298***	-0.272***	-0.257***
Size	0.012	-0.179***	0.424***	-0.030**	0.008	0.335***	-	0.016	0.034***	0.019	-0.025*
Growth	0.327***	-0.029**	-0.085***	0.074***	0.073***	-0.094***	0.016	-	0.210***	0.052***	0.008
ROA	0.668***	0.334***	-0.021	0.094***	0.112***	-0.400***	-0.037***	0.285***	-	0.501***	0.358***
ROA(t-1)	0.570***	0.348***	-0.040*	0.109***	0.151***	-0.370***	-0.056***	0.130***	0.644***	-	0.509***
ROA(t-2)	0.482***	0.364***	-0.067*	0.117***	0.120***	-0.341***	-0.092***	0.067***	0.500***	0.642***	-

Table 2.3 The Effect of Internal and External Governance on the R&D valuation

This table presents the results on the relationship between corporate governance (both internal and external corporate governance) and the market valuation of R&D. The dependent variable is Tobin's Q. Other variables follow the definitions in Table 2.1. The industry (and year) are included, but not reported. Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pool	F-M	Pool	F-M	Pool	F-M
RD Dummy	0.502***	0.482***	0.459***	0.427***	0.447***	0.421***
	[0.000]	[0.008]	[0.000]	[0.009]	[0.000]	[0.008]
IGR* RD Dummy	0.523***	0.649***			0.559***	0.690***
	[0.005]	[0.003]			[0.003]	[0.003]
EGR * RD Dummy			0.378*	0.158	0.423*	0.168
			[0.091]	[0.371]	[0.062]	[0.352]
IGR * EGR *RD Dummy					-1.390	-1.787***
					[0.117]	[0.006]
IGR * EGR					0.385	0.164
					[0.193]	[0.480]
IGR	0.081	0.033			0.174**	0.123**
	[0.247]	[0.408]			[0.018]	[0.032]
EGR			0.506***	0.474***	0.518***	0.484***
			[0.000]	[0.000]	[0.000]	[0.000]
Capx Dummy	0.078**	0.071	0.083**	0.077*	0.080**	0.074*
	[0.024]	[0.110]	[0.016]	[0.085]	[0.020]	[0.093]
Lev	-1.188***	-0.994***	-1.133***	-0.962***	-1.137***	-0.963***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.071***	0.068**	0.069***	0.064**	0.057***	0.056**
	[0.000]	[0.014]	[0.000]	[0.025]	[0.000]	[0.025]
Growth	1.527***	1.448***	1.493***	1.418***	1.501***	1.419***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ROA	3.190***	3.447***	3.231***	3.463***	3.223***	3.464***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	2.106***	2.380***	2.093***	2.392***	2.100***	2.390***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-2)}$	1.722***	1.740***	1.725***	1.746***	1.719***	1.737***
	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]
Constant	1.330***	0.793*	1.483***	1.062**	1.592***	0.751**
	[0.000]	[0.061]	[0.000]	[0.029]	[0.000]	[0.017]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
observation	5,952	9	5,952	9	5,952	9
Adjusted R^2	0.407	-	0.411	-	0.413	-
Average R^2	-	0.462	-	0.464	-	0.468

Table 2.4 The Effect of Internal and External Governance on the R&D valuation: Sub-sample Results

Panel A presents the descriptive statistics of the main variables used in sub-samples. The low-EG subsample is the one with *EGR* below the median at year *t*, and the high-EG subsample is the one with *EGR* above the median at year *t*. The low-IG subsample is the one with *IGR* below the median at year *t*, and the high-IG subsample is the one with *IGR* above the median at year *t*. Panel B presents the results of the association between internal corporate governance and the R&D valuation in the low-EG sample versus the high-EG sample. The median level of *EGR* (1,554 out of 5,952 observations) are included in both low-EG and high-EG sample. Excluding them from both sub-samples do not change the results. The dependent variable is Tobin's Q. Other variables follow the definitions in Table 2.1. The industry (and year) are included, but not reported. Panel C presents the results of the association between external corporate governance and the R&D valuation in the low-IG sample versus the high-IG sample. The median level of *IGR* (741 out of 5952 observations) are included in both low-IG and high-IG sample. Excluding them from both sub-samples do not change the results. The dependent variable is Tobin's Q. Other variables follow the definitions in Table 2.1. In both Panel B and C, column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Descriptive statistics in different sub-samples

	Low-EG Sample (n=3,503)		High-EG Sample (n=4,003)		Low-IG Sample (n=3,353)		High-IG Sample (n=3,340)	
Variable	mean	median	mean	Median	mean	median	mean	Median
Tobq	2.087	1.623	2.368	1.862	2.259	1.765	2.219	1.733
RD	0.043	0.024	0.053	0.031	0.051	0.028	0.047	0.026
RD Dummy	0.251	0.000	0.251	0.000	0.251	0.000	0.251	0.000
Independence	0.689	0.714	0.661	0.667	-	-	-	-
Exposure	1.011	1.000	0.963	0.857	-	-	-	-
Eindex	-	-	-	-	-2.229	-2.000	-2.552	-3.000
Capx	0.051	0.041	0.052	0.039	0.055	0.040	0.049	0.040
Capx Dummy	0.501	1.000	0.500	1.000	0.500	1.000	0.501	1.000
Lev	0.214	0.215	0.180	0.160	0.174	0.148	0.222	0.224
Size	7.258	7.153	7.314	7.067	6.816	6.676	7.769	7.645
Growth	0.097	0.079	0.121	0.096	0.121	0.099	0.095	0.076
ROA	0.075	0.074	0.082	0.084	0.080	0.080	0.076	0.076
$ROA_{(t-1)}$	0.079	0.076	0.084	0.085	0.084	0.083	0.079	0.077
$ROA_{(t-2)}$	0.082	0.078	0.089	0.087	0.090	0.086	0.082	0.079

Table 2.4 - Continued

Panel B. IG's association with R&D valuation in low/high-EG sample

	Low-EG Sample		High-EG Sample	
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	0.544***	0.470***	0.282***	0.250**
	[0.000]	[0.007]	[0.000]	[0.035]
IGR * RD Dummy	0.498**	0.627***	0.355	0.435**
	[0.027]	[0.004]	[0.131]	[0.024]
IGR	-0.057	-0.058	0.230**	0.197
	[0.495]	[0.274]	[0.017]	[0.102]
Capx Dummy	0.070*	0.087*	0.118***	0.111**
	[0.083]	[0.075]	[0.008]	[0.032]
Lev	-0.985***	-0.684***	-1.419***	-1.337***
	[0.000]	[0.003]	[0.000]	[0.000]
Size	0.107***	0.080*	0.046***	0.050**
	[0.000]	[0.074]	[0.006]	[0.016]
Growth	1.149***	1.136***	1.661***	1.628***
	[0.000]	[0.000]	[0.000]	[0.000]
ROA	3.595***	3.714***	3.137***	3.397***
	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	1.886***	2.187***	1.832***	2.177***
	[0.000]	[0.003]	[0.000]	[0.000]
$ROA_{(t-2)}$	2.480***	2.619***	1.476***	1.493***
	[0.000]	[0.000]	[0.000]	[0.009]
Constant	0.256	1.696**	1.584***	1.393***
	[0.162]	[0.036]	[0.000]	[0.002]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Observation	3,503	9	4,003	9
Adjusted R^2	0.446	-	0.379	-
Average R^2	-	0.534	-	0.443

Table 2.4 - Continued

Panel C. EG's association with R&D valuation in high/low-IG sample

	Low-IG Sample		High-IG Sample	
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	0.213***	0.134	0.633***	0.610***
	[0.002]	[0.155]	[0.000]	[0.003]
EGR * RD Dummy	0.927***	0.660**	0.012	-0.280
	[0.001]	[0.031]	[0.969]	[0.301]
EGR	0.497***	0.440***	0.659***	0.620***
	[0.000]	[0.002]	[0.000]	[0.000]
Capx Dummy	0.112**	0.094*	-0.002	0.029
	[0.017]	[0.096]	[0.969]	[0.678]
Lev	-1.434***	-1.342***	-0.897***	-0.661***
	[0.000]	[0.000]	[0.000]	[0.008]
Size	0.091***	0.087***	0.052***	0.046*
	[0.000]	[0.010]	[0.002]	[0.065]
Growth	1.485***	1.410***	1.466***	1.453***
	[0.000]	[0.000]	[0.000]	[0.000]
ROA	2.890***	3.040***	3.525***	4.018***
	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	1.988***	2.576***	2.153***	2.370***
	[0.000]	[0.001]	[0.000]	[0.004]
$ROA_{(t-2)}$	1.812***	1.769***	1.406***	1.497*
	[0.000]	[0.002]	[0.000]	[0.056]
Constant	1.415***	1.642***	1.067***	1.322**
	[0.000]	[0.009]	[0.000]	[0.019]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Observation	3,353	9	3,340	9
Adjusted R^2	0.401	-	0.427	-
Average R^2	-	0.472	-	0.521

Table 2.5 The Effect of Internal and External Governance on the R&D Valuation: Lagged Governance and R&D Investment

This table presents the results using lagged value of internal and external governance and their corresponding interaction terms as well as lagged R&D investment in R&D valuation regressions to address the endogeneity problem; Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M	(5) Pool	(6) F-M
RD $Dummy_{(t-1)}$	0.477***	0.437**	0.443***	0.408**	0.428***	0.386**
	[0.000]	[0.029]	[0.000]	[0.029]	[0.000]	[0.031]
$IGR_{(t-1)}$*RD $Dummy_{(t-1)}$	0.230	0.385*			0.314*	0.493*
	[0.246]	[0.085]			[0.091]	[0.052]
$EGR_{(t-1)}$*RD $Dummy_{(t-1)}$			0.294	0.062	0.298	0.075
			[0.212]	[0.759]	[0.208]	[0.658]
$IGR_{(t-1)}$*$EGR_{(t-1)}$*RD $Dummy_{(t-1)}$					-1.863**	-1.994**
					[0.049]	[0.039]
$IGR_{(t-1)}$*$EGR_{(t-1)}$					-0.044	-0.014
					[0.886]	[0.944]
$IGR_{(t-1)}$	-0.023	-0.062			0.073	0.036
	[0.759]	[0.177]			[0.339]	[0.493]
$EGR_{(t-1)}$			0.441***	0.401***	0.436***	0.387***
			[0.000]	[0.004]	[0.000]	[0.003]
Capx Dummy	0.098***	0.089**	0.103***	0.097**	0.101***	0.095**
	[0.008]	[0.043]	[0.005]	[0.021]	[0.006]	[0.030]
Lev	-1.193***	-0.992***	-1.142***	-0.960***	-1.154***	-0.967***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.069***	0.068**	0.060***	0.057**	0.057***	0.058**
	[0.000]	[0.021]	[0.000]	[0.036]	[0.000]	[0.035]
Growth	1.423***	1.312***	1.402***	1.282***	1.403***	1.283***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]
ROA	2.988***	3.344***	3.000***	3.369***	2.988***	3.360***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	2.382***	2.481***	2.381***	2.515***	2.372***	2.483***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-2)}$	1.795***	1.857***	1.790***	1.845***	1.804***	1.866***
	[0.000]	[0.007]	[0.000]	[0.007]	[0.000]	[0.008]
Constant	0.386*	0.783	0.687***	0.745**	0.684***	0.931**
	[0.059]	[0.103]	[0.002]	[0.022]	[0.002]	[0.016]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
Observations	4938	8	4938	8	4938	8
Adjusted R^2	0.415	-	0.419	-	0.420	-
Average R^2	-	0.474	-	0.475	-	0.479

Table 2.6 The Effect of Internal and External Governance on the R&D valuation: Intrinsic Value

This table presents the results on the relationship between corporate governance (both internal and external corporate governance) and the intrinsic value of R&D. Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pool	F-M	Pool	F-M	Pool	F-M
RD Dummy	0.268***	0.222**	0.244***	0.188**	0.216***	0.163**
	[0.000]	[0.022]	[0.000]	[0.029]	[0.001]	[0.049]
IGR * RD Dummy	0.374*	0.350			0.431**	0.428
	[0.064]	[0.192]			[0.041]	[0.196]
EGR * RD Dummy			0.133	0.123	0.183	0.134
			[0.593]	[0.389]	[0.465]	[0.293]
IGR * EGR *RD Dummy					-2.546***	-3.131***
					[0.009]	[0.010]
IGR* EGR					0.677*	0.640
					[0.085]	[0.128]
IGR	-0.133	-0.101			-0.041	0.010
	[0.168]	[0.163]			[0.679]	[0.889]
EGR			0.351***	0.348***	0.323***	0.330***
			[0.001]	[0.004]	[0.003]	[0.006]
Capx Dummy	-0.068	-0.029	-0.067	-0.026	-0.067	-0.028
	[0.156]	[0.523]	[0.161]	[0.559]	[0.159]	[0.544]
Lev	-0.862***	-0.822***	-0.850***	-0.820***	-0.848***	-0.810***
	[0.000]	[0.008]	[0.000]	[0.005]	[0.000]	[0.010]
Size	-0.022	-0.020**	-0.036**	-0.033**	-0.032*	-0.032**
	[0.223]	[0.027]	[0.033]	[0.025]	[0.084]	[0.025]
Growth	0.586***	0.676***	0.566***	0.652***	0.556***	0.648***
	[0.000]	[0.003]	[0.000]	[0.004]	[0.000]	[0.004]
ROA	2.179***	2.531***	2.206***	2.564***	2.198***	2.580***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]
$ROA_{(t-1)}$	1.429***	1.719**	1.415***	1.717**	1.417***	1.722**
	[0.000]	[0.031]	[0.000]	[0.026]	[0.000]	[0.026]
$ROA_{(t-2)}$	1.561***	1.709***	1.566***	1.696***	1.538***	1.681***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]
Constant	1.273**	1.070**	1.472**	1.077***	1.445**	1.162***
	[0.048]	[0.014]	[0.023]	[0.002]	[0.025]	[0.006]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
Observations	3410	6	3410	6	3410	6
Adjusted R^2	0. 247	-	0. 248	-	0.250	-
Average R^2	-	0.310	-	0.311	-	0.318

Table 2.7 The Effect of Internal and External Governance on the R&D valuation: Industry-Median Adjusted Values

This table presents the results on the relationship between corporate governance (both internal and external corporate governance) and the market value of R&D where all variables are (1-digit SIC code) industry-median adjusted. Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M	(5) Pool	(6) F-M
RD	5.356***	5.022***	4.797***	4.482***	4.728***	4.454***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]
IGR * RD	3.821**	3.715*			4.760**	4.666**
	[0.036]	[0.053]			[0.010]	[0.037]
EGR * RD			3.924*	3.138	4.404**	3.516
			[0.060]	[0.243]	[0.033]	[0.224]
IGR * EGR*RD					-10.775	-15.091*
					[0.168]	[0.065]
IGR * EGR					0.411	0.339
					[0.124]	[0.119]
IGR	0.021	-0.018			0.120*	0.079**
	[0.747]	[0.628]			[0.079]	[0.025]
EGR			0.479***	0.462***	0.489***	0.462***
			[0.000]	[0.001]	[0.000]	[0.001]
Capx	0.163***	0.179***	0.151***	0.167**	0.152***	0.173***
	[0.001]	[0.009]	[0.002]	[0.010]	[0.002]	[0.008]
Lev	-1.133***	-0.966***	-1.070***	-0.933***	-1.087***	-0.946***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.094***	0.093***	0.087***	0.086***	0.078***	0.080***
	[0.000]	[0.007]	[0.000]	[0.009]	[0.000]	[0.010]
Growth	1.505***	1.419***	1.471***	1.382***	1.476***	1.371***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ROA	3.242***	3.447***	3.297***	3.487***	3.288***	3.485***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	2.080***	2.375***	2.077***	2.391***	2.086***	2.392***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-2)}$	1.698***	1.731***	1.721***	1.747***	1.709***	1.712***
	[0.000]	[0.003]	[0.000]	[0.004]	[0.000]	[0.004]
Constant	0.158	-0.127	0.258*	-0.026	0.244*	-0.041
	[0.286]	[0.128]	[0.062]	[0.693]	[0.091]	[0.554]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
Observations	5952	9	5952	9	5952	9
Adjusted R^2	0.412	-	0.415	-	0.417	-
Average R^2	-	0.466	-	0.469	-	0.475

Table 2.8 The Effect of Internal and External Governance on the R&D valuation: Other Robustness Tests

This table presents other robustness tests results described in Section 2.5.3.4. In all the panels, the dependent variables are Tobin's Q. In each panel, column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Investigate capitalized R&D

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pool	F-M	Pool	F-M	Pool	F-M
RD Dummy	0.112***	0.103**	0.100**	0.086**	0.089**	0.080*
	[0.005]	[0.018]	[0.013]	[0.039]	[0.027]	[0.088]
IGR * RD Dummy	0.033***	0.043***			0.033***	0.043***
	[0.006]	[0.002]			[0.006]	[0.002]
EGR * RD Dummy			-0.009	-0.013	-0.006	-0.011
			[0.415]	[0.136]	[0.457]	[0.128]
IGR * EGR *RD Dummy					-0.010**	-0.011**
					[0.034]	[0.016]
IGR * EGR					0.125	0.072
					[0.593]	[0.735]
IGR	-0.024	-0.043*			0.056	0.041
	[0.672]	[0.063]			[0.345]	[0.188]
EGR			0.381***	0.378***	0.377***	0.376***
			[0.000]	[0.000]	[0.000]	[0.000]
Capx Dummy	0.039	0.040	0.045	0.047*	0.045	0.046*
	[0.175]	[0.111]	[0.116]	[0.071]	[0.118]	[0.066]
Lev	-1.229***	-1.103***	-1.181***	-1.066***	-1.179***	-1.064***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.080***	0.081**	0.071***	0.071**	0.068***	0.068**
	[0.000]	[0.013]	[0.000]	[0.023]	[0.000]	[0.022]
Growth	1.127***	1.082***	1.106***	1.066***	1.104***	1.059***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ROA	3.918***	4.116***	3.943***	4.127***	3.938***	4.145***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	2.324***	2.662***	2.316***	2.671***	2.313***	2.661***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-2)}$	2.215***	2.254***	2.202***	2.259***	2.192***	2.227***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]
Constant	1.256***	1.033*	1.389***	1.206***	1.418***	1.332***
	[0.000]	[0.050]	[0.000]	[0.006]	[0.000]	[0.005]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
observation	5,402	9	5,402	9	5,402	9
Adjusted R^2	0.418	-	0.420	-	0.422	-
Average R^2	-	0.484	-	0.486	-	0.490

Table 2.8 – continued

Panel B. Investigate R&D in its continuous form

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pool	F-M	Pool	F-M	Pool	F-M
RD	5.469***	5.168***	5.071***	4.799***	5.006***	4.810***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]
IGR * RD	0.313**	0.355**			0.347**	0.381**
	[0.037]	[0.037]			[0.022]	[0.031]
EGR * RD			0.221	0.163	0.230	0.152
			[0.123]	[0.310]	[0.107]	[0.334]
IGR * EGR *RD					-0.074*	-0.119**
					[0.061]	[0.030]
IGR * EGR					0.356	0.170
					[0.229]	[0.552]
IGR	0.012	-0.030			0.093	0.041
	[0.865]	[0.417]			[0.188]	[0.228]
EGR			0.489***	0.468***	0.495***	0.469***
			[0.000]	[0.001]	[0.000]	[0.001]
Capx	0.063*	0.067	0.065*	0.070	0.065*	0.073
	[0.068]	[0.138]	[0.057]	[0.125]	[0.058]	[0.109]
Lev	-1.161***	-0.986***	-1.102***	-0.957***	-1.109***	-0.955***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.095***	0.093***	0.087***	0.086***	0.081***	0.083***
	[0.000]	[0.006]	[0.000]	[0.009]	[0.000]	[0.008]
Growth	1.517***	1.447***	1.484***	1.408***	1.486***	1.403***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ROA	3.180***	3.374***	3.239***	3.403***	3.234***	3.407***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	2.113***	2.407***	2.109***	2.414***	2.111***	2.408***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-2)}$	1.692***	1.706***	1.709***	1.729***	1.704***	1.722***
	[0.000]	[0.003]	[0.000]	[0.004]	[0.000]	[0.003]
Constant	1.063***	0.689**	1.229***	0.861***	1.263***	0.868***
	[0.000]	[0.031]	[0.000]	[0.006]	[0.000]	[0.003]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
observation	5,952	9	5,952	9	5,952	9
Adjusted R^2	0.421	-	0.425	-	0.427	-
Average R^2	-	0.472	-	0.475	-	0.480

Table 2.8 - continued

Panel C. Investigate board variables in their continuous forms

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M
RD Dummy	0.445***	0.420**	0.461***	0.417***
	[0.000]	[0.011]	[0.000]	[0.009]
Independence* RD Dummy	0.017	0.043***		
	[0.273]	[0.008]		
Independence*Eindex*RD Dummy	-0.012**	-0.016***		
	[0.013]	[0.010]		
Exposure * RD Dummy			0.053***	0.050**
			[0.003]	[0.031]
Exposure * Eindex* RD Dummy			-0.013	-0.017**
			[0.230]	[0.029]
Eindex * RD Dummy	0.020*	0.008	0.026*	0.014
	[0.073]	[0.594]	[0.087]	[0.240]
Independence*Eindex	0.019	-0.005		
	[0.782]	[0.943]		
Exposure*Eindex			0.027	0.007
			[0.134]	[0.641]
Eindex	0.085***	0.081***	0.084***	0.075***
	[0.000]	[0.000]	[0.000]	[0.000]
Independence	0.004	-0.088	-0.002	-0.074
	[0.965]	[0.399]	[0.983]	[0.463]
Exposure	0.070***	0.068***	0.072***	0.069***
	[0.004]	[0.002]	[0.006]	[0.005]
Capx Dummy	0.070**	0.068	0.064*	0.058
	[0.032]	[0.115]	[0.063]	[0.183]
Lev	-1.134***	-0.958***	-1.120***	-0.965***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.053***	0.049**	0.052***	0.052**
	[0.000]	[0.036]	[0.000]	[0.031]
Growth	1.511***	1.427***	1.497***	1.426***
	[0.000]	[0.000]	[0.000]	[0.000]
ROA	3.195***	3.422***	3.221***	3.450***
	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	2.177***	2.461***	2.164***	2.450***
	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-2)}$	1.790***	1.792***	1.770***	1.800***
	[0.000]	[0.004]	[0.000]	[0.004]
Constant	1.485***	1.234***	1.468***	1.164***
	[0.000]	[0.000]	[0.000]	[0.001]
Observations	5952	9	5952	9
Adjusted R^2	0.416	-	0.418	-
Average R^2	-	0.470	-	0.470

Table 2.8 – continued

Panel D. Using Gindex to proxy for external corporate governance

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pool	F-M	Pool	F-M	Pool	F-M
RD Dummy	0.510***	0.489***	0.479***	0.443***	0.457***	0.432***
	[0.000]	[0.009]	[0.000]	[0.009]	[0.000]	[0.008]
IGR * RD Dummy	0.047***	0.061***			0.048***	0.064**
	[0.005]	[0.007]			[0.008]	[0.013]
EGR * RD Dummy			0.023	0.009	0.022	0.021
			[0.187]	[0.514]	[0.101]	[0.375]
IGR * EGR *RD Dummy					-0.013*	-0.016*
					[0.092]	[0.069]
IGR * EGR					0.452	0.280
					[0.292]	[0.334]
IGR	0.092	0.042			0.142*	0.099
	[0.194]	[0.372]			[0.058]	[0.123]
EGR			0.122***	0.114***	0.122***	0.116***
			[0.001]	[0.006]	[0.001]	[0.007]
Capx Dummy	0.078**	0.069	0.080**	0.075*	0.078**	0.069
	[0.025]	[0.126]	[0.021]	[0.099]	[0.024]	[0.140]
Lev	-1.230***	-1.024***	-1.218***	-1.017***	-1.218***	-1.014***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.070***	0.065**	0.081***	0.073**	0.072***	0.068**
	[0.000]	[0.021]	[0.000]	[0.019]	[0.000]	[0.018]
Growth	1.570***	1.477***	1.549***	1.460***	1.558***	1.462***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ROA	3.112***	3.363***	3.153***	3.374***	3.147***	3.387***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	2.072***	2.379***	2.078***	2.409***	2.079***	2.379***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-2)}$	1.792***	1.804***	1.810***	1.840***	1.804***	1.820***
	[0.000]	[0.003]	[0.000]	[0.004]	[0.000]	[0.004]
Constant	0.952***	1.107***	1.091***	1.244***	1.080***	1.241***
	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.001]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
observation	6008	9	6008	9	6008	9
Adjusted R^2	0.406	-	0.406	-	0.409	-
Average R^2	-	0.462	-	0.461	-	0.467

Table 2.8 – continued

Panel E. Further control size's effect on R&D valuation

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pool	F-M	Pool	F-M	Pool	F-M
RD Dummy	0.517***	0.493***	0.491***	0.460***	0.471***	0.449***
	[0.000]	[0.008]	[0.000]	[0.008]	[0.000]	[0.010]
IGR * RD Dummy	0.039*	0.051**			0.040*	0.053**
	[0.073]	[0.019]			[0.079]	[0.020]
EGR * RD Dummy			0.021	0.009	0.021	0.011
			[0.219]	[0.593]	[0.213]	[0.764]
IGR * EGR *RD Dummy					-0.013*	-0.019***
					[0.051]	[0.003]
Size * RD Dummy	0.051	0.053*	0.086***	0.092**	0.069*	0.077**
	[0.132]	[0.063]	[0.004]	[0.013]	[0.051]	[0.030]
IGR * EGR					0.369	0.146
					[0.209]	[0.528]
IGR	0.069	0.034			0.165**	0.129**
	[0.318]	[0.409]			[0.023]	[0.032]
EGR			0.514***	0.481***	0.522***	0.490***
			[0.000]	[0.000]	[0.000]	[0.000]
Capx Dummy	0.066*	0.059	0.071**	0.064	0.069**	0.062
	[0.056]	[0.176]	[0.041]	[0.147]	[0.046]	[0.157]
Lev	-1.179***	-0.997***	-1.111***	-0.948***	-1.123***	-0.961***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.069***	0.065**	0.064***	0.058**	0.054***	0.051**
	[0.000]	[0.014]	[0.000]	[0.026]	[0.000]	[0.025]
Growth	1.539***	1.460***	1.504***	1.427***	1.512***	1.431***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ROA	3.129***	3.372***	3.159***	3.369***	3.160***	3.388***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-1)}$	2.169***	2.415***	2.146***	2.418***	2.159***	2.418***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$ROA_{(t-2)}$	1.760***	1.769***	1.747***	1.754***	1.752***	1.759***
	[0.000]	[0.004]	[0.000]	[0.005]	[0.000]	[0.004]
Constant	1.329***	1.002***	1.492***	1.194***	1.502***	1.202***
	[0.000]	[0.002]	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
observation	5,952	9	5,952	9	5,952	9
Adjusted R^2	0.412	-	0.416	-	0.418	-
Average R^2	-	0.465	-	0.468	-	0.472

Table 2.9 The Effect of Internal and External Governance on the Level of R&D

This table presents the results on the relationship between corporate governance (both internal and external corporate governance) and the level of R&D. The dependent variable is R&D, research and development expenditure scaled by the book value of assets at year t. IGR and EGR are defined in Table 2.1. OCF(t-1) is operating cash flows deflated by total assets, lagged one year; Ltd(t-1) is long-term debt and debt in current liabilities deflated by total assets, lagged one year; Size(t-1) is the natural log of total assets, lagged one year; MS(t-1) is the market share (a firm's total sales as a proportion of sales by all other firms in the same industry) lagged one year; TAN(t-1) is PPE deflated by total assets, lagged one year; Div(t-1) is total dividends deflated by total assets, lagged one year; Tax(t-1) is income taxes deflated by total assets, lagged one year. The industry (and year) are included, but not reported. Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pool	F-M	Pool	F-M	Pool	F-M
IGR_t	0.016***	0.015***			0.019***	0.018***
	[0.000]	[0.010]			[0.000]	[0.004]
EGR_t			0.012***	0.011***	0.015***	0.013***
			[0.000]	[0.001]	[0.000]	[0.000]
$OCF_{(t-1)}$	-0.023*	-0.014	-0.022*	-0.013	-0.023*	-0.015
	[0.078]	[0.550]	[0.088]	[0.574]	[0.076]	[0.538]
$Ltd_{(t-1)}$	-0.046***	-0.045***	-0.040***	-0.040***	-0.042***	-0.042***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]
$Size_{(t-1)}$	-0.007***	-0.007***	-0.006***	-0.006***	-0.007***	-0.007***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$MS_{(t-1)}$	0.144***	0.162***	0.144***	0.160***	0.136***	0.153***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$TAN_{(t-1)}$	-0.048***	-0.052***	-0.047***	-0.050***	-0.047***	-0.051***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Div_{(t-1)}$	-0.174***	-0.166***	-0.156***	-0.143***	-0.171***	-0.161***
	[0.000]	[0.002]	[0.001]	[0.002]	[0.000]	[0.001]
$Tax_{(t-1)}$	-0.088***	-0.106*	-0.092***	-0.113*	-0.088***	-0.107*
	[0.003]	[0.068]	[0.002]	[0.066]	[0.003]	[0.070]
$Growth_{(t-1)}$	0.004	0.004	0.003	0.003	0.003	0.003
	[0.202]	[0.547]	[0.409]	[0.656]	[0.340]	[0.632]
Constant	0.093***	0.098***	0.098***	0.102***	0.099***	0.103***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
Observations	6,076	9	6,076	9	6,076	9
Adjusted R^2	0.433	-	0.434	-	0.437	-
Average R^2	-	0.469	-	0.469	-	0.472

Table 2.10 The Effect of Internal and External Governance on the Level of R&D: Lagged Governance Variables

This table presents the results using lagged values of internal and external governance in R&D level regressions to address the endogeneity problem; Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.9.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pool	F-M	Pool	F-M	Pool	F-M
$IGR_{(t-1)}$	0.016***	0.014***			0.018***	0.017***
	[0.000]	[0.000]			[0.000]	[0.000]
$EGR_{(t-1)}$			0.009***	0.009**	0.011***	0.012***
			[0.001]	[0.022]	[0.000]	[0.007]
$OCF_{(t-1)}$	-0.021	-0.010	-0.021	-0.010	-0.021	-0.011
	[0.122]	[0.725]	[0.122]	[0.703]	[0.115]	[0.691]
$Ltd_{(t-1)}$	-0.041***	-0.041***	-0.036***	-0.036***	-0.037***	-0.038***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]
$Size_{(t-1)}$	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***	-0.007***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$MS_{(t-1)}$	0.117***	0.139***	0.116***	0.136***	0.110***	0.131***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$TAN_{(t-1)}$	-0.050***	-0.054***	-0.049***	-0.053***	-0.049***	-0.053***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Div_{(t-1)}$	-0.143***	-0.146***	-0.128***	-0.130***	-0.141***	-0.146***
	[0.004]	[0.002]	[0.009]	[0.003]	[0.004]	[0.002]
$Tax_{(t-1)}$	-0.056*	-0.083	-0.058*	-0.086	-0.053	-0.081
	[0.089]	[0.125]	[0.076]	[0.119]	[0.102]	[0.137]
$Growth_{(t-1)}$	0.002	0.003	0.000	0.002	0.001	0.002
	[0.628]	[0.612]	[0.969]	[0.768]	[0.860]	[0.720]
Constant	0.083***	0.132***	0.090***	0.121***	0.092***	0.144***
	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No	Yes	No
Observations	4951	8	4951	8	4951	8
Adjusted R^2	0.436	-	0.438	-	0.440	-
Average R^2	-	0.473		0.474	-	0.477

Table 2.11 Characteristics of Outside Directorship

This table presents the 10 firms with the highest R&D valuation and the characteristics of the outside directorships hold by their directors. A firm's R&D valuation is computed by regressing the equation (2.1) without including board variables. The coefficient of *RD* is defined as the R&D valuation of a sample firm. The equation is regressed based on all available data from Compustat, spanning from 1962-2008. The information of a director's outside directorship is obtained from http://people.forbes.com/search. "Related" directorship means that directorship is for the same or the related industries (e.g., up or down stream industries).

Ticker	Company Name	No. of directors with outside directorship	No. of directors with outside related directorship	Percentage (100%)	No. of outside directorship	No. of outside related directorships	Percentage (100%)
ECL	ECOLAB INC	10	5	50.00	13	5	38.46
FO	FORTUNE BRANDS INC	10	6	60.00	13	7	53.85
ZIGO	ZYGO CORP	5	4	80.00	8	5	62.50
JAVA	SUN MICROSYSTEMS INC	11	9	81.82	16	10	62.50
ADP	AUTOMATIC DATA PROCESSING	8	2	25.00	10	2	20.00
PG	PROCTER & GAMBLE CO	18	11	61.11	30	11	36.67
SMTC	SEMTECH CORP	2	2	100.00	3	2	66.67
ITW	ILLINOIS TOOL WORKS	10	6	60.00	17	6	35.29
SNA	SNAP-ON INC	7	2	28.57	10	3	30.00
LZB	LA-Z-BOY INC	6	3	50.00	10	6	60.00
SNSTA	SONESTA INTL HOTELS -CL A	4	3	75.00	8	5	62.50

Table 3.1 Sample Selection & Descriptive Statistics: Expected Future Cash flows Analysis

Panel A presents the selection procedure of the sample used in the expected future cash flows analysis. The sample consists of 5,871 firm-year observations covering from 1998 to 2006. Data on financial items are from Compustat. Data on expected future cash flows are calculated based on analyst forecast data from I/B/E/S. Data on board items are from RiskMetrics. Panel B presents the summary statistics of the data used in the expected future cash flows analysis. All variables are winsorized at the 1st and 99th percentile values. Panel C presents the summary statistics comparison between three types of data. They are data where R&D is missing, R&D is zero and R&D is positive, respectively.

EFC_Dis is the discounted expected future cash flows, calculated as the sum of the adjusted analysts' consensus EPS (earnings per share) forecast for the 5 years ahead scaled by the book value of assets at year t, where the adjusted ESP forecasts are net present value of t-year-ahead EPS forecasts computed by dividing EPS forecasts with a constant discount rate of 10%. EFC is the Expected Future Cash flows, calculated as the sum of the analysts' consensus EPS forecast for the 5 years ahead scaled by the book value of assets at year t. RD is research and development expenditure, scaled by the book value of assets at year t. RD Dummy is equal to one if RD is above 75th percentile for that year, and zero otherwise. IG is equal to one if the sum of Independence and Exposure are ranked above the median for that year, and zero otherwise. Here Independence and Exposure are in the forms of fractional rank. Independence is the number of independent directors as a percentage of the total number of directors. The definition of independence follows the IRRC definition. Exposure is the average number of outside directorships in other firms held by independent directors. Capx is capital expenditure, scaled by the book value of assets at year t. Capx Dummy is equal to one if Capx is above median for that year, and zero otherwise. Lev is total debt divided by total assets. Size is firm size, measured as the natural logarithm of total assets; Growth is annual growth rate of annual sales;

Panel A. Sample selection procedure

Criteria	N
Compustat Industrial Annual data (FTP Version), 1998-2006	119, 023
Less: Observations with sales, asset, book/market value and capital expenditure less than zero	(56, 459)
Missing value to compute other financial variables, 1998-2006	(8, 825)
Subtotal	53, 739
Merge with I/B/E/S data	29, 286
Less: Missing value to compute expected future cash flows	(5, 114)
Subtotal	24, 172
Merge with RiskMetrics data set on directors	10, 383
Less: Missing R&D expenditure data	(4, 512)
Final Sample	5, 871

Table 3.1 - Continued

Panel B. Descriptive statistics of the data used in the regression (n=5871)

VARIABLE	MEAN	STD	P25	MEDIAN	P75
EFC_Dis	0.350	0.258	0.169	0.292	0.468
EFC	0.478	0.351	0.232	0.397	0.636
RD	0.049	0.057	0.004	0.027	0.076
RD Dummy	0.251	0.433	0.000	0.000	1.000
Independence	0.673	0.169	0.571	0.700	0.800
Exposure	0.987	0.702	0.444	1.000	1.429
IG	0.502	0.500	0.000	1.000	1.000
Capx	0.052	0.041	0.024	0.040	0.068
Capx Dummy	0.500	0.500	0.000	1.000	1.000
Lev	0.197	0.165	0.027	0.187	0.310
Size	7.347	1.461	6.269	7.184	8.260
Growth	0.134	0.259	0.014	0.097	0.205

Panel C. Descriptive statistics comparison: missing-RD data, zero-RD data and positive-RD data

VARIABLE	RD is missing (n=4512)		RD is zero (n=1189)		RD is nonmissing/nonzero (n=4682)	
	Mean	**median**	**mean**	**median**	**mean**	**median**
EFC_Dis	0.254	0.191	0.334	0.269	0.353	0.296
EFC	0.344	0.259	0.455	0.365	0.484	0.404
RD	-	-	-	-	0.062	0.041
RD Dummy	-	-	-	-	0.251	0.000
Independence	0.646	0.667	0.615	0.625	0.688	0.714
Exposure	0.915	0.778	0.852	0.750	1.022	1.000
IG	0.499	0.000	0.499	0.000	0.502	1.000
Capx	0.057	0.041	0.078	0.068	0.046	0.036
Capx Dummy	0.501	1.000	0.501	1.000	0.500	1.000
Lev	0.268	0.274	0.220	0.189	0.191	0.187
Size	8.005	7.796	7.309	7.183	7.357	7.186
Growth	0.135	0.088	0.141	0.114	0.133	0.090

Table 3.2 Univariate Correlation: Expected Future Cash flows Analysis

This table provides the Pearson and Spearman correlation of the variables used in the expected future cash flows. The Pearson (Spearman) correlation coefficients are presented above (below) the diagonal. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively. All variables follow the definitions in Table 3.1.

Variable	EFC_Dis	RD Dummy	IG	Capx Dummy	Lev	Sze	Growth
EFC_Dis	1.000	0.149***	-0.051	0.136***	-0.364***	-0.108***	0.142***
RD Dummy	0.116***	1.000	-0.023	-0.089***	-0.292***	-0.208***	0.022*
IG	-0.057	-0.023*	1.000	-0.012	0.129***	0.336***	-0.090***
Capx Dummy	0.152***	-0.089***	-0.012	1.000	-0.059***	0.013	0.006
Lev	-0.383***	-0.310***	0.154***	-0.044***	1.000	0.325***	-0.038***
Size	-0.124***	-0.223***	0.336***	0.008	0.369***	1.000	-0.037***
Growth	0.225***	0.005	-0.117***	0.037***	-0.108***	-0.050	1.000

Table 3.3 Multivariate Regression: Expected Future Cash flows Analysis

This table presents the results on the relationship between R&D and expected future cash flows, as well as boards' impact on the relationship between R&D and expected future cash flows. The dependent variable is EFC_dis. Other variables follow the definitions in Table 3.1. The industry (and year) are included, but not reported. Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method, based on annual cross-sectional regressions. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	0.032***	0.035**	0.032***	0.035**
	[0.001]	[0.044]	[0.001]	[0.048]
IG*RD Dummy			0.059***	0.064**
			[0.000]	[0.026]
IG			-0.003	-0.003
			[0.662]	[0.562]
Capx Dummy	0.064***	0.066***	0.065***	0.066***
	[0.000]	[0.000]	[0.000]	[0.000]
Lev	-0.530***	-0.531***	-0.525***	-0.526***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.002	0.002	0.002	0.002
	[0.410]	[0.643]	[0.455]	[0.627]
Growth	0.117***	0.131***	0.116***	0.128***
	[0.000]	[0.001]	[0.000]	[0.001]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Constant	0.577***	0.499***	0.579***	0.499***
	[0.000]	[0.000]	[0.000]	[0.000]
observation	5871	9	5871	9
Adjusted R^2	0.210	-	0.212	-
Average R^2	-	0.249	-	0.254

Table 3.4 Sensitivity Test Results: Expected Future Cash flows Analysis

This table presents the various sensitivity results on expected future cash flows analysis. Panel A uses EFC instead of EFC_dis as the dependent variable. Panel B uses analyst forecast data as of June to compute EFC_dis. Panel C uses realized future earnings to proxy for the expected future cash flows. Panel D replaces RD Dummy with its continuous value. Panel E constructs RD Dummy based on the capitalized R&D asset by capitalizing past and current R&D expenses. Panel F replaces IG with the disaggregated continuous values of board independence and exposure. In each panel, column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method, based on annual cross-sectional regressions. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use EFC instead of EFC_dis as the dependent variable

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	0.053***	0.056**	0.053***	0.056**
	[0.000]	[0.018]	[0.000]	[0.020]
IG*RD Dummy			0.081***	0.088**
			[0.000]	[0.028]
IG			-0.003	-0.003
			[0.755]	[0.660]
Capx Dummy	0.087***	0.089***	0.087***	0.089***
	[0.000]	[0.000]	[0.000]	[0.000]
Lev	-0.719***	-0.719***	-0.712***	-0.713***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.000	-0.001	-0.000	-0.001
	[0.961]	[0.913]	[0.981]	[0.889]
Growth	0.165***	0.181***	0.163***	0.178***
	[0.000]	[0.000]	[0.000]	[0.001]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Constant	0.805***	0.701***	0.809***	0.701***
	[0.000]	[0.000]	[0.000]	[0.000]
observation	5871	9	5871	9
Adjusted R^2	0.213	-	0.215	-
Average R^2	-	0.252	-	0.258

Table 3.4 – continued

Panel B. Use analyst forecast data as of June to compute EFC_dis

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M
RD Dummy	0.042***	0.045***	0.042***	0.044***
	[0.000]	[0.006]	[0.000]	[0.007]
IG*RD Dummy			0.051***	0.056**
			[0.002]	[0.020]
IG			0.001	0.000
			[0.828]	[0.900]
Capx Dummy	0.064***	0.066***	0.064***	0.066***
	[0.000]	[0.000]	[0.000]	[0.000]
Lev	-0.523***	-0.521***	-0.519***	-0.517***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.003	0.002	0.002	0.002
	[0.320]	[0.504]	[0.453]	[0.538]
Growth	0.122***	0.131***	0.121***	0.130***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Constant	0.564***	0.490***	0.568***	0.491***
	[0.000]	[0.000]	[0.000]	[0.000]
observation	5896	9	5896	9
Adjusted R^2	0.207	-	0.209	-
Average R^2	-	0.244	-	0.248

Table 3.4 – continued

Panel C. Use realized future earnings to proxy for the expected future cash flows

	With discount rate		Without discount rate	
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	0.188***	0.188***	0.257***	0.258***
	[0.000]	[0.000]	[0.000]	[0.000]
IG*RD Dummy		0.085**		0.107**
		[0.035]		[0.049]
IG		-0.017		-0.024
		[0.246]		[0.235]
Capx Dummy	0.001	0.000	0.000	-0.001
	[0.928]	[0.985]	[1.000]	[0.948]
Lev	-0.578***	-0.564***	-0.766***	-0.748***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.005	0.006	0.006	0.008
	[0.373]	[0.278]	[0.376]	[0.272]
Growth	-0.017	-0.019	-0.016	-0.018
	[0.374]	[0.341]	[0.544]	[0.506]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Constant	0.270***	0.240***	0.376***	0.336***
	[0.000]	[0.000]	[0.000]	[0.000]
observation	2490	4	2490	4
Adjusted R^2	0.239	-	0.238	-
Average R^2	-	0.241	-	0.240

Table 3.4 – continued

Panel D. Investigate R&D in its continuous form

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M
RD	0.214**	0.291*	0.225**	0.295*
	[0.020]	[0.084]	[0.014]	[0.083]
IG*RD			0.291**	0.320*
			[0.039]	[0.068]
IG			-0.002	-0.001
			[0.809]	[0.773]
Capx	0.881***	0.899***	0.884***	0.898***
	[0.000]	[0.000]	[0.000]	[0.000]
Lev	-0.532***	-0.535***	-0.530***	-0.535***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.003	0.003	0.003	0.003
	[0.171]	[0.408]	[0.189]	[0.344]
Growth	0.111***	0.120***	0.109***	0.118***
	[0.000]	[0.001]	[0.000]	[0.001]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Constant	0.555***	0.475***	0.556***	0.475***
	[0.000]	[0.000]	[0.000]	[0.000]
observation	5871	9	5871	9
Adjusted R^2	0.209	-	0.209	-
Average R^2	-	0.249	-	0.252

Table 3.4 – continued

Panel E. Investigate capitalized R&D

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	0.027**	0.036**	0.026**	0.035**
	[0.011]	[0.017]	[0.010]	[0.019]
IG*RD Dummy			0.060***	0.049*
			[0.001]	[0.064]
IG			-0.008	-0.006
			[0.273]	[0.359]
Capx Dummy	0.074***	0.071***	0.074***	0.071***
	[0.000]	[0.000]	[0.000]	[0.000]
Lev	-0.619***	-0.605***	-0.611***	-0.599***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.004	0.001	0.004	0.002
	[0.171]	[0.767]	[0.151]	[0.589]
Growth	0.000	0.092***	0.000	0.090***
	[0.477]	[0.008]	[0.508]	[0.008]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Constant	0.335***	0.387***	0.319***	0.361***
	[0.000]	[0.003]	[0.000]	[0.008]
observation	5222	9	5222	9
Adjusted R^2	0.206	-	0.208	-
Average R^2	-	0.248	-	0.253

Table 3.4 – continued

Panel F. Investigate board variables in their continuous forms

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M
RD Dummy	0.033***	0.036**	0.034***	0.036**
	[0.001]	[0.040]	[0.000]	[0.043]
Independence*RD Dummy	0.098*	0.103**		
	[0.060]	[0.026]		
Exposure*RD Dummy			0.033**	0.033**
			[0.011]	[0.013]
Independence	-0.010	-0.010	-0.012	-0.012
	[0.611]	[0.586]	[0.550]	[0.510]
Exposure	-0.009	-0.008	-0.009	-0.008
	[0.257]	[0.282]	[0.269]	[0.302]
Capx Dummy	0.065***	0.066***	0.064***	0.065***
	[0.000]	[0.000]	[0.000]	[0.000]
Lev	-0.527***	-0.529***	-0.528***	-0.529***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.004	0.004	0.004	0.004
	[0.139]	[0.288]	[0.124]	[0.303]
Growth	0.116***	0.130***	0.115***	0.129***
	[0.000]	[0.001]	[0.000]	[0.001]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
Constant	0.572***	0.493***	0.575***	0.497***
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	5871	9	5871	9
Adjusted R^2	0.211	-	0.212	-
Average R^2	-	0.253	-	0.254

Table 3.5 Sample Selection & Descriptive Statistics: Cost of Equity Analysis

Panel A presents the selection procedure of the sample used in the cost of equity analysis. The sample consists of 4,493 firm-year observations covering from 1998 to 2006. Data on financial items are from Compustat. Data on stock market data are from CRSP. Data on cost of equity are estimated based on the data from I/B/E/S. Data on board items are from RiskMetrics.

Panel B presents the summary statistics of the data used in the cost of equity analysis. All variables are winsorized at the 1st and 99th percentile values. rmean proxies for the cost of equity. It is the average of four implied equity premium, *rgls*, *rct*, *roj* and *rpeg*. Specifically, I estimate *rgls* from the methodologies described in Gebhardt, Lee, and Swaminathan (2001), *rct* from Claus, and Thomas (2001), *roj* from Ohlson, and Juettner-Nauroth (2005), which is implemented by Gode and Mohanram (Gode and Mohanram 2003) and *rpeg* from Easton (2004). RD is research and development expenditure, scaled by the book value of assets at year t. RD Dummy is equal to one if RD is above 75th percentile for that year, and zero otherwise. IG is equal to one if the sum of Independence and Exposure are ranked above the median for that year, and zero otherwise. Here Independence and Exposure are in the forms of fractional rank. Independence is the number of independent directors as a percentage of the total number of directors. The definition of independence follows the IRRC definition. Exposure is the average number of outside directorships in other firms held by independent directors. Beta is estimated for each firm year by regressing 60 lagged monthly returns against the corresponding monthly market return, requiring a minimum of 30 months. MV is the natural log of the total market value of equity. BMratio is the ratio of the book value of equity to the market value of equity. EPSVAR, earnings variability, is the standard deviation of annual earnings per share over the last five years scaled by total assets per share, requiring a minimum of three yearly observations. LTG is the I/B/E/S estimate of long-term earnings growth. Growth is annual growth rate of annual sales.

Panel C presents the summary statistics comparison between three types of data. They are data where R&D is missing, R&D is zero and R&D is positive, respectively.

Panel A. Sample selection procedure

Criteria	N
Compustat Industrial Annual data (FTP Version), 1993-2006	183,006
Less: Observations if less than 3 yearly observations to compute earnings variability	(93,374)
Pior-1998 data	(18,373)
Subtotal, 1998-2006	75,001
Less: Observations with sales, asset, book/market value and capital expenditure less than zero	(19,881)
Missing value to compute other financial variables	(43)
Subtotal	55,077
Merge with CRSP with non-missing data to compute Beta	35,166
Merge with I/B/E/S data	21,920
Less: Missing value to estimate cost of equity	(6,555)
Subtotal	15,365
Merge with RiskMetrics data set on directors	8,501
Less: Missing R&D expenditure data	(4,008)
Final Sample	4,493

Table 3.5 – continued

Panel B. Descriptive statistics of the data used in the regression (n=4493)

VARIABLE	MEAN	STD	P25	MEDIAN	P75
rmean	0.100	0.024	0.085	0.096	0.112
rct	0.084	0.024	0.069	0.080	0.095
rgls	0.099	0.024	0.085	0.099	0.113
roj	0.108	0.026	0.091	0.103	0.121
rpeg	0.110	0.037	0.086	0.102	0.126
RD	0.043	0.050	0.003	0.025	0.067
RD Dummy	0.251	0.434	0.000	0.000	1.000
Independence	0.670	0.169	0.556	0.700	0.800
Exposure	0.983	0.704	0.429	1.000	1.429
IG	0.501	0.500	0.000	1.000	1.000
Beta	1.113	0.765	0.585	0.943	1.494
MV	7.713	1.510	6.639	7.516	8.601
BMratio	0.419	0.280	0.228	0.357	0.533
EPSVAR	0.047	0.055	0.016	0.028	0.054
LTG	0.163	0.067	0.119	0.150	0.195
Growth	0.085	0.161	0.020	0.089	0.165

Panel C. Descriptive statistics comparison: missing-RD data, zero-RD data and positive-RD data

VARIABLE	RD is missing (n=4008)		RD is zero (n=976)		RD is nonmissing/nonzero (n=3517)	
	mean	Median	mean	median	mean	median
rmean	0.105	0.100	0.102	0.098	0.100	0.096
rct	0.092	0.089	0.088	0.085	0.083	0.079
rgls	0.101	0.099	0.106	0.105	0.097	0.097
roj	0.112	0.106	0.107	0.103	0.109	0.103
rpeg	0.113	0.104	0.105	0.100	0.112	0.103
RD	-	-	0.000	0.000	0.055	0.037
RD Dummy	-	-	1.000	1.000	0.251	0.000
Independence	0.650	0.667	0.611	0.625	0.687	0.714
Exposure	0.873	0.714	0.837	0.714	1.023	1.000
IG	0.500	1.000	0.501	1.000	0.501	1.000
Beta	0.736	0.652	0.877	0.848	1.178	0.972
MV	0.533	0.494	0.495	0.398	0.397	0.344
BMratio	7.749	7.606	7.471	7.314	7.780	7.579
EPSVAR	0.022	0.013	0.027	0.019	0.052	0.032
LTG	0.130	0.123	0.163	0.157	0.163	0.149
Growth	0.080	0.078	0.111	0.106	0.078	0.083

Table 3.6 Univariate Correlation: Cost of Equity Analysis

Panel A presents the Pearson and Spearman correlation of the four individual implied cost of equity estimates and the average cost of equity estimate. The Pearson (Spearman) correlation coefficients are presented above (below) the diagonal. Panel B presents the Pearson and Spearman correlation of the variables used in the cost of equity analysis. The Pearson (Spearman) correlation coefficients are presented above (below) the diagonal. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively. All variables follow the definitions in Table 3.1.

Panel A. Cross-correlations between implied cost of capital estimates

Variable	rmean	Rct	rgls	roj	rpeg
rmean	1.000	0.824***	0.762***	0.958***	0.900***
rct	0.795***	1.000	0.662***	0.741***	0.551***
rgls	0.750***	0.630***	1.000	0.576***	0.510***
roj	0.945***	0.721***	0.546***	1.000	0.942***
rpeg	0.893***	0.549***	0.497***	0.932***	1.000

Panel B. Pearson and Spearman correlations between variables used in the cost of equity analysis

Variable	rmean	RD Dummy	IG	Beta	MV	BMratio	EPSVAR	LTG	Growth
rmean	1.000	-0.141***	-0.001	0.002**	-0.325***	0.401***	-0.005	-0.017	-0.058***
RD Dummy	-0.140***	1.000	-0.023	0.414***	0.045***	-0.204***	0.376***	0.343***	0.018
IG	-0.018	-0.023	1.000	-0.069***	0.291***	-0.065***	-0.021	-0.184***	-0.099***
Beta	0.025*	0.366***	-0.064***	1.000	-0.051***	-0.022	0.409***	0.382***	0.036**
MV	-0.347***	0.016	0.290***	-0.035**	1.000	-0.503***	-0.109***	-0.072***	0.080***
BMratio	0.392***	-0.231***	-0.061***	-0.017	-0.539***	1.000	-0.105***	-0.246***	-0.190***
EPSVAR	0.019	0.427***	-0.022	0.374***	-0.140***	-0.120***	1.000	0.303***	0.055***
LTG	-0.029**	0.351***	-0.224***	0.412***	-0.088***	-0.284***	0.325***	1.000	0.282***
Growth	-0.076***	0.045***	-0.131***	0.097***	0.091***	-0.246***	0.039***	0.376***	1.000

Table 3.7 Validation of Cost of Equity Measure

This table validates the average implied cost of equity estimate by documenting the relations between *rmean* and the three commonly-used risk proxies, *Beta*, *BMratio* and *MV*. The dependent variable is *rmean*. Other variables follow the definitions in Table 3.10. The industry and year are included, but not reported. All columns are pooled regression with white-adjusted robust P-values presented in the brackets below the coefficients estimates. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	(1)	(2)	(3)	(4)
Beta	0.002***			0.002***
	[0.001]			[0.001]
BMratio		0.031***		0.024***
		[0.000]		[0.000]
MV			-0.005***	-0.003***
			[0.000]	[0.000]
Constant	0.094***	0.084***	0.134***	0.107***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	Yes	Yes	Yes
Observations	4493	4493	4493	4493
Adjusted R^2	0.150	0.266	0.235	0.287

Table 3.8 Multivariate Regression: Cost of Equity Analysis

This table presents the results on the relationship between R&D and the cost of equity, as well as boards' impact on the relationship between R&D and the cost of equity. The dependent variable is rmean. Other variables follow the definitions in Table 3.10. The industry (and year) are included, but not reported. Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method, based on annual cross-sectional regressions. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M
RD Dummy	-0.004***	-0.003**	-0.004***	-0.003**
	[0.000]	[0.048]	[0.000]	[0.047]
IG*RD Dummy			-0.002	-0.003*
			[0.110]	[0.058]
IG			0.003	0.002
			[0.260]	[0.379]
Beta	0.001**	0.001*	0.001**	0.001*
	[0.029]	[0.089]	[0.023]	[0.075]
BMratio	0.025***	0.024***	0.025***	0.023***
	[0.000]	[0.000]	[0.000]	[0.000]
MV	-0.002***	-0.002***	-0.003***	-0.003***
	[0.000]	[0.001]	[0.000]	[0.001]
EPSVAR	0.021***	0.021***	0.019***	0.020***
	[0.002]	[0.003]	[0.004]	[0.004]
LTG	0.018**	0.028	0.020***	0.029
	[0.022]	[0.162]	[0.010]	[0.127]
Growth	0.001	0.000	0.002	0.001
	[0.699]	[0.918]	[0.488]	[0.697]
Constant	0.100***	0.099***	0.101***	0.100***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	4493	9	4493	9
Adjusted R^2	0.292	-	0.294	-
Average R^2	-	0.341	-	0.345

Table 3.9 Sensitivity Test Results: Cost of Equity Analysis

This table presents the various sensitivity results on the cost of equity analysis. Panel A uses stock price data as of January while continue use I/B/E/S data as of June to estimate the implied cost of equity. Panel B uses CRSP/IBES data as of 3/7 months after fiscal year end to estimate the implied cost of equity. Panel C uses industry adjusted EP ratio to proxy for the cost of equity. Panel D replaces RD Dummy with its continuous value. Panel E constructs RD Dummy based on the capitalized R&D asset by capitalizing past and current R&D expenses. Panel F replaces IG with the disaggregated continuous values of board independence and exposure. In each panel, column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method, based on annual cross-sectional regressions. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use stock price data as of January to estimate implied cost of equity

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.004***	-0.004***	-0.004***	-0.004***
	[0.000]	[0.003]	[0.000]	[0.003]
IG*RD Dummy			-0.003**	-0.003***
			[0.013]	[0.007]
IG			0.002	0.002
			[0.360]	[0.530]
Beta	0.001**	0.002*	0.002*	0.003*
	[0.041]	[0.062]	[0.081]	[0.088]
BMratio	0.031***	0.027***	0.031***	0.027***
	[0.000]	[0.000]	[0.000]	[0.000]
MV	-0.003***	-0.003***	-0.003***	-0.003***
	[0.000]	[0.001]	[0.000]	[0.001]
EPSVAR	0.004	0.015	0.004	0.014
	[0.368]	[0.130]	[0.408]	[0.155]
LTG	0.018***	0.022**	0.020***	0.022**
	[0.006]	[0.020]	[0.003]	[0.018]
Growth	-0.002	-0.001	-0.001	-0.000
	[0.365]	[0.765]	[0.517]	[0.991]
Constant	0.110***	0.108***	0.111***	0.109***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	4424	9	4424	9
Adjusted R^2	0.420	-	0.423	-
Average R^2	-	0.427	-	0.431

Table 3.9 - continued

Panel B. Use 3-month-ahead CRSP & 7-month-ahead I/B/E/S data to estimate implied cost of equity

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.004***	-0.004**	-0.004***	-0.004**
	[0.000]	[0.019]	[0.000]	[0.018]
IG*RD Dummy			-0.004**	-0.005**
			[0.013]	[0.020]
IG			0.003	0.002
			[0.594]	[0.723]
Beta	0.002***	0.003**	0.002***	0.003**
	[0.000]	[0.033]	[0.000]	[0.027]
BMratio	0.027***	0.026***	0.027***	0.026***
	[0.000]	[0.000]	[0.000]	[0.000]
MV	-0.003***	-0.002***	-0.003***	-0.003***
	[0.000]	[0.001]	[0.000]	[0.001]
EPSVAR	0.007*	0.015**	0.007	0.014**
	[0.098]	[0.034]	[0.118]	[0.040]
LTG	0.023***	0.019	0.025***	0.021
	[0.004]	[0.202]	[0.002]	[0.161]
Growth	-0.004**	-0.005	-0.003*	-0.005
	[0.047]	[0.203]	[0.087]	[0.284]
Constant	0.095***	0.101***	0.096***	0.102***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	4534	9	4534	9
Adjusted R^2	0.308	-	0.311	-
Average R^2	-	0.339	-	0.346

Table 3.9 - continued

Panel C. Use four different measures of cost of equity as the dependent variables (Pooled results)

	(1)	(2)	(3)	(4)
VARIABLES	*rgls*	*rct*	*roj*	*rpeg*
RD Dummy	-0.004***	-0.007***	-0.003***	-0.001
	[0.000]	[0.000]	[0.001]	[0.566]
IG*RD Dummy	0.000	-0.003*	-0.004**	-0.004
	[0.997]	[0.068]	[0.019]	[0.101]
IG	0.001	0.003	0.003	0.004
	[0.379]	[0.220]	[0.185]	[0.331
Beta	0.001**	0.002***	0.001**	0.005***
	[0.023]	[0.000]	[0.041]	[0.000]
BMratio	0.039***	0.002	0.023***	0.037***
	[0.000]	[0.251]	[0.000]	[0.000]
MV	-0.003***	-0.002***	-0.002***	-0.003***
	[0.000]	[0.000]	[0.000]	[0.000]
EPSVAR	0.014**	0.004	0.020***	0.039***
	[0.026]	[0.507]	[0.008]	[0.000]
LTG	0.004	0.016*	0.052***	0.004
	[0.520]	[0.063]	[0.000]	[0.718]
Growth	0.013***	0.010***	-0.003	-0.013***
	[0.000]	[0.000]	[0.190]	[0.001]
Constant	0.108***	0.096***	0.098***	0.103***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	4493	4493	4493	4493
Adjusted R^2	0.458	0.236	0.264	0.264

Table 3.9 - continued

Panel D. Use Industry adjusted EP ratio to proxy for cost of equity

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.007***	-0.007***	-0.007***	-0.007***
	[0.000]	[0.001]	[0.000]	[0.001]
IG*RD Dummy			-0.003*	-0.002
			[0.082]	[0.280]
IG			0.002	0.002
			[0.162]	[0.268]
Growth	-0.001	0.001	-0.000	0.002
	[0.813]	[0.833]	[0.954]	[0.696]
Beta	0.004***	0.004***	0.004***	0.004***
	[0.000]	[0.005]	[0.000]	[0.005]
Lev	0.015***	0.015**	0.014***	0.015**
	[0.000]	[0.019]	[0.000]	[0.021]
Size	-0.001**	-0.001	-0.001**	-0.001
	[0.026]	[0.396]	[0.010]	[0.301]
Constant	0.000	-0.000	0.001	0.007
	[0.919]	[0.996]	[0.802]	[0.651]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	5176	9	5176	9
Adjusted R^2	0.080	-	0.081	-
Average R^2	-	0.203	-	0.207

Table 3.9 - continued

Panel E. Investigate R&D in its continuous form

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD	-0.029***	-0.019	-0.029***	-0.019
	[0.002]	[0.140]	[0.002]	[0.172]
IG*RD			-0.017	-0.022*
			[0.174]	[0.073]
IG			0.003	0.002
			[0.497]	[0.620]
Beta	0.001*	0.001	0.001**	0.001
	[0.060]	[0.257]	[0.048]	[0.201]
BMratio	0.025***	0.023***	0.025***	0.023***
	[0.000]	[0.000]	[0.000]	[0.000]
MV	-0.002***	-0.002***	-0.003***	-0.003***
	[0.000]	[0.001]	[0.000]	[0.001]
EPSVAR	0.021***	0.020***	0.019***	0.019***
	[0.003]	[0.006]	[0.005]	[0.009]
LTG	0.017**	0.027	0.019**	0.029
	[0.028]	[0.181]	[0.012]	[0.146]
Growth	0.001	0.000	0.002	0.001
	[0.655]	[0.927]	[0.450]	[0.687]
Constant	0.098***	0.098***	0.100***	0.099***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	4493	9	4493	9
Adjusted R^2	0.290	-	0.292	-
Average R^2	-	0.339	-	0.344

Table 3.9 - continued

Panel F. Investigate capitalized R&D

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.004***	-0.003**	-0.004***	-0.002*
	[0.000]	[0.032]	[0.000]	[0.053]
IG*RD Dummy			-0.003*	-0.004*
			[0.073]	[0.090]
IG			0.003	0.003
			[0.242]	[0.314]
Beta	0.001*	0.001	0.001**	0.001
	[0.060]	[0.309]	[0.045]	[0.215]
BMratio	0.023***	0.022***	0.022***	0.022***
	[0.000]	[0.000]	[0.000]	[0.000]
MV	-0.002***	-0.002***	-0.002***	-0.002***
	[0.000]	[0.004]	[0.000]	[0.003]
EPSVAR	0.029***	0.028***	0.028**	0.028***
	[0.009]	[0.006]	[0.013]	[0.007]
LTG	0.026***	0.029*	0.029***	0.032**
	[0.002]	[0.071]	[0.001]	[0.044]
Growth	-0.003	-0.002	-0.003	-0.002
	[0.209]	[0.419]	[0.317]	[0.597]
Constant	0.054***	0.099***	0.057***	0.092***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	3981	9	3981	9
Adjusted R^2	0.263	-	0.267	-
Average R^2	-	0.338	-	0.346

Table 3.9 - continued

Panel G. Investigate board variables in their continuous forms

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.004***	-0.003	-0.004***	-0.003**
	[0.000]	[0.108]	[0.000]	[0.045]
Independence*RD Dummy	-0.000	-0.006		
	[0.946]	[0.314]		
Exposure*RD Dummy			-0.001	-0.002*
			[0.188]	[0.097]
Independence	0.005	0.005	0.005	0.006
	[0.516]	[0.627]	[0.518]	[0.628]
Exposure	0.002	0.002	0.002	0.002
	[0.201]	[0.136]	[0.201]	[0.128]
Beta	0.001**	0.001	0.001**	0.001
	[0.028]	[0.118]	[0.028]	[0.186]
BMratio	0.025***	0.023***	0.025***	0.023***
	[0.000]	[0.000]	[0.000]	[0.000]
MV	-0.003***	-0.003***	-0.003***	-0.003***
	[0.000]	[0.000]	[0.000]	[0.000]
EPSVAR	0.019***	0.019***	0.019***	0.020***
	[0.006]	[0.008]	[0.005]	[0.006]
LTG	0.021***	0.030	0.021***	0.030
	[0.006]	[0.119]	[0.006]	[0.123]
Growth	0.002	0.001	0.002	0.001
	[0.451]	[0.731]	[0.422]	[0.607]
Constant	0.101***	0.100***	0.101***	0.100***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	4493	9	4493	9
Adjusted R^2	0.294	-	0.294	-
Average R^2	-	0.349	-	0.347

Table 4.1 Credit Rating Classifications

This table shows the credit rating classifications schedule.

Firm credit ratings (RATING) are the long-term issuer credit ratings compiled by Standard & Poor's and reported on Compustat (data item 280). The ratings range from AAA (highest rating) to D (lowest rating - debt in payment default). These ratings reflect S&P's assessment of the creditworthiness of the obligor with respect to its senior debt obligations. For purposes of the analysis, the multiple ratings are collapsed into seven categories according to the schedule provided below.

S&P Debt rating	Compustat data280	Assigned RATING score
AAA	2	7
AA+	4	6
AA	5	6
AA-	6	6
A+	7	5
A	8	5
A-	9	5
BBB+	10	4
BBB	11	4
BBB-	12	4
BB+	13	3
BB	14	3
BB-	15	3
B+	16	2
B	17	2
B-	18	2
CCC+	19	1
CCC or CC	20, 23	1
C	21, 24	1
D or SD	27, 29, 90	1

Table 4.2 Sample Selection & Descriptive Statistics: Cost of Debt Analysis

Panel A presents the selection procedure of the sample used in the cost of debt analysis. The sample consists of 2,812 firm-year observations covering from 1998 to 2005. Data on financial items and credit ratings are from Compustat. Data on board items are from RiskMetrics.

Panel B presents the summary statistics of the data used in the cost of debt analysis. All variables (except *Rating* and *Sub*) are winsorized at the 1st and 99th percentile values. Rating proxies for the cost of debt. It is measured as the long-term issuer credit ratings compiled by Standard & Poor's and reported on Compustat (data item 280), which are collapsed into seven categories according to the schedule provided in Table 4.1. RD is research and development expenditure, scaled by the book value of assets at year t. RD Dummy is equal to one if RD is above 75th percentile for that year, and zero otherwise. IG is equal to one if the sum of Independence and Exposure are ranked above the median for that year, and zero otherwise. Here Independence and Exposure are in the forms of fractional rank. Independence is the number of independent directors as a percentage of the total number of directors. The definition of independence follows the IRRC definition. Exposure is the average number of outside directorships in other firms held by independent directors. DE is the ratio of long-term debt to book value of equity. Times is income before interest expense divided by interest expense. ROA is net income before R&D expenditures (adjusted for the tax saving of R&D expenditure) scaled by total assets. Sub is a dummy variable coded as one if a firm has subordinated debt, zero otherwise. PPE is gross PPE divided by total assets.

Panel C presents the summary statistics comparison between three types of data. They are data where R&D is missing, R&D is zero and R&D is positive, respectively.

Panel A. Sample selection procedure

Criteria		N
Compustat Industrial Annual data (FTP Version), 1998-2006		119, 023
Less:	Observations with sales, asset, book/market value and capital expenditure less than zero	(56, 459)
	Missing value to compute other financial variables	(18, 332)
	Missing value of credit ratings (t+1)	(33, 436)
Subtotal, 1998-2005		10, 296
Merge with RiskMetrics data set on directors		5, 747
Less:	Missing R&D expenditure data	(2, 935)
Final Sample		2, 812

Table 4.2 - continued

Panel B. Descriptive statistics of the data used in the regression (n=2812)

VARIABLE	MEAN	STD	P25	MEDIAN	P75
Rating	3.901	1.120	3.000	4.000	5.000
RD	0.031	0.039	0.003	0.017	0.042
RD Dummy	0.251	0.434	0.000	0.000	1.000
Independence	0.693	0.165	0.583	0.727	0.818
Exposure	1.255	0.744	0.714	1.200	1.714
IG	0.500	0.500	0.000	1.000	1.000
DE	0.979	1.415	0.319	0.594	1.053
ROA	0.063	0.082	0.027	0.062	0.102
Times	7.801	19.162	1.713	3.567	7.182
Size	8.223	1.265	7.316	8.013	9.004
Sub	0.156	0.363	0.000	0.000	0.000
PPE	0.533	0.306	0.298	0.470	0.726

Panel C. Descriptive statistics comparison: missing-RD data, zero-RD data and positive-RD data

VARIABLE	RD is missing (n=2935)		RD is zero (n=566)		RD is nonmissing/nonzero (n=2246)	
	mean	median	mean	median	mean	median
Rating	3.935	4.000	1.000	0.942	3.969	4.000
RD	-	-	0.000	0.000	0.039	0.025
RD Dummy	-	-	1.000	0.000	0.252	0.000
Independence	0.653	0.667	0.182	0.176	0.707	0.750
Exposure	1.010	0.857	0.000	0.775	1.293	1.250
IG	0.501	1.000	0.000	0.500	0.502	1.000
DE	1.312	0.816	0.005	1.206	0.973	0.583
ROA	-	-	-0.131	0.049	0.067	0.068
Times	4.671	2.667	-2.148	11.939	7.777	3.664
Size	8.414	8.219	5.939	1.079	8.283	8.064
Sub	0.189	0.000	0.000	0.437	0.130	0.000
PPE	0.645	0.634	0.000	0.304	0.513	0.436

Table 4.3 Univariate Correlation: Cost of Debt Analysis

This table provides the Pearson and Spearman correlation of the variables used in the cost of debt analysis. The Pearson (Spearman) correlation coefficients are presented above (below) the diagonal. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively. All variables follow the definitions in Table 4.2.

Variable	Rating	RD Dummy	IG	DE	Times	ROA	Size	Sub	PPE
Rating	1.000	-0.011*	0.257***	-0.226***	0.241***	0.422***	0.559***	-0.216***	0.106***
RD Dummy	-0.017**	1.000	0.036*	-0.154***	0.172***	0.281***	0.026	-0.185***	-0.222***
IG	0.264***	0.036*	1.000	-0.005	0.007	0.080***	0.290***	-0.120***	0.097***
DE	-0.295***	-0.304***	0.001	1.000	-0.185***	-0.222***	0.003	0.259***	0.021
Times	0.519***	0.118***	0.071***	-0.563***	1.000	0.480***	0.090***	-0.114***	-0.084***
ROA	0.441***	0.343***	0.091***	-0.425***	0.807***	1.000	0.117***	-0.155***	-0.061***
Size	0.545***	0.027	0.294***	-0.067***	0.143***	0.084***	1.000	-0.032*	0.029
Sub	-0.247***	-0.185***	-0.120***	0.295***	-0.252***	-0.241***	-0.058***	1.000	-0.038**
PPE	0.140***	-0.239***	0.096***	0.151***	-0.034*	-0.045**	0.035*	-0.047**	1.000

Table 4.4 Multivariate Regression: Cost of Debt Analysis

This table presents the results on the relationship between R&D and credit ratings, as well as boards' impact on the relationship between R&D and credit ratings. The dependent variable is Rating. Other variables follow the definitions in Table 4.2. The industry (and year) are included, but not reported. Column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method, based on annual cross-sectional regressions. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.405***	-0.417***	-0.495***	-0.517***
	[0.000]	[0.000]	[0.000]	[0.000]
IG*RD Dummy			0.168**	0.187*
			[0.013]	[0.080]
IG			0.058*	0.059**
			[0.087]	[0.041]
DE	-0.128***	-0.156***	-0.129***	-0.156***
	[0.000]	[0.001]	[0.000]	[0.001]
Times	0.003**	0.004*	0.003***	0.004*
	[0.010]	[0.068]	[0.006]	[0.059]
ROA	3.956***	4.053***	3.887***	3.978***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.479***	0.480***	0.468***	0.467***
	[0.000]	[0.000]	[0.000]	[0.000]
Sub	-0.399***	-0.419***	-0.391***	-0.409***
	[0.000]	[0.000]	[0.000]	[0.000]
PPE	0.272***	0.209**	0.252***	0.184**
	[0.000]	[0.027]	[0.000]	[0.043]
Constant	0.171	0.499***	0.281	0.617***
	[0.484]	[0.002]	[0.255]	[0.002]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	2812	8	2812	8
Adjusted R^2	0.596	-	0.599	-
Average R^2	-	0.636	-	0.642

Table 4.5 Sensitivity Test Results: Cost of Debt Analysis

This table presents the various sensitivity results on the cost of debt analysis. Panel A uses sales as the deflator to compute the variables used in the analysis. Panel B uses the market value of equity as the deflator to compute the variables used in the analysis. Panel C investigates the contemporaneous relationship between credit ratings and the independent variables used in the analysis. Panel D replaces RD Dummy with its continuous value. Panel E constructs RD Dummy based on the capitalized R&D asset by capitalizing past and current R&D expenses. Panel F replaces IG with the disaggregated continuous values of board independence and exposure. In all panels, the dependent variable is Rating and other variables follow the definitions in Table 4.2. In each panel, column 1, 3, 5 are pooled regression with white-adjusted robust p-values presented in the brackets below the coefficients estimates. Column 2, 4, 6 are the coefficients and p-values of Fama-MacBeth method, based on annual cross-sectional regressions. *, **, *** denote two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Using sales as deflator

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.409***	-0.414***	-0.488***	-0.499***
	[0.000]	[0.000]	[0.000]	[0.000]
IG*RD Dummy			0.165**	0.180*
			[0.021]	[0.098]
IG			0.091***	0.091***
			[0.007]	[0.010]
DE	-0.135***	-0.166***	-0.136***	-0.166***
	[0.000]	[0.001]	[0.000]	[0.001]
Times	0.006***	0.007**	0.006***	0.008**
	[0.000]	[0.013]	[0.000]	[0.014]
ROA	1.650***	1.596***	1.647***	1.601***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.491***	0.493***	0.474***	0.474***
	[0.000]	[0.000]	[0.000]	[0.000]
Sub	-0.440***	-0.444***	-0.423***	-0.428***
	[0.000]	[0.000]	[0.000]	[0.000]
PPE	-0.217***	-0.208***	-0.211***	-0.202***
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.321	0.631***	0.451*	0.757***
	[0.175]	[0.000]	[0.057]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	2812	8	2812	8
Adjusted (Average) R^2	0.572	0.611	0.576	0.619

Table 4.5 – continued

Panel B. Using market value of equity as deflator

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M
RD Dummy	-0.418***	-0.424***	-0.477***	-0.493***
	[0.000]	[0.000]	[0.000]	[0.000]
IG*RD Dummy			0.102	0.129
			[0.112]	[0.136]
IG			0.108***	0.105**
			[0.001]	[0.032]
DE	-0.086***	-0.102***	-0.088***	-0.104***
	[0.000]	[0.003]	[0.000]	[0.003]
Times	0.002	0.003	0.002	0.003
	[0.152]	[0.172]	[0.120]	[0.174]
ROA	2.755***	2.730***	2.708***	2.701***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.477***	0.475***	0.461***	0.459***
	[0.000]	[0.000]	[0.000]	[0.000]
Sub	-0.368***	-0.370***	-0.348***	-0.341***
	[0.000]	[0.000]	[0.000]	[0.000]
PPE	-0.179***	-0.219***	-0.180***	-0.224***
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.353	0.691***	0.467**	0.800***
	[0.124]	[0.000]	[0.042]	[0.000]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	2812	8	2812	8
Adjusted R^2	0.618	-	0.621	-
Average R^2	-	0.658	-	0.664

Table 4.5 - continued

Panel C. Investigate contemporaneous relationship between rating & independent variables

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.385***	-0.390***	-0.459***	-0.470***
	[0.000]	[0.000]	[0.000]	[0.000]
IG*RD Dummy			0.142**	0.149*
			[0.025]	[0.063]
IG			0.041	0.047**
			[0.188]	[0.042]
DE	-0.107***	-0.119***	-0.108***	-0.120***
	[0.000]	[0.000]	[0.000]	[0.000]
Times	0.003***	0.004**	0.003***	0.004**
	[0.001]	[0.035]	[0.001]	[0.036]
ROA	3.414***	3.492***	3.365***	3.436***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.493***	0.496***	0.484***	0.487***
	[0.000]	[0.000]	[0.000]	[0.000]
Sub	-0.400***	-0.411***	-0.395***	-0.404***
	[0.000]	[0.000]	[0.000]	[0.000]
PPE	0.251***	0.198***	0.237***	0.174**
	[0.000]	[0.009]	[0.000]	[0.019]
Constant	-0.738***	-0.375***	-0.672***	-0.302**
	[0.000]	[0.004]	[0.000]	[0.028]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	3225	9	3225	9
Adjusted R^2	0.601	-	0.602	-
Average R^2	-	0.633	-	0.637

Table 4.5 – continued

Panel D. Investigate R&D in its continuous form

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD	-4.967***	-5.204***	-4.946***	-5.134***
	[0.000]	[0.000]	[0.000]	[0.000]
IG*RD			1.378*	1.562
			[0.095]	[0.138]
IG			0.102***	0.106***
			[0.001]	[0.005]
DE	-0.127***	-0.153***	-0.128***	-0.154***
	[0.000]	[0.001]	[0.000]	[0.001]
Times	0.003**	0.004*	0.003***	0.004*
	[0.012]	[0.069]	[0.009]	[0.072]
ROA	3.985***	4.106***	3.929***	4.072***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.473***	0.473***	0.460***	0.459***
	[0.000]	[0.000]	[0.000]	[0.000]
Sub	-0.398***	-0.416***	-0.387***	-0.404***
	[0.000]	[0.000]	[0.000]	[0.000]
PPE	0.263***	0.194*	0.241***	0.171*
	[0.000]	[0.056]	[0.000]	[0.079]
Constant	0.273	0.609***	0.368	0.716***
	[0.260]	[0.001]	[0.131]	[0.001]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	2812	8	2812	8
Adjusted R^2	0.598	-	0.600	-
Average R^2	-	0.637	-	0.643

Table 4.5 – continued

Panel E. Investigate capitalized R&D

	(1)	(2)	(3)	(4)
VARIABLES	Pool	F-M	Pool	F-M
RD Dummy	-0.390***	-0.411***	-0.482***	-0.523***
	[0.000]	[0.000]	[0.000]	[0.000]
IG*RD Dummy			0.169**	0.216**
			[0.021]	[0.025]
IG			0.073**	0.066**
			[0.035]	[0.019]
DE	-0.122***	-0.148***	-0.123***	-0.149***
	[0.000]	[0.001]	[0.000]	[0.001]
Times	0.002**	0.004	0.002**	0.004
	[0.030]	[0.152]	[0.017]	[0.128]
ROA	4.644***	4.837***	4.573***	4.741***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.493***	0.495***	0.478***	0.478***
	[0.000]	[0.000]	[0.000]	[0.000]
Sub	-0.386***	-0.400***	-0.377***	-0.393***
	[0.000]	[0.000]	[0.000]	[0.000]
PPE	0.340***	0.278**	0.313***	0.248**
	[0.000]	[0.024]	[0.000]	[0.038]
Constant	-0.337***	-0.525	-0.211*	0.155
	[0.005]	[0.401]	[0.095]	[0.765]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	2592	8	2592	8
Adjusted R^2	0.602	-	0.605	-
Average R^2	-	0.642	-	0.648

Table 4.5 – continued

Panel F. Investigate board variables in their continuous forms

VARIABLES	(1) Pool	(2) F-M	(3) Pool	(4) F-M
RD Dummy	-0.414***	-0.413***	-0.422***	-0.435***
	[0.000]	[0.000]	[0.000]	[0.000]
Independence*RD Dummy	0.129	0.059		
	[0.557]	[0.807]		
Exposure*RD Dummy			0.207***	0.212***
			[0.000]	[0.000]
Independence	0.103	0.075	0.113	0.083
	[0.280]	[0.402]	[0.225]	[0.356]
Exposure	0.085***	0.081***	0.078***	0.074***
	[0.000]	[0.004]	[0.000]	[0.004]
DE	-0.129***	-0.156***	-0.127***	-0.154***
	[0.000]	[0.001]	[0.000]	[0.001]
Times	0.003***	0.004*	0.003***	0.004*
	[0.007]	[0.065]	[0.005]	[0.057]
ROA	3.929***	4.034***	3.890***	3.995***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.459***	0.460***	0.461***	0.462***
	[0.000]	[0.000]	[0.000]	[0.000]
Sub	-0.383***	-0.401***	-0.394***	-0.414***
	[0.000]	[0.000]	[0.000]	[0.000]
PPE	0.234***	0.167*	0.248***	0.176**
	[0.000]	[0.066]	[0.000]	[0.045]
Constant	0.219	0.552***	0.203	0.551***
	[0.385]	[0.005]	[0.426]	[0.007]
Industry effects included	Yes	Yes	Yes	Yes
Year effects included	Yes	No	Yes	No
observation	2812	8	2812	8
Adjusted R^2	0.598	-	0.602	-
Average R^2	-	0.640	-	0.643