The Role of Corporate Governance on Long-Term Financial Performance and Market Valuation of R&D Investments in the Biotechnology Industry

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Abstract: We examine how corporate governance structure affects biotech firms' long-term financial performance and market valuation of R&D investments. The biotech industry is characterized by its large R&D investments with uncertain payoffs. Absent monitoring and bonding, the management can make suboptimal investment decisions to maximize their own benefits at shareholders' expenses. Corporate governance reduces agency problems and aligns the interests of managers and shareholders. Our results show that the financial performance and market valuation of biotech firms' R&D investments depend critically on the firms' corporate governance structure.

INTRODUCTION

Regulators, in response to the recent high profile scandals (e.g., Adelphia, Enron, and World Com), have enacted rules intended to strengthen the quality of corporate governance.[1] Empirical evidence indicates that weak corporate governance is associated with financial reporting fraud (e.g., Dechow et al. 1996; Beasley 1996), but empirical studies examining the relation between the quality of governance mechanisms and the firm's investment decisions and subsequent financial performance yield mixed results (e.g. Coles et al. 2001; Gompers et al. 2003; Cremers and Nair 2003 among others)[2].

Larcker et al. (2005) provide a possible explanation for the mixed findings: The sample size and specific firms included in prior research vary considerably and make it difficult to draw substantive conclusions. As many of the empirical studies investigating the relation between corporate governance and firm performance across industries, Coles et al. (2001) suggest examining the underlying issue in a more refined, industry-level context. Nonfinancial corporate governance information may be particularly relevant to the market valuation and subsequent financial performance of R&D investments in high tech sectors, where the productivity of R&D is a vital determinant of long-term success. Accordingly, our study focuses on the innovative, fast-changing biotech industry.

This paper examines how corporate governance structure affects biotech firms' long-term financial performance and market valuation of R&D investments. Absent monitoring and bonding, corporate executives can make suboptimal investment decisions in order to maximize their own utility at shareholders' expenses. Corporate governance reduces agency problems and aligns the interests of managers and shareholders. Therefore, we hypothesize and empirically

[1] For example, NYSE (2004) and NASDAQ (2004) have both recently enacted rules requiring that their member firms have boards of directors with a majority of independent directors.
[2] Larcker et al. (2005) and Coles et al. (2001) provide critical reviews of previous empirical research in this area.

examine that the financial performance and market valuation of biotech firms' R&D investments depend critically on the firms' corporate governance structure.

The biotech industry is characterized by short-cycle technological developments requiring large investments with very uncertain payoffs. The periodic R&D expenditure is the only innovation-relevant financial information required to be disclosed in corporate financial reports. Current accounting practice requires full expensing of R&D cost and as a result, fails to sufficiently inform market participants about a firm's R&D activities and potential future earnings power. Several prior studies turn the attention to nonfinancial information and examine the relationship between intangible asset proxies and firm performance (Shortridge 2004; Rajgopal et al. 2003; Ely et al. 2003; Trueman et al. 2001 among others). These studies suggest that financial and nonfinancial information are complimentary and both should be included when assessing financial and market performance. We extend this line of research and examine whether nonfinancial corporate governance information is associated with the subsequent financial performance and market valuation of R&D investments in the U.S. biotech industry.

Our analysis unfolds in two steps. First, we examine whether corporate governance is associated with the financial performance of R&D investments in the U.S. biotech industry. Financial performance is measured as operating income before depreciation and the expensing of R&D, scaled by net sales. Each of the subsequent five years' financial performance is regressed on current year's governance variables interacting with R&D expenditures, controlling for the firm's tangible assets. The results indicate that corporate governance matters in one year subsequent financial performance of biotech firm's R&D investments.

Second, we investigate the impact of corporate governance on the market valuation of biotech firms' R&D investments. Specifically, we use a return model and incorporate eight

governance variables interacting with R&D expenditures to test whether corporate governance information is useful to investors in judging the economic merit of firm's R&D investment decisions. Using a sample of 751 firm-year observations over the years 1997-1999, we present evidence suggesting that the relation between firm values and R&D investments tend to be more precisely measured when corporate governance information is presented.

Our paper contributes to the existing literature in several ways. This is the first known study to investigate the relation between corporate governance and firm performance on the industry level. We find evidence suggesting that the financial performance of a biotech firm's R&D investments can be more precisely measured when corporate governance information is presented. As corporate governance and disclosure are considered necessary measures to protect shareholders, our results provide empirical evidence to policy makers and regulators for implementing new corporate governance requirements and disclosure guidelines.

We are also among the first to examine both main effects and the interaction terms of governance mechanisms with R&D expenditure to provide more coherent evidence on the benefits of these mechanisms. Prior studies implicitly assume an indirect impact of corporate governance on firm values by including only the interaction terms between governance and R&D expenditure, but not the main effects of governance variables, in the regression models (e.g., Chung et al. 2003). We relax this assumption and posit that corporate governance may influence firm value directly and indirectly through a firm's R&D investment decisions. We believe that the inclusion of main effects of governance variables along with their interaction terms with R&D expenditure better reflects how governance mechanisms work in practice.

This paper proceeds as follows: The next section reviews prior research on corporate governance and develops hypothesis. The third section discusses the research design and outlines

data sources. The fourth section presents research findings, and the final section concludes the study.

PRIOR RESEARCH AND HYPOTHESIS DEVELOPMENT

The theoretical foundation for most corporate governance empirical studies is agency theory. At the core of agency theory is the premise that firms can institute various mechanisms to better align the interests of both management and shareholders (Coarse 1937; Fama and Jensen 1983; Jensen and Meckling 1976). Without these monitoring mechanisms there is an increasing risk of top management executing its duties in a self-serving manner, perhaps, to the detriment of the shareholders' best interest. Properly implemented corporate governance (monitoring) mechanisms should align the interest of both parties and increase the performance (short- and long-term) of the firm.

Several recent research studies use different approaches and alternative views to explain the relationships among corporate governance mechanisms and a firm's financial performance. Gompers et al. (2003) find significant correlation between shareholder rights and several forward-looking performance measures. They build an index using various governance-related variables and find that the governance index is highly correlated with stock returns, Tobin's q, sales growth, and profits. Chung et al. (2003) examine the cross-sectional association between a firm's market value and its capital and R&D expenditures during the period 1991-1995. The results show that the market valuation of the firm's investments depends critically on analyst following and board composition, but not on institutional holdings. More recently, Larcker et al. (2005) build 14 governance constructs using principal components analysis and find that these 14 governance constructs are related to future operating performance but have a somewhat

mixed association with abnormal accruals, Tobin's Q, and future excess stock returns, and little relation to class action lawsuit and accounting restatements.

Coles et al. (2001) examine the relationship between the typical agency theory constructs of monitoring, incentives and ownership structure, with financial performance. The results indicate that while some of the traditional agency variables do impact performance, both individually and as interactions, industry performance is a strong and significant driver of performance for sample firms. They conclude that, while firms may use governance packages to deal with agency issues, further research could provide important evidence on these issues by focusing on examining a more refined, industry-level context. Our paper extends this line of research by examining a set of corporate governance variables and its affect on the market valuation and subsequent financial performance of R&D investments in the U.S. biotech industry.

The biotech industry is characterized by its large R&D investments. Given the large R&D investments, the level of information asymmetry is much higher than other industries that have lower R&D investment. Aboody and Lev (2000) identify three dimensions where R&D differs from other capital or financial inputs (e.g., property, plant and equipment) related to information asymmetry. First, R&D projects are unique to the firm as opposed to most other investments that have some common traits across firms within an industry. Second, since there is no organized market to trade R&D, as exist for most physical and financial assets, there are no asset prices from which to obtain information. Third, R&D is immediately expensed, in order to comply with accounting rules, so that no information on value and productivity changes of R&D is disclosed to investors. Given those three dimensions, Aboody and Lev find that insider gains are substantially larger in R&D-intensive firms as compared to firms with no R&D costs. The

high information asymmetries associated with R&D-intensive firms could lead to opportunistic behavior by management (e.g., insider gains, timing R&D investments to maximize bonuses). A set of corporate governance mechanisms may mitigate the inherent agency issues found in the biotech industry and lead to better R&D investment decisions, suggesting the following hypotheses:

> H_1: Biotech firms with good corporate governance will have higher financial performance of its R&D investments than firms that do not exhibit good corporate governance.
>
> H_2: Biotech firms with good corporate governance will have higher market value of its R&D investments than firms that do not exhibit good corporate governance.

Drawing on prior studies (Klein 1998; Bhagat and Black 2001; Coles et al. 2001; Cohen, Krishnamoorthy and Wright 2004; Larcker et al. 2005 among others) we measure corporate governance by the percentage of independent directors on the board (INDEPENDENCE), the number of directors on the board (BOD_SIZE), the number of meetings by the board (BOD_MEETING), the number of years the CEO led the company (TENURE), whether the CEO is also the founder of the company (FOUNDER) or chairman of the board (DUAL), the percentage of equity ownership by management and directors (MGMT), and the percentage of a firm's stock held by outside blockholders (BLOCK). While the type or number of corporate governance variables vary considerably in the extant literature from one variable (most notably IBOD) to an index of 51 factors (Brown and Caylor 2004), we believe there are three basic categories that can help ensure managers act in the best interest of its shareholders. The three basic categories are board characteristics, CEO involvement, and ownership structure.

Board Characteristics

We include three board characteristics in our study, board independence, board size and the number of board meetings. A high percentage of independent directors on the board enhances the monitoring of managerial opportunism and reduces management's chance of expropriation. While some mixed results are noted in the extant literature (e.g., Bhagat and Black 2002), most empirical evidence suggests a positive association between board independence and firm performance (Rosenstein and Wyatt 1990; Coles et al. 2001; Chung et al. 2003). We expect a positive relationship between board independence (INDEPENDENCE) and our dependent variables.

While boards perform an important monitoring function, the reduced communication and decision-making quality of larger boards may outweigh the benefits of increased monitoring (Jensen 1983). Consistent with that line of reasoning, Yermack (1996) finds a negative relationship between board size and Tobin's Q and profitability. Additionally, Brown and Caylor (2004) show that firms with board sizes between six and 15 have higher returns on equity and profitability than do firms with larger boards. We expect a negative relationship between board size (BOD_SIZE) and our dependent variables.

We expect a positive relationship between the number of board meetings held (BOD_MEETING) and our dependent variables. The number of meetings held should be evidence of effective monitoring activity (Cohen et al. 2004; Larcker et al. 2005). If the board does not meet regularly, it is unlikely that effective monitoring of management will occur, even if the board is the appropriate size and has a high percentage of independent directors.

CEO Involvement

We include three variables that proxy for CEO involvement, the tenure of the CEO, whether the CEO is also the founder of the company, and whether the CEO is also the chairman

of the board. According to the stewardship theory, if a CEO is not a good steward of the firm's resources we would not expect the CEO being retained as long as a CEO considered a good steward (Coles et al. 2001). Another perspective discussed by Cole et al. (2001) is that of a long-term CEO becoming "stale in the saddle" (Miller 1991, p 34). In other words, the tenure of the CEO has a positive effect on performance up to a certain point, at which time it becomes negative. Coles et al. (2001) find no evidence of CEO tenure and market value and firm performance. Given the competing arguments we do not have a predicted sign for the TENURE coefficient.

Within the bio-tech industry it is not uncommon to find the founder of a firm running the business, especially for smaller firms. One would expect the founder to have intimate knowledge and experience to select the appropriate R&D investments to maximize future financial performance. We include a variable to test whether a CEO who is also a founder will affect the performance of R&D investments. We predict a positive sign for the FOUNDER coefficient.

Having a separate CEO and chairman of the board limits the CEO's power from hindering outside monitoring, thus indicating "good" corporate governance (Beasley and Salterio 2001). Empirical evidence indicates that firms are more valuable when the CEO is separate from the board of directors (Yermack 1996; Brown and Caylor 2004). We expect firms that have a combined CEO and chairman to have lower performance and market value.

Ownership Structure

We examine two corporate governance variables related to ownership, the percentage of ownership by management and board of directors and the percentage of block ownership.

Equity ownership by management and the board is argued to be beneficial by aligning their interests with that of the other shareholders (Coles et al. 2001). The percentage of blockholders typically is seen as "good" corporate governance through the monitoring benefit of an active shareholder. Blockholders have the power to pressure management if they observe management not acting in the interest of the shareholders (Jensen 1993; Shleifer and Vishny 1997). Ashbaugh-Skaife et al. (2006) call this the "management disciplining" role of corporate governance. We expect a positive relationship between the percent of equity ownership by management and directors (MGMT) and the percent of blockholder ownership (BLOCK) with our dependent variables.

METHODOLOGY AND SAMPLE

Explanatory Variables

Data about the board characteristics, CEO involvement, and ownership structure are hand-collected from proxy statements for years 1997-1999. INDEPENDENCE measures the percentage of independent directors on the board. Independent directors are outsiders who have no ties to the firm beyond being a board member (Klein 2002). BOD_SIZE measures the number of directors on the board. BOD_MEETING is the number of board meetings. TENURE is the number of years the CEO led the company. FOUNDER is equal to one if the CEO is also the founder of the company, and zero otherwise. DUAL measures CEO duality and is equal to one if the CEO is also the chairman of the board, and zero otherwise. MGMT and BLOCK measure the percentages of shares owned by the company's management and directors and by outside blockholders (who own at least 5% of the firm), respectively. Panel A of Table 1 summarizes all the corporate governance variables.

Models

Financial Performance Model

Financial performance model empirically tests the ability of corporate governance mechanisms to affect biotech firms' long-term financial performance of R&D investments. Financial performance is defined as operating income, before depreciation and the expensing of R&D, scaled by sales. We estimate the following model modified from work done by Lev and Sougiannis (1996):

$$
\begin{aligned}
(OI/S)_{jt+k} = \gamma_0 + \sum_{yr=1997}^{1999} \alpha_{yr+1}\ YR + \gamma_1\ (TA/S)_{j,t+k-1} + \sum_k \gamma_{2,k} (R\ \&\ D/S)_{j,t} \\
+ \sum_k \gamma_{3,k} \mathrm{INDEPENDENCE}_{j,t} + \sum_k \gamma_{4,k} \mathrm{BOD\_SIZE}_{j,t} + \sum_k \gamma_{5,k} \mathrm{BOD\_MEETING}_{j,t} \\
+ \sum_k \gamma_{6,k} \mathrm{TENURE}_{j,t} + \sum_k \gamma_{7,k} \mathrm{FOUNDER}_{j,t} + \sum_k \gamma_{8,k} \mathrm{DUAL}_{j,t} + \sum_k \gamma_{9,k} \mathrm{MGMT}_{j,t} \\
+ \sum_k \gamma_{10,k} \mathrm{BLOCK}_{j,t} + \sum_k \gamma_{11,k} \mathrm{INDEPENDENCE} * (R\ \&\ D/S)_{j,t} \\
+ \sum_k \gamma_{12,k} \mathrm{BOD\_SIZE} * (R\ \&\ D/S)_{j,t} + \sum_k \gamma_{13,k} \mathrm{TENURE} * (R\ \&\ D/S)_{j,t} \\
+ \sum_k \gamma_{14,k} \mathrm{FOUNDER} * (R\ \&\ D/S)_{j,t} + \sum_k \gamma_{15,k} \mathrm{DUAL} * (R\ \&\ D/S)_{j,t} \\
+ \sum_k \gamma_{16,k} \mathrm{MGMT} * (R\ \&\ D/S)_{j,t} + \sum_k \gamma_{17,k} \mathrm{BLOCK} * (R\ \&\ D/S)_{j,t} + \varepsilon_{jt}, \\
k=1,2,\ldots 5. \qquad (1)
\end{aligned}
$$

where OI is annual operating income, before depreciation and R&D expenses, of firm j in year t; S is annual sales; YR is the year dummy variable included to control for time variation; TA is the value of plant and equipment and inventory measured at the beginning of year; R&D is annual

R&D expenditures; INDEPENDENCE, BOD_SIZE, BOD_MEETING, TENURE, FOUNDER, DUAL, MGMT, and BLOCK are the governance variables defined in the previous section. If coefficients γ_{11} to γ_{17} in equation (1) appear to be jointly statistically significant, one can conclude that corporate governance matters in the future financial performance of R&D investments.

Market Valuation Model

We use a return model as a baseline model to examine the impact of corporate governance on the market valuation of biotech firms' R&D investment. As R&D spending in the biotech industry is the highest of any U.S. industry group[3], the effectiveness and productivity of R&D investments are vital determinants of long-term success in the biotech industry. Corporate governance provides managerial monitoring and the prospect of favorable outcomes from R&D investment. Therefore, we include corporate governance mechanisms as other relevant information along with accounting data, such as change in earnings and earnings, in the valuation model. This results in the following model in equation (2):

$$\begin{aligned} RETURN_{jt} = \beta_0 + \sum_{yr=1997}^{1999} \beta_{yr+1}\, YR + \beta_1 \frac{\Delta E_{jt}}{MV_{jt-1}} + \beta_2 \frac{E_{jt}}{MV_{jt-1}} + \beta_3 \frac{R\,\&\,D_{jt}}{MV_{jt-1}} \\ + \beta_4\, INDEPENDENCE_{jt} + \beta_5\, BOD\_SIZE_{jt} + \beta_6\, BOD\_SIZE_{jt} + \beta_7\, TENURE_{jt} \\ + \beta_8\, FOUNDER_{jt} + \beta_9\, DUAL_{jt} + \beta_{10}\, MGMT_{jt} + \beta_{11}\, BLOCK_{jt} \\ + \beta_{12}\, INDEPENDENCE_{jt} * \frac{R\,\&\,D_{jt}}{MV_{jt-1}} + \beta_{13}\, BOD\_SIZE_{jt} * \frac{R\,\&\,D_{jt}}{MV_{jt-1}} \end{aligned}$$

[3] We calculated the percentage of R&D spending to sales for high tech industries (two-digit SIC code equals to 28, 29, 35, 36, 37, 38, and 48) in the period 1995-2001. The biotech industry (two-digit SIC=28) was the highest in the high tech sector on R&D spending as a percentage of revenues for four years and the second highest for two years.

$$+ \beta_{14}\,\text{BOD\_MEETING}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}} + \beta_{15}\,\text{TENURE}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$$

$$+ \beta_{16}\,\text{FOUNDER}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}} + \beta_{17}\,\text{DUAL}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}} + \beta_{18}\,\text{MGMT}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$$

$$+ \beta_{19}\,\text{BLOCK}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}} + \beta_{20}\,\text{BM}_{jt} + \beta_{21}\,\text{MV}_{jt} + \varepsilon_{jt}, \qquad (2)$$

where RETURN_{jt} is the change in market value of firm j in year t divided by market value of the firm at the beginning of year; YR is the year dummy variable included to control for time variation; ΔE_{jt} is measured as change in earnings before R&D expenditures of firm j in year t; E_{jt} is the earnings before R&D expenditures of firm j in year t; R&D is the annual R&D expenditures; INDEPENDENCE, BOD_SIZE, BOD_MEETING, TENURE, FOUNDER, DUAL, MGMT, and BLOCK are the same set of corporate governance variables in equation (1). $\text{INDEPENDENCE}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$, $\text{BOD\_SIZE}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$, $\text{BOD\_MEETING}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$, $\text{TENURE}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$, $\text{FOUNDER}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$, $\text{DUAL}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$, $\text{MGMT}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$, and $\text{BLOCK}_{jt} * \frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$ are interaction terms of $\frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$ and each of the corporate governance variables. BM is the book-to-market ratio; and MV_{jt-1} and MV_{jt} are total market value of firm j at the end of year t-1 and year t, respectively. BM_{jt} and MV_{jt} are included as control variables.

An implicit assumption in equation (2) is that each corporate governance variable may influence returns directly (β_4 through β_{11}) or indirectly through the interaction with $\frac{\text{R \& D}_{jt}}{\text{MV}_{jt-1}}$ (β_{12} through β_{19}). Our main focus is how corporate governance structure affects biotech firms'

market valuation of R&D investment. If the interaction variables are jointly statistically significant, one can conclude that the R&D is valued differently based on the value of the interacted governance variables.

Sample

The initial sample consists of firms with 2-digit SIC equals to 28 and fiscal year ends in December over the years 1997-1999. A search of Compustat results in 1,315 firm-year observations. Missing R&D and other financial data eliminates 252 observations from further consideration. Missing corporate governance data claims another 257 observations. We further eliminate 55 observations with negative book values and/or zero R&D expenditures. This left a final sample of 751 firm-year observations. All financial data are obtained from Compustat database. Data used to construct corporate governance variables are hand-collected from proxy statements for years 1997-1999.

RESULTS

Panel B of Table 1 provides descriptive statistics for the variables used in regression models. The board in the sample biotech firms ranges from two to eighteen directors. On average, 66% of the board consists of independent directors and the board meets seven times a year. About half of the biotech firms' CEOs are also chairmen of the board. The management and blockholders on average own 16% and 20% of sample biotech companies, respectively. Operating income before depreciation and R&D expenses, scaled by net sales (OI/S) ranges from -86.50 to 33.03. The large standard deviation (5.70) and the relatively low median (0.2) indicate high variability in biotech firms' profitability. Similar pattern and variability can be found in

R&D expenditures, where $R\&D/MV_{t-1}$ and R&D/S range from nearly zero to 1.74 and from nearly zero to 337, respectively.

Table 2 provides a correlation matrix for financial and governance variables. The lower half of the Table reports Pearson correlations and the upper half reports Spearman rank correlations. The variable MV is highly and positively correlated with BOD_SIZE but negatively correlated with MGMT, suggesting that large biotech firms tend to have more directors on the board and less percentage of management ownership than small biotech firms.

Insert Tables 1 and 2 about here

Table 3 reports the effects of corporate governance on one-year subsequent financial performance of R&D investments.[4] The interaction terms are jointly significantly associated with the biotech firms' one-year subsequent financial performance ($F = 20.01$, $p < 0.01$), indicating that corporate governance matters in the financial performance of biotech firms' R&D investments. Specifically, the variable INDEPENDENCE*R&D/S has a positive and significant coefficient, suggesting that board independence enhances the monitoring of management and is associated with increased financial performance of R&D investments. The coefficient on FOUNDER*R&D/S is positive, significant at the 0.01 level. The evidence indicates that a CEO who is also founder of the company has more expertise and experience in identifying profitable R&D projects than CEO who is not.

Consistent with our prediction, we find a negative coefficient on DUAL*R&D/S. The R&D investments are more profitable when firms having a separate CEO and chairman of the

[4] The influence of corporate governance on two, three, four, and five years subsequent financial performance of R&D investments are insignificant and thus not tabulated.

board. We also find a positive impact of MGMT on one-year subsequent financial performance, providing support that ownership by management and directors helps align their interests with that of the other shareholders. Contrary to our prediction, we find a negative coefficient on BLOCK*R&D/S. One possible explanation is the "wealth redistribution" hypothesis (Ashbaugh-Skaife et al. 2006). As the percentage of blockholders increases, so does the likelihood that they will use their influence to affect wealth transfers away from minority shareholders and bondholders. The concentrated ownership allows blockholders to exercise undue influence over management (Shleifer and Vishny 1997). Generally our results support H1.

Table 4 offers direct evidence concerning the influence of corporate governance on the market capitalization of R&D expenditures. The explanatory power of the full model is almost 19 percent higher than that of the regression with only financial variables ($R^2 = 0.19$ v.s. 0.16), indicating that corporate governance adds incremental value relevance over traditional financial information to the market valuation of the biotech companies.[5] The interaction terms are jointly significantly associated with the biotech firms' market returns ($F = 4.49$, $p < 0.01$). This result suggests that corporate governance, when used in conjunction with R&D expenditures, gives investors a more useful basis upon which to judge the economic merit of the firm's R&D investment decisions.

We observe that BOD_SIZE has negative influence on the market valuation of R&D. The reduced communications and decision-making quality of large boards may outweigh the benefits of monitoring. We also observe that the market valuation of R&D increases with the number of board meetings (BOD_MEETING), suggesting that the market is able to perceive a positive

[5] Larcker et al. (2005) argue that while most studies focus on statistical significance, studies should also look at the incremental explanatory power of the governance variables in order to draw any substantive conclusions.

relationship between the diligence of board members and the value created by R&D investments. The negative impact of TENURE on the market valuation of R&D indicates that market returns of R&D decreases as a long-term CEO becomes "stale in the saddle". Consistent with our predication, we find a positive impact of ownership by management and the board (MGMT) on the market valuation of R&D. While these results appear to support hypothesis H_2, the results on the DUAL variable are contrary to our expectations. The results suggest that the market value of R&D investments is higher for firms where the CEO is also the chairman of the board. The result is not consistent with our findings on financial performance of R&D investments, where a negative association is found.

Insert Tables 3 and 4 about here

CONCLUSION

This study provides evidence that one-year subsequent financial performance and market valuation of biotech firms' R&D investments depend critically on the firms' corporate governance structure. We identify a number of governance variables, including board characteristics, CEO involvement, and ownership structure, that may affect a biotech firm's R&D investment decisions. We find that corporate governance matters when examining the financial performance of R&D investments. The inclusion of main effects of governance variables along with their interaction terms with R&D expenditure better reflects how governance mechanisms work in practice. We also find that the relation between R&D expenditures and firm values tends to be more precisely measured when a biotech firm's corporate governance structure is considered.

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Table 1 Variable Definitions and Descriptive Statistics

Panel A: Variable Definitions

Variables	Definitions
Dependent	
RETURN	Change in market value of a firm in year t divided by market value of the firm at the beginning of year
OI/S	Operating income, before depreciation and the expensing of R&D, scaled by net sales
Financial	
$\Delta E/MV_{t-1}$	Change in earnings before R&D expenditures, scaled by market value at the beginning of year
E/MV_{t-1}	Earnings before R&D expenditures, scaled by market value at the beginning of year
$R\&D/MV_{t-1}$	R&D expenditures, scaled by market value at the beginning of year
TA/S	The value of plant and equipment and inventory measured at the beginning of year , scaled by net sales
R&D/S	R&D expenditures, scaled by net sales
Governance	
INDEPENDENCE	Percentage of independent directors on the board
BOD_SIZE	Number of directors on the board
BOD_MEETING	Number of board meetings
TENURE	Number of years the CEO led the company
FOUNDER	One if the CEO is also the founder of the company, and zero otherwise
DUAL	One if the CEO is also the chairman of the board of directors, and zero otherwise
MGMT	Percentage of equity ownership by management and directors
BLOCK	Percentage of a company's outstanding voting stock held by outside blockholders, where block is defined at the 5% ownership level
Control	
BM	Book-to-market ratio
MV	Total market value of a firm at the end of a given year
YEAR	Year dummies

Table 1 Continued

Panel B: Descriptive Statistics

Variables	Mean	Std Dev	Min	Median	Max
Dependent					
RETURN	0.46	1.58	-0.93	0.08	18.30
OI/S	-0.59	5.70	-86.50	0.2	33.03
Financial					
$\Delta E/MV_{t-1}$	0.01	0.19	-1.55	0.00	2.30
E/MV_{t-1}	0.01	0.17	-1.06	0.03	2.43
$R\&D/MV_{t-1}$	0.12	0.17	0.00	0.07	1.74
TA/S	1.20	3.77	0.02	0.51	43
R&D/S	3.70	19.93	0.00	0.30	337
Governance					
INDEPENDENCE	0.66	0.18	0	0.71	1
BOD_SIZE	7.60	2.31	2	7	18
BOD_MEETING	7.03	3.02	0	6	24
TENURE	5.97	5.51	0	5	47
FOUNDER	0.19	0.39	0	0	1
DUAL	0.51	0.50	0	1	1
MGMT	0.16	0.16	0	0.11	1
BLOCK	0.20	0.18	0	0.18	1
Control					
BM	1.64	29.91	0.00	0.25	816.25
MV	4516.95	18681.55	0.71	163.91	174083.93

Table 2 Correlation Matrix

Variables	$\Delta E/MV_{t-1}$	E/MV_{t-1}	$R\&D/MV_{t-1}$	TA/S	R&D/S	INDEPEN-DENCE	BOD_ SIZE	BOD_ MEETING	TENURE	FOUNDER	DUAL	MGMT	BLOCK	BM	MV
$\Delta E/MV_{t-1}$	1	**0.41**	0.03	-0.20	-0.08	-0.02	0.01	-0.03	-0.05	-0.08	0.01	-0.04	-0.03	-0.04	0.06
		(0.00)	(0.36)	(0.00)	(0.03)	(0.60)	(0.83)	(0.37)	(0.20)	(0.02)	(0.74)	(0.31)	(0.48)	(0.30)	(0.11)
E/MV_{t-1}	0.38	1	-0.17	-0.29	**-0.43**	0.10	0.25	-0.01	0.07	-0.16	0.08	-0.20	-0.02	0.18	0.39
	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.78)	(0.06)	(0.00)	(0.02)	(0.00)	(0.55)	(0.00)	(0.00)
$R\&D/MV_{t-1}$	0.16	-0.09	1	0.08	**0.69**	0.00	-0.27	-0.01	-0.13	0.06	-0.30	0.18	0.13	0.06	**-0.46**
	(0.00)	(0.02)		(0.05)	(0.00)	(0.90)	(0.00)	(0.83)	(0.00)	(0.11)	(0.00)	(0.00)	(0.00)	(0.10)	(0.00)
TA/S	-0.02	-0.06	0.00	1	0.38	-0.05	-0.03	-0.03	0.02	0.15	0.01	-0.05	0.03	0.02	0.02
	(0.68)	(0.14)	(0.99)		(0.00)	(0.20)	(0.43)	(0.45)	(0.61)	(0.00)	(0.85)	(0.22)	(0.37)	(0.62)	(0.64)
R&D/S	-0.01	-0.08	0.09	0.60	1	-0.02	-0.27	-0.08	-0.04	0.19	-0.26	0.16	0.06	-0.26	-0.33
	(0.79)	(0.04)	(0.02)	(0.00)		(0.55)	(0.00)	(0.04)	(0.35)	(0.00)	(0.00)	(0.00)	(0.09)	(0.00)	(0.00)
INDEPENDENCE	-0.05	0.00	0.00	-0.01	-0.03	1	0.28	0.18	-0.04	-0.12	0.03	-0.38	0.04	-0.04	0.24
	(0.19)	(0.93)	(0.95)	(0.71)	(0.45)		(0.00)	(0.00)	(0.25)	(0.00)	(0.35)	(0.00)	(0.25)	(0.32)	(0.00)
BOD_SIZE	-0.03	0.10	-0.17	-0.05	-0.06	0.29	1	0.17	0.02	-0.15	0.13	-0.29	0.00	-0.08	**0.54**
	(0.44)	(0.00)	(0.00)	(0.19)	(0.11)	(0.00)		(0.00)	(0.65)	(0.00)	(0.00)	(0.00)	(0.94)	(0.04)	(0.00)
BOD_MEETING	-0.04	-0.03	0.04	-0.03	-0.06	0.13	0.12	1	-0.09	-0.11	0.04	-0.22	-0.02	-0.01	0.15
	(0.33)	(0.36)	(0.23)	(0.44)	(0.12)	(0.00)	(0.00)		(0.01)	(0.00)	(0.24)	(0.00)	(0.60)	(0.89)	(0.00)
TENURE	-0.04	0.06	-0.12	0.04	-0.03	-0.09	0.05	-0.06	1	0.31	0.28	0.01	-0.07	-0.14	0.14
	(0.27)	(0.12)	(0.00)	(0.28)	(0.50)	(0.02)	(0.14)	(0.10)		(0.00)	(0.00)	(0.87)	(0.07)	(0.00)	(0.00)
FOUNDER	-0.06	-0.08	0.01	0.13	0.04	-0.11	-0.15	-0.09	0.26	1	0.07	0.22	0.03	-0.11	-0.06
	(0.09)	(0.02)	(0.88)	(0.00)	(0.28)	(0.00)	(0.00)	(0.01)	(0.00)		(0.05)	(0.00)	(0.48)	(0.00)	(0.12)
DUAL	0.04	0.04	-0.17	-0.02	0.02	0.05	0.15	0.03	0.20	0.07	1	-0.08	-0.10	-0.10	0.24
	(0.30)	(0.30)	(0.00)	(0.56)	(0.69)	(0.17)	(0.00)	(0.48)	(0.00)	(0.05)		(0.03)	(0.01)	(0.01)	(0.00)
MGMT	0.05	-0.05	0.10	-0.03	-0.01	-0.39	-0.24	-0.17	0.02	0.18	-0.02	1	-0.17	0.13	**-0.52**
	(0.17)	(0.19)	(0.01)	(0.50)	(0.72)	(0.00)	(0.00)	(0.00)	(0.63)	(0.00)	(0.66)		(0.00)	(0.00)	(0.00)
BLOCK	0.01	-0.05	0.07	-0.01	-0.01	0.05	-0.01	-0.01	-0.05	-0.01	-0.10	-0.21	1	0.08	0.02
	(0.73)	(0.19)	(0.07)	(0.71)	(0.73)	(0.22)	(0.71)	(0.86)	(0.15)	(0.79)	(0.01)	(0.00)		(0.03)	(0.62)
BM	0.19	-0.09	0.03	0.00	0.00	-0.07	-0.08	-0.06	-0.03	-0.02	-0.04	0.08	-0.03	1	-0.37
	(0.00)	(0.01)	(0.43)	(1.00)	(0.93)	(0.05)	(0.03)	(0.08)	(0.35)	(0.55)	(0.22)	(0.03)	(0.40)		(0.00)
MV	-0.01	0.07	-0.13	-0.03	-0.05	0.14	0.45	0.11	0.00	-0.11	0.17	-0.22	-0.17	-0.01	1
	(0.73)	(0.07)	(0.00)	(0.49)	(0.23)	(0.00)	(0.00)	(0.00)	(0.99)	(0.00)	(0.00)	(0.00)	(0.00)	(0.74)	

The lower corner of the matrix reports Pearson correlations, and the upper corner reports Spearman rank correlations. Correlations greater than 0.40 are in bold, and probability > |r| under H_0: Rho = 0 is in parenthesis. See Panel A of Table 1 for variable definitions.

Table 3 Effects of Corporate Governance on Financial Performance of R&D Investments

Variables	Coefficients A	
TA/S	-1.08	***
	(-17.39)	
R&D/S	-0.22	
	(-0.96)	
INDEPENDENCE	-0.64	
	(-0.43)	
BOD_SIZE	0.22	**
	(2.17)	
BOD_MEETING	-0.14	*
	(-1.80)	
TENURE	-0.00	
	(-0.02)	
FOUNDER	-0.18	
	(-0.29)	
DUAL	0.34	
	(0.71)	
MGMT	-0.29	
	(-0.17)	
BLOCK	1.26	
	(0.95)	
INDEPENDENCE*R&D/S	0.54	***
	(2.68)	
BOD_SIZE*R&D/S	0.00	
	(0.90)	
BOD_MEETING*R&D/S	0.02	
	(1.50)	
TENURE*R&D/S	0.01	
	(1.02)	
FOUNDER*R&D/S	0.28	***
	(3.83)	
DUAL*R&D/S	-0.23	***
	(-4.76)	
MGMT*R&D/S	0.64	***
	(2.85)	
BLOCK*R&D/S	-1.06	***
	(-8.30)	
Adj. R2	0.53	
F-stat. for overall model	40.99	***
F-stat. for interactions	20.01	***
Obs	630	

Two-tailed t-statistics are in the parenthesis. The notations *, **, and *** refer to significance at the 10%, 5%, and 1% levels. The coefficients of year dummies are not reported here.

Table 4 Effects of Corporate Governance on Market Valuation of R&D Investments

Variables	Coefficients	
	A	B
$\Delta E/MV_{t-1}$	1.56 ***	1.27 ***
	(4.80)	(3.66)
E/MV_{t-1}	-1.82 ***	-1.70 ***
	(-5.26)	(-4.56)
$R\&D/MV_{t-1}$	1.72 ***	1.01
	(5.43)	(0.41)
INDEPENDENCE		0.26
		(0.61)
BOD_SIZE		0.05
		(1.58)
BOD_MEETING		-0.06 **
		(-2.44)
TENURE		0.02 *
		(1.68)
FOUNDER		0.11
		(0.62)
DUAL		-0.24 *
		(-1.67)
MGMT		-0.51
		(-1.08)
BLOCK		0.19
		(0.48)
INDEPENDENCE*$R\&D/MV_{t-1}$		0.34
		(0.17)
BOD_SIZE*$R\&D/MV_{t-1}$		-0.56 **
		(-2.45)
BOD_MEETING*$R\&D/MV_{t-1}$		0.47 ***
		(3.77)
TENURE*$R\&D/MV_{t-1}$		-0.23 ***
		(-2.82)
FOUNDER*$R\&D/MV_{t-1}$		1.19
		(1.31)
DUAL*$R\&D/MV_{t-1}$		2.29 ***
		(2.94)
MGMT*$R\&D/MV_{t-1}$		4.12 **
		(2.11)
BLOCK*$R\&D/MV_{t-1}$		0.44
		(0.23)
BM	-0.01 ***	-0.00 **
	(-2.80)	(-2.49)
MV	0.00	0.00
	(0.95)	(0.55)
Adj. R^2	0.16	0.19
F-stat. for overall model	21.97 ***	8.66 ***
F-stat. for interactions		4.49 ***
Obs	751	751

Two-tailed t-statistics are in the parenthesis. The notations *, **, and *** refer to significance at the 10%, 5%, and 1% levels. The coefficients of year dummies are not reported here.