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Boards: Does one size fit all?☆

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Abstract

This paper reexamines the relation between firm value and board structure. We find that complex firms, which have greater advising requirements than simple firms, have larger boards with more outside directors. The relation between Tobin's Q and board size is U-shaped, which, at face value, suggests that either very small or very large boards are optimal. This relation, however, arises from differences between complex and simple firms. Tobin's Q increases (decreases) in board size for complex (simple) firms, and this relation is driven by the number of outside directors. We find some evidence that R&D-intensive firms, for which the firm-specific knowledge of insiders is relatively important, have a higher fraction of insiders on the board and that, for these firms, Q increases with the fraction of insiders on the board. Our findings challenge the notion that restrictions on board size and management representation on the board necessarily enhance firm value.

JEL classification: G32; G34; K22

Keywords: Corporate governance; Directors; Board composition; Board size; Tobin's Q

1. Introduction

The board of directors of a corporation is meant to perform the critical functions of monitoring and advising top management. Conventional wisdom suggests that a greater level of board independence allows for more effective monitoring and improves firm performance. Several studies show how outside

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(non-management) directors on the board affect discrete tasks, including hiring and firing of the Chief Executive Officer (CEO) (Weisbach, 1988; Borokhovich, Parrino, and Trapani, 1996), adoption of anti-takeover devices (Brickley, Coles, and Terry, 1994), and negotiating takeover premiums (Byrd and Hickman, 1992; Cotter, Shivdasani, and Zenner, 1997).

A second factor perceived to affect the board's ability to function effectively is the size of the board. Lipton and Lorsch (1992) and Jensen (1993) suggest that larger boards could be less effective than smaller boards because of coordination problems and director free-riding. Yermack (1996) and Eisenberg, Sundgren, and Wells (1998) provide evidence that smaller boards are associated with higher firm value, as measured by Tobin's Q.

Collectively, these and similar studies have been interpreted as implying that smaller, outsider-dominated boards are optimal. For instance, TIAA-CREF, one of the largest pension funds in the world, has stated that it will invest only in companies that have a majority of outside directors on the board. Similarly, CALPERS, another large pension fund, recommends that the CEO should be the only inside (member of the management team) director on a firm's board (also see Jensen, 1993). The Sarbanes-Oxley Act of 2002 requires that the audit committee consist entirely of outside directors, and both the New York Stock Exchange and Nasdaq require listed firms to use a majority of independent directors on the board. It appears that such institutional and regulatory pressure has resulted in decreases over time in both average board sizes (Wu, 2004) and the representation of insiders on the board (Huson, Parrino, and Starks, 2001).

Nonetheless, many firms persist in having large boards and boards with high insider representation. As Hermalin and Weisbach (2003) ask: "Why hasn't economic Darwinism eliminated (these) unfit organizational form(s)?" Shouldn't one board structure fit all firms? One obvious response is to suggest that "inside and affiliated directors play valuable roles that may be lost in a single-minded drive for greater board independence" (Bhagat and Black, 2001). Along the same lines, McConnell (2002) urges caution in compelling companies to conform to a single model of board composition.

The purpose of this paper is to examine carefully both the reasoning and data behind the now-conventional wisdom that smaller and more independent boards are better boards. In particular, we argue that complex firms, such as those that are diversified, those that are large, and those that rely more on debt financing, have greater advising requirements. Because larger boards potentially bring more experience and knowledge and offer better advice (Dalton, Daily, Johnson, and Ellstrand, 1999), complex firms should have larger boards. In particular, such firms should have more outsiders on the board who then serve to provide advice and expertise to the CEO (Hermalin and Weisbach, 1988; Agrawal and Knoeber, 2001; and Fich, 2005). By contrast, firms for which the firm-specific knowledge of insiders is relatively important, such as R&D-intensive firms, are likely to benefit from greater representation of insiders on the board. Thus, such firms should have a higher fraction of insiders on the board.

If firms choose board structure to maximize firm value, if there are no transaction costs to altering board structure, and if suitable control variables are included in the regression specification, then there should be no observable relation between board structure and firm performance (Demstez and Lehn, 1985; Coles, Lemmon, and Meschke, 2006). If transaction costs are significant, however, firms could deviate from their optimal board structure. We argue that, under certain conditions, complex firms are likely to have smaller boards than optimal and that R&D-intensive firms are likely to have fewer insiders on the board than is optimal. If so, we argue in Section 2 that firm performance increases in board size in complex firms and in insider fraction in R&D-intensive firms.

We examine these hypotheses using a sample of 8,165 firm-year observations from Compact Disclosure and Investor Responsibility Research Center (IRRC) over the period 1992–2001. Consistent with our hypotheses, we find that complex firms (such as large firms, diversified firms, and high-debt firms) have larger boards and that this relation is typically driven by the number of outsiders. We find only weak evidence, however, that insider representation on the board is positively related to R&D intensity.

We also estimate performance-on-structure regressions similar to those in Yermack (1996), where the dependent variable is Tobin's Q. We find that the previously documented negative association between board size and Q does not hold for firms with extensive advising needs. We find that Q is positively associated with board size in complex firms. This relation appears to be driven by outside directors, the idea being that they provide valuable advice to the CEO and management team. Moreover, when firm-specific knowledge of insiders is relatively important, measured by R&D intensity in our analysis, Q is positively related to the fraction of insiders on the board. These results are robust to our best attempts to address endogeneity concerns.

Our findings add to the literature in at least three ways. First, we contribute to the literature on performance and board structure. Our evidence of a positive relation, for some important classes of firms, between Q and board size is new. So is our finding of a positive relation between Q and insider representation on the board in high-R&D firms. This latter finding builds on the results in Rosenstein and Wyatt (1997) and Klein (1998), while the former finding complements the results in Adams and Mehran (2003) for banks.[1] Our results cast doubt on the suggestion that smaller boards with a lower proportion of insiders are necessarily optimal for all firms. If prior evidence, such as that provided in Yermack (1996), is seen to provide a foundation for the notion that smaller and more independent boards necessarily are better boards, then our empirical design and results are instructive. A stronger interpretation is that, for certain types of firms, larger boards and less independent boards increase firm value.

We also add to the literature on the determinants of board structure. We find that complex firms (those with high advising needs) have larger boards and R&D-intensive firms have a larger fraction of insiders on the board. These results build on Hermalin and Weisbach (1988) and complement evidence in contemporaneous working papers, including Boone, Field, Karpoff, and Raheja (2007), Linck, Netter, and Yang (2007), and Lehn, Patro, and Zhao (2004).

Finally, our evidence suggests that boards play an important advisory role in certain types of firms. This supports recent findings in Adams and Ferreira (2007), Adams and Mehran (2003), and Agrawal and Knoeber (2001) regarding the advisory role of boards.

The remainder of the paper is arranged as follows. Section 2 discusses related literature and develops hypotheses. Section 3 describes the data, and Section 4 presents univariate results. Section 5 discusses determinants of board structure. Section 6 presents results relating Q to board structure. Section 7 discusses additional robustness tests. Section 8 concludes.

2. Prior literature and new hypotheses

In this section, we discuss related literature and develop our primary hypotheses. We start by noting that directors serve different functions. Non-management directors (outsiders) monitor top management and advise the CEO on business strategy, while management directors (insiders) formulate strategy and convey information about the firm to the outside directors (Mace, 1971; Lorsch and MacIver, 1989; Lipton and Lorsch, 1992; Jensen, 1993).

2.1. Advising needs, firm complexity, and board size

The monitoring role of the board has been studied extensively, and the general consensus is that smaller boards are more effective at monitoring. The argument is that smaller groups are more cohesive, more productive, and can monitor the firm more effectively, while larger groups are not good monitors because of problems such as social loafing and higher co-ordination costs (Lipton and Lorsch, 1992; Jensen, 1993). The results of Yermack (1996), who finds a negative relation between Q and board size, are interpreted by many to provide empirical support for this notion that smaller boards are better boards.[2]

The advisory role of the board, however, has received far less attention.[3] Dalton, Daily, Johnson, and Ellstrand (1999) argue that larger boards offer better advice to the CEO. Such advice is more likely to come from outsiders on the board. Various studies suggest that outsiders provide better advice. Dalton, Daily, Johnson, and Ellstrand (1999) argue that "(outside) directors provide a quality of advice to the CEO otherwise

[1]Rosenstein and Wyatt (1997) find that, in certain instances, addition of an insider to the board increases stock price. Klein (1998) finds that firm performance is positively related to the fraction of insiders on the investment and finance committee. Adams and Mehran (2003) find that Q is positively related to board size for banks.

[2]Also, Kini, Kracaw, and Mian (1995) provide evidence that board size is reduced following a disciplinary takeover.

[3]Exceptions include Klein (1998), Booth and Deli (1999), Agrawal and Knoeber (2001), Adams and Mehran (2003), and Adams and Ferreira (2007).

unavailable from corporate staff.'' Hermalin and Weisbach (1988) note that ''the CEO may choose an outside director who will give good advice and counsel, who can bring valuable experience and expertise to the board.'' Agarwal and Knoeber (2001) show that the proportion of outsiders with political expertise on the board is related to firms' need for political advice. Fich (2005) concludes that CEOs from other firms are sought as directors because of their ability to provide expert advice.

What kinds of firms require greater advice? Klein (1998) suggests complex firms have greater advisory needs. Firms can be complex along different dimensions, such as scope of operations, size, and the extent of reliance on external capital.

2.1.1. *Scope of operations*

Diversified firms operate in multiple segments and tend to be more complex (Rose and Shephard, 1997). Hermalin and Weisbach (1988) suggest that CEOs of diversified firms have greater need for advice. Yermack (1996) suggests that diversified firms are likely to have large boards because they require outside expertise for a greater number of industries. General Electric, a diversified company, serves to illustrate this point. The firm has a large and diverse board, with directors from the financial services, retail, tools and fasteners, automotive and industrial products, paper and packaging, and truck leasing industries.

2.1.2. *Firm size*

A related strand of literature, starting with Pfeffer (1972), suggests that boards are chosen to maximize the provision of important resources to the firm (see also Pfeffer and Salancik, 1978; Klein, 1998; Lynall, Golden, and Hillman, 2003). Klein (1998) suggests that advisory needs of the CEO increase with the extent to which the firm depends on the environment for resources. Larger firms are likely to have more external contracting relationships (Booth and Deli, 1996) and, thus, require larger boards (Pfeffer, 1972). For example, in the defense industry, John Shalikashvili, the retired chairman of the Joint Chiefs of Staff, and Rozanne Ridgway, former assistant secretary of state for Europe and Canada, are both on the board of Boeing. Similarly, the board of Gulfstream Aerospace at one time included Henry Kissinger, Donald Rumsfeld, and Colin Powell as directors. Most likely these directors were selected not for monitoring, but for their ability to provide advice in obtaining defense contracts.

2.1.3. *Leverage*

Firms with high leverage depend on external resources to a greater extent and could have greater advising requirements (Pfeffer, 1972; Klein, 1998). Booth and Deli (1999) find that commercial bankers on corporate boards serve to provide expertise on the market for bank debt. Guner, Malmendier, and Tate (2005) find that both commercial and investment bankers on the board enhance access to external finance.

Diversification, firm size, and leverage are all proxies for complexity and the CEO's need for advice. As firm complexity increases along any of these dimensions, so, too, does the need for a bigger board.[4] To extract this unobserved complexity factor, we use the method of factor analysis. Factor analysis serves to reduce the dimensionality of the variables. Further, using a single complexity factor score instead of the three variables individually increases the power of the regression-based tests by circumventing difficulties arising from multi-collinearity.

In a similar manner to other studies that have used factor analysis (Guay, 1999; Gaver and Gaver, 1993), for each firm-year observation in our sample, we compute a factor score based on the number of segments, log(sales), and leverage. The factor score for a firm-year observation is a linear combination of the transformed (to standard normal) values of these three variables. We term the resulting factor score as ADVICE because it increases in firm complexity and hence in the firm's need for advice. As expected, ADVICE is positively related to the number of segments, log(sales), and leverage. In our sample, firms that have a high factor score include General Electric, ITT Industries, and Boeing, which are typically viewed as

[4]Outside consultants can provide similar advisory services without being on the board. Why should the management team rely on outside directors for advice instead of consultants? Casamatta (2003) argues that there are significant costs to aligning the incentives of outside consultants. In contrast, outside directors often are compensated with restricted stock and stock options, face potential liability from litigation, and face reputational effects in the labor market (Fama, 1980; Coles and Hoi, 2003).

complex firms. Firms with above-median factor score are termed "complex" and those below median are termed "simple" (for want of a better word).

The above discussion leads to Hypothesis 1:

Hypothesis 1. Complex firms will have larger boards and more outside directors than simple firms.

2.2. Firm-specific knowledge, R&D intensity, and board composition

There has been a general push, led by institutions, regulators, and legislators, toward more independent boards. Several factors, however, support placing insiders on the board. Inside directors possess more firm-specific knowledge (Fama and Jensen, 1983) and, thus, are helpful in firms operating in uncertain environments (Williamson, 1975). Insiders with specific knowledge are better positioned to select appropriate strategies (Baysinger and Hoskisson, 1990; Fama, 1980). We use R&D intensity to proxy for the importance of such firm-specific knowledge. This is consistent with studies (e.g., Raheja, 2005) suggesting that firms with high project verification costs (such as R&D-intensive firms) benefit from having more insiders on the board.

In related work, Burkart, Gromb, and Panunzi (1997) state that it could be optimal to reduce monitoring and cede discretion to the management team in firms in which the manager's initiative leads to higher value. Managerial initiative is likely to be a critical determinant of firm value in R&D-intensive firms. If the fraction of outsiders is correlated with monitoring intensity, we expect high-R&D firms to be monitored less and, hence, all else equal, to have a higher fraction of insiders on the board. Even absent these arguments, monitoring R&D-intensive firms requires more firm-specific knowledge. Thus, in such firms, having higher fraction of outsiders on the board does not necessarily improve the effectiveness of monitoring. The above arguments lead to Hypothesis 2.

Hypothesis 2. High-R&D firms will have a higher fraction of insiders on the board.

2.3. Board structure and firm performance

While the literature on board size predominantly suggests that smaller boards perform better (Yermack, 1996), evidence on the relation between board composition and performance is mixed. Weisbach (1988), Borokhovich, Parrino, and Trapani (1996), Brickley, Coles, and Terry (1994), Byrd and Hickman (1992), and Cotter, Shivdasani, and Zenner (1997) find that more independent boards add value in some circumstances. Baysinger and Butler (1985), Hermalin and Weisbach (1991), and Bhagat and Black (2001) find no relation between the fraction of outside directors on the board and Tobin's Q. Yermack (1996) and Agrawal and Knoeber (1996) find a negative relation between the fraction of outside directors and Tobin's Q, and Rosenstein and Wyatt (1997) and Klein (1998) find that insiders add value.

The question arises as to whether standard empirical designs that regress performance on firm structure are informative. Often the answer is no, with the difficulty being that such designs typically do not solve the standard endogeneity and causation problems. For example, if shareholders are free to costlessly adjust organization form to maximize value, there would be no reason to observe an empirical relation between two endogenous variables (see Demsetz and Lehn, 1985, and Coles, Lemmon, and Meschke, 2006, among others), such as performance and board structure. That is, in a properly specified model, including on the right-hand side the underlying determinants of both the dependent variable and an endogenously determined independent variable would reduce or eliminate any ability to detect such a relation between the two variables.

We provide two illustrative models that address such difficulties. Both models predict a nontrivial relation between Q and board structure. Our first model relies on transaction cost based departures from optimal board structure. We also develop a second model, with negligible transactions costs, in which the data would be interpreted as tracing an envelope of optimal board structure and jointly determined performance. We focus here on developing the logic for the first model and defer description of the second model to Appendix A.

For ease of exposition, we assume that there are only two kinds of firms. To streamline our presentation, we concentrate primarily on simple versus complex firms, but similar arguments apply to low-R&D versus high-R&D firms as well. Suppose a hump-shaped function between Q and board size holds for both simple

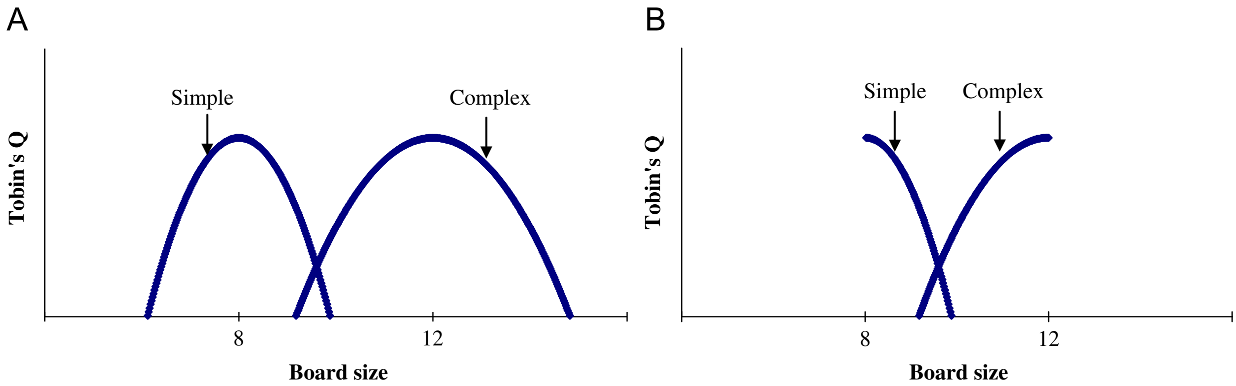

Fig. 1. Transaction costs-based model that provides a basis for the relation between Q and board structure. The figure presents hypothetical data based on a transaction costs-based model. We use board size to illustrate our point although similar arguments could be made for board composition. In this world, there are two types of firms, simple and complex, each having distinct optimal board sizes. In Panel A, transaction costs are significant and hence deviations from optimal board size are likely to be permanent. Assume that the deviations are random. The locus of points represents the objective function that firms maximize in the absence of transaction costs. In Panel B, transaction costs are still significant and deviations from optimal board size are likely to be permanent. Now, however, assume that the deviations are not random. Specifically, if simple firms have larger than optimal boards and complex firms have smaller than optimal boards, then only a part of the objective function is observed (left of the peak for complex and right of the peak for simple).

and complex firms and the unique maximum occurs for simple firms at board size of, say, 8, and for complex firms at 12. Also assume that book assets is predetermined so that maximizing value (or surplus net of initial investment) is tantamount to maximizing Q.

Now, consider a world in which there are transaction costs to changing board structure. There are likely to be long-lived deviations from optimal board size when the transaction costs of altering board structure exceed the benefits (as represented by a move to the maximum). If deviations from optimal board size are random, because any deviation from optimal board size is detrimental to firm value, the data would trace a hump-shaped relation between board size and Q for both complex and simple firms. As depicted in Panel A of Fig. 1, the location of the relation differs by type of firm. But for both types of firms, simple and complex, the data and corresponding figures represent the objective functions that firms would maximize in the absence of substantial impediments/costs.

Suppose now that deviations from optimal board size are not random. Specifically, if simple firms have larger boards than optimal and complex firms have smaller boards than optimal, we would observe only the part of the hump-shaped relation that is to one side of the optimum (Panel B of Fig. 1). This picture suggests that if there are long-lived deviations from optimal board size as described here, Q should be negatively related to board size for simple firms and positively related to board size for complex firms.

Why would simple firms tend to have larger boards than optimal and complex firms have smaller boards than optimal? Transaction costs are a possibility, but what are the transaction costs that hinder simple (complex) firms from downsizing (upsizing) their board sizes quickly? We consider possible candidates below. While we make our arguments using board size, arguments in the same style would also apply to board composition.

Firms switch from simple to complex or vice versa (about 9% of our sample firm-years). For example, a focused firm could diversify, which would then imply an increase in the optimal board size.[5] If the newly diversified firm, however, increases board size either slowly or not at all (because of transaction costs) toward the new optimum, then we would observe a positive relation between board size and Q. Similarly, if a diversified firm decides to refocus, then the optimal board size decreases. If it takes time for the newly focused

[5]Similar arguments would apply for other aspects of complexity. As firms evolve, they grow bigger, becoming more complex. Likewise, changes in profitability, maturity, and firm risk could lead to changes in debt requirements, leading to changes in firm complexity.

firm to decrease the board size to the new optimum, then we would observe a negative relation between board size and Q for focused firms.

For newly simple firms, four transaction and contracting costs potentially impede downsizing. (1) The structure of board election processes (e.g., staggered board) can impede downsizing. (2) In bringing a director on to the board, the firm establishes an implicit contract with that director that he will not be fired unless he performs poorly. Removing a director for non-performance-related reasons (i.e., purely for downsizing reasons) could affect the firm's reputation as it pertains to honoring implicit contracts, making it more difficult for the firm to attract other qualified directors in future. (3) The CEO can face personal costs to firing a board member with whom he has built a professional and personal relationship. For firms in the IRRC database, the average incumbent director has served for 9 years. CEOs personally could find it difficult to dismiss someone they have worked with for such a long period of time. (4) Legal costs could be incurred for firing a director before his or her term is complete. In this case, the firm would first have to identify the director who is to be let go, and then wait until his or her term is over to downsize the board. This could delay a value-increasing downsizing. Consistent with these arguments, Dahya, McConnell, and Travlos (2002) and Linck, Netter, and Yang (2005) find that firms increase board independence (in response to the Cadbury committee recommendations and the Sarbanes–Oxley regulations, respectively) by adding outside directors instead of by removing inside directors.

For newly complex firms, at least three transaction costs impede upsizing. (1) Political pressure for one-size-fits-all boards arises from listing requirements, institutional investors, business groups (Conference Board, Business Roundtable), purveyors of corporate governance indices (e.g., Institutional Shareholder Services), the business press, regulators, politicians, and academia (e.g., Lipton and Lorsch, 1992; Jensen, 1993). For instance, Wu (2004) attributes the reduction in board size in the 1990s to institutional pressure. (2) It could take time for the firm to identify board members who have the requisite skills. (3) The dollar cost associated with adding a board member could be a deterrent, though such costs appear to be modest. Yermack (2004) estimates that the average director compensation from all sources is about \$100,000. The present value of such costs for a single director, even if they grow, is likely to be less than \$2 million. The cost of using a search firm to identify and recruit a new director can be as large as \$300,000. If a board slot requires a search for a director to fill that seat only once every 9 years, the present value of search costs for the incremental board slot seems to be small. Management and director time could be the largest component of search costs.

The arguments above suggest that, in the presence of transaction costs that reduce a firm's ability to adjust its board structure quickly, there should be a detectable relation between board structure and performance. Specifically, our arguments give rise to Hypotheses 3 and 4.

Hypothesis 3. Tobin's Q increases in board size for complex firms.

Hypothesis 4. Tobin's Q increases in the fraction of insiders on the board for high-R&D firms.

3. Data and summary statistics

We start with firms on Execucomp because this database has readily available data on CEO characteristics such as age, ownership, and tenure. We obtain board data for these firms from Compact Disclosure for the years 1992–1997 and from IRRC for the years 1998–2001. Compact Disclosure gives the name, age, and designation of both officers and directors, obtained from the company's proxy statements. If no proxy date is specified, we cannot align the data, in which case we delete the observation. We cross-check Compact Disclosure information with the proxy statements (using Lexis–Nexis) for one thousand randomly selected firm-year observations. We also perform the check for all cases in which board size exceeded 16 or was smaller than 5 (essentially, the top and bottom 5% of the distribution of board size) and when board size changed by three or more slots in 1 year. In the few cases in which there is disagreement, we use the information from the proxy statement. We obtain financial data and segment information on firms from Compustat. In 1998 the Financial Accounting Standards Board (FASB) changed the segment reporting requirements. Therefore, for segment data after 1998, we use the methodology suggested in Berger and Hann (2003) to classify firms as single-segment or multi-segment.

While IRRC provides detailed information on affiliation of directors, Compact Disclosure identifies only whether the director is an officer of the firm. Thus, we cannot differentiate among the various types of affiliated (or grey) directors. Fortunately, such a distinction is not required to test our hypotheses. Independent directors generally are viewed as effective monitors and also serve an advisory role. Affiliated directors (such as legal counsel and investment bankers) generally are not viewed as effective monitors because of conflicts of interest but, nevertheless, also serve an advisory role (Klein, 1998; Booth and Deli, 1996). Our hypotheses relate to the advisory role of boards. Thus, as is common on the literature, we classify all directors who are officers of the company as insiders and combine affiliated and independent directors as outsiders (see Borokhovich, Parrino, and Trapani, 1996; Huson, Parrino, and Starks, 2001; Lehn, Patro, and Zhao, 2004).

Our measure of board composition is the fraction of insiders on the board. Generally we measure board size by the number of directors on the board. In some cases, based on the idea that the extra value of a larger board is the advice and external resources provided by outside directors, we use the number of outsiders. As a measure of firm value, we approximate Tobin's Q as book assets minus book equity plus market value of equity all divided by book assets. This calculation is consistent with much of the literature. Because we do not have data on replacement cost of assets or market value of debt, it is only an approximation. But our measure does avoid the ad hoc assumptions about depreciation and inflation rates that some other measures of Q require. Our approximation is likely to be highly correlated with actual Q. Chung and Pruitt (1994) find that this proxy explains at least 96.6% of the variability of the Tobin's Q of Lindenberg and Ross (1981).

The sample consists of 8,165 firm-year observations. Table 1 presents summary statistics on board structure and firm and CEO characteristics. Appendix B provides more detailed definitions of the variables. The median

Table 1
Summary statistics

The sample consists of 8,165 observations on Execucomp firms from 1992 to 2001. Board data are taken from Compact Disclosure and from Investor Responsibility Research Center (IRRC). Accounting and segment data are from Compustat. *Board size* is the number of board members. *Insiders* is the number of employee directors. *Outsiders* is board size less insiders. *Insider fraction* is the ratio of number of insiders to board size. *Tobin's Q* is the ratio of market value of assets to book value of assets. *Segments* is the number of business segments in which the firm operates. *Leverage* is the ratio of book value of total debt to book value of assets. *R&D intensity* is the ratio of research and development (R&D) expenditure to book value of assets. *Risk* is standard deviation of daily excess returns. *ROA* is the ratio of earnings before interest, taxes, depreciation, and amortization to book value of assets. *Intangible assets* is one minus the ratio of net property, plant, and equipment to book value of assets. *Free cash flow* is the ratio of operating cash flow less preferred and equity dividend payments to the book value of assets. *Firm age* is the number of years since the first trading date on CRSP. All variables are winsorized at the 5th and 95th percentile values.

	Mean	Median	25th percentile	75th percentile
Board characteristic				
Board size	10.4	10.0	8.0	12.0
Insiders	2.2	2.0	1.0	3.0
Outsiders	8.1	8.0	6.0	10.0
Insider fraction	0.22	0.20	0.13	0.29
Firm characteristic				
Tobin's Q	1.79	1.41	1.13	2.06
Sales (millions of dollars)	4120	1839	878	4749
Segments	2.6	2.0	1.0	4.0
Leverage	0.246	0.249	0.126	0.358
R&D intensity	0.019	0.000	0.000	0.022
Risk (percent)	2.6	2.4	1.7	3.3
ROA	0.138	0.134	0.088	0.186
Intangible assets	0.677	0.722	0.507	0.867
Free cash flow	0.082	0.076	0.040	0.119
Firm age (years)	28.1	25.0	11.0	39.5
CEO characteristic				
CEO tenure (years)	6.6	5.0	2.0	10.0
CEO age (years)	55.3	56.0	51.0	60.0
CEO ownership (percent)	1.85	0.27	0.08	1.25

board has ten members, with two insiders and eight outsiders. The median insider fraction is 0.20. These numbers are similar to those in other recent studies. For example, Bhagat and Black (2001) report a median board of 11 members with 3 insiders using data for the year 1991. Huson, Parrino, and Starks (2001) find that, for the period 1989–1994, the median board size is 12, with median insider fraction of 0.21. Yermack (1996) finds that, over the period 1984–1991, the median sample firm has 12 board members with an insider fraction of 0.33.

The median firm in our sample has sales of $1.8 billion. For 62% of the firm-year observations the firm operates in more than one business segment, in which case we say that the firm is diversified. The median number of segments is two. Median leverage is 0.25 and only 40% of the firms have non-zero R&D expenditures. Mean CEO ownership of 1.85% (median = 0.27%) is comparable with other studies, such as Bhagat and Black (2001), that examine large firms. Because we use Execucomp, our sample includes relatively large firms, so CEO ownership in our sample is lower than in studies such as Denis and Sarin (1999) and Holderness (2006), that use a more representative sample of firms.

4. Univariate results

To provide an initial assessment of our hypotheses, we compare board structures across various subsamples of firms. Table 2 presents the results. Panel A indicates that board size is 24% higher for complex firms compared with simple firms (11.3 versus 9.1, $p<0.01$). The difference in board size between simple and complex firms is the result of the higher number of outsiders on the board of complex firms (9.1 versus 6.9, $p<0.01$). These results are consistent with Hypothesis 1 that firms with greater advising needs require larger boards and, specifically, more outsiders.

Hypothesis 2 is that R&D-intensive firms have a higher fraction of insiders on the board. To capture R&D intensity, we define all firms that have R&D to assets ratio greater than the 75th percentile (R&D to assets = 0.022) in a given year as high-R&D (or R&D-intensive) firms. We choose the 75th percentile because R&D expenses are skewed, with 60% of the observations having zero R&D. Contrary to our expectation, in Panel B, insider fraction is similar (0.22) across high-R&D and low-R&D firms ($p = 0.37$).

We now provide evidence relating to Q. We sort firms each year based on whether they have a board size that is above the median (large boards) or below the median (small boards) and whether they have an insider fraction that is above-median or below-median. Panel C of Table 2 indicates that, for complex firms, Q is higher for firms with large boards (average $Q = 1.69$) compared with firms with small boards (1.57). This is consistent with Hypothesis 3. For simple firms, we find the opposite: On average, Q is higher for firms with small boards (2.06) compared with those with large boards (1.86). In both cases, this difference is statistically significant ($p<0.01$). We get similar results when we use number of outsiders on the board instead of board size.

Panel D of Table 2 indicates that, for both low-R&D and high-R&D firms, Q is higher for firms that have high insider fraction. The difference in Q between the high and low insider fraction groups is, however, greater for high-R&D firms (2.54–2.27 = 0.27) than for low-R&D firms (1.69–1.49 = 0.20). This suggests that high-R&D firms benefit more from increasing the representation of insiders on the board, which would be consistent with Hypothesis 4, but the difference of 0.07 (= 0.27–0.20) is not significantly different from zero ($t = 1.38$).

5. Multivariate results: determinants of board structure

While the results above are generally consistent with our hypotheses, the analysis does not control for other determinants of board structure and Q. In this section, we extend our analysis to a multivariate setting. We rely on important prior contributions, such as Hermalin and Weisbach (1988), Denis and Sarin (1999), Bhagat and Black (2001), and Baker and Gompers (2003), for guidance on control variables.

Our multivariate specifications are estimated using ordinary least squares (OLS). We use two approaches to address the difficulties associated with outliers in the data. First, we winsorize all variables at the 5th and 95th percentile values. The results are qualitatively similar if we winsorize all variables at the 1st and 99th percentile values. Second, here and throughout, we also estimate each regression model using the least absolute deviation

Table 2
Univariate results

Panel A reports the means of board size for firms based on whether they have high or low advising needs, while Panel B reports the means of board composition for firms based on whether they have high or low research and development (R&D). Panels C and D report the mean Tobin's Q for these two groups. We compute a factor score based on number of business segments, firm size, and leverage to capture the intensity of advising needs. Complex firms are those with high advising needs and have above-median factor score. Simple firms are those with low advising needs and have below median-factor score. High-R&D (low-R&D) firms have above (below) 75th percentile ratio of R&D intensity. Large (small) boards are firms with board sizes greater (less) than the median values. Large (small) insider fraction are firms whose insider fraction is greater (less) than the median values. Fractile values are computed separately for each year. Absolute values of t-statistics are reported and are based on two-sided t-tests of difference in means.

Panel A: Do complex firms have larger boards and more outsiders on the board?

	Board size	Outsiders	Insiders
Complex firms (high-advising needs)	11.3	9.1	2.2
Simple firms (low-advising needs)	9.1	6.9	2.2
t-statistic	(38.5)	(42.1)	(0.2)

Panel B: Do high-R&D firms have higher fraction of insiders on the board?

	Insider fraction
High-R&D firms	0.22
Low-R&D firms	0.22
t-statistic	(0.88)

Panel C: Does Tobin's Q increase in board size for complex firms?

	Large board	Small board	t-statistic
Complex firms (high-advising needs)	1.69	1.57	(4.3)
Simple firms (low-advising needs)	1.86	2.06	(5.0)

Panel D: Does Tobin's Q increase in the fraction of insiders on the board for high-R&D firms?

	Large insider fraction	Small insider fraction	t-statistic
High-R&D firms	2.54	2.27	(5.5)
Low-R&D firms	1.69	1.49	(10.5)

criterion (instead of least squares) with respect to departures from the median (as in Gompers, Ishii, and Metrick, 2003a, b). We denote these as median regressions in the text and the tables.

Throughout, we report t-statistics based on robust standard errors. As in most studies using panel data, the standard errors could be biased because the contemporaneous residuals are correlated across firms. We approach this issue using several different methods. In particular, we use year and industry (two-digit standard industrial classification (SIC)) dummy variables throughout and implement least absolute deviation regressions in addition to OLS. Also, for the OLS regressions, we implement the procedure of Fama and MacBeth (1973), estimate bootstrapped standard errors, and estimate robust standard errors that also are adjusted for clustering within firms. Our results are robust to these various alternative estimation techniques. Section 7 provides more detail on our robustness tests, including endogeneity corrections using simultaneous systems of equations.

5.1. Determinants of board size

While the determinants of insider representation on the board have been studied extensively, there is limited evidence on factors affecting board size. We argue that CEOs of diversified firms, larger firms, and high-debt

Table 3
Do complex firms have larger boards and more outsiders on the board?

The dependent variable is either log of board size (Models 1, 2) or log of outsiders on the board (Models 3, 4). We compute a factor score based on number of business segments, firm size, and leverage. ADVICE dummy equals one if this factor score is greater than the median value and zero otherwise. Absolute values of t-statistics based on robust standard errors are reported in parentheses, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Dependent variable:			
	log(board size)		log(outsiders)	
Independent variables	Model 1 OLS	Model 2 Median	Model 3 OLS	Model 4 Median
ADVICE dummy	0.118***	0.123***	0.163***	0.179***
	(18.9)	(15.6)	(20.9)	(20.8)
R&D dummy	0.003	−0.007	0.035***	0.021*
	(0.3)	(0.6)	(3.3)	(1.8)
Log(firm age)	0.082***	0.087***	0.098***	0.105***
	(21.0)	(17.8)	(20.1)	(19.8)
Log(CEO tenure)	−0.011***	−0.012***	−0.018***	−0.018***
	(5.3)	(4.8)	(7.1)	(6.7)
Log(CEO age)	0.152***	0.210***	0.085**	0.098***
	(5.4)	(6.2)	(2.4)	(2.7)
Risk	−0.036***	−0.041***	−0.045***	−0.045***
	(10.6)	(9.6)	(10.6)	(9.7)
ROA	0.096	0.079	0.045	0.066
	(1.2)	(0.8)	(0.4)	(0.6)
ROA_{t-1}	−0.064	−0.093	−0.107	−0.073
	(0.7)	(0.8)	(1.0)	(0.6)
ROA_{t-2}	−0.024	−0.052	−0.114	−0.182*
	(0.3)	(0.6)	(1.2)	(1.8)
Free cash flow	−0.132**	−0.051	−0.110	−0.039
	(2.1)	(0.6)	(1.3)	(0.4)
Intangible assets	−0.018	−0.003	−0.061**	0.007
	(0.8)	(0.1)	(2.3)	(0.2)
Intercept, industry, and year dummies	Yes	Yes	Yes	Yes
Number of observations	5,833	5,833	5,830	5,830
R^2 (Pseudo-R^2)	44%	28%	44%	26%

firms require more advice. Such firms, therefore, require larger boards. As a new explanatory variable, we use a dummy variable, ADVICE dummy, which captures firm complexity. ADVICE dummy equals one if the firm is complex (that is, it has above median complexity factor score) and equals zero otherwise.

Using the dummy variable in this manner allows us to easily assess the economic impact of complexity on board size and to graphically represent the economic impact of board size on Q (in Section 6) for complex firms. Nevertheless, here and throughout, we also replicate all regression specifications using the corresponding continuous measures. That is, we use the underlying factor score (ADVICE) instead of the ADVICE dummy. Similarly, we replace the factor score by its individual components, firm size, diversification level, and debt. We obtain similar inferences in all cases (see Sections 7.4 and 7.5).

Table 3 presents estimates from regressions of log(board size) on ADVICE, as well as control variables.[6] For both OLS (Model 1) and median regressions (Model 2), the estimated coefficient on ADVICE is significantly positive ($p<0.01$). The parameter estimates indicate that board size is about 12% larger for

[6]We use log(board size) and log(outsiders) to be consistent with the literature. Here and throughout, we obtain similar results if we use board size and number of outsiders instead.

complex firms. These results are consistent with our hypothesis that firms that with greater advisory needs require larger boards.

In terms of control variables, we find that the coefficients on firm age and CEO age are significantly positive, while that on CEO tenure is significantly negative. These results are consistent with Denis and Sarin (1999) and Baker and Gompers (2003). In contrast to these two studies, which find an insignificant relation, our coefficient on firm risk is significantly negative.

Models 3 and 4 estimate similar regressions with the dependent variable being log(outsiders). We obtain similar inferences. Firms with greater advisory requirements have 16–18% more outsiders on the board, consistent with our hypothesis that such outside board members play an important advisory role.[7]

5.2. Determinants of board composition

Our hypothesis is that R&D-intensive firms have a higher fraction of insiders. For the reasons mentioned in Section 5.1, we use the R&D dummy as the main independent variable. In Section 7, we discuss the robustness of our results to using R&D scaled by assets instead of the R&D dummy.

Table 4 reports the results. Contrary to our expectation, R&D intensity is negatively related to insider fraction in Model 1 (but not in Model 2). We find that insider fraction is positively related to CEO age, CEO ownership, and profitability, consistent with Hermalin and Weisbach (1988, 1998), but is unrelated to CEO tenure. As in Denis and Sarin (1999), we find that bigger firms have a lower fraction of insiders. Finally, insider fraction increases in risk and intangible assets but is unrelated to free cash flow.[8]

To sum up, the evidence supports our hypothesis that firms with greater advising requirements require more directors on the board, specifically more outsiders. We do not find, however, that R&D-intensive firms have higher insider representation on the board.

These findings should be placed in the context of three contemporaneous, related papers, Boone, Field, Karpoff, and Raheja (2007), Lehn, Patro, and Zhao (2004), and Linck, Netter, and Yang (2007). Boone, Field, Karpoff, and Raheja (2007) examine the evolution of corporate boards over the 10-year period following firms' initial public offerings. They find that corporate boards increase in size and add more outsiders as operations of a firm expand, which supports our complexity hypothesis. Lehn, Patro, and Zhao, using a sample of 81 firms that survived over the period 1935–2000, find that board size is positively related to firm size and insider representation is positively related to proxies for growth opportunities. Our evidence supports the first of these results, but we find little to support or contradict the second. Finally, Linck, Netter, and Yang (2007) also find that large firms have large boards with more outside directors, which is consistent with our complexity hypothesis.

6. Multivariate results: effect of board structure on Q

We now explore the relation between board size and insider fraction on Tobin's Q for various types of firms. We first attempt to replicate the results on board size and Q in Yermack (1996) using a similar specification in our full sample.[9] Our results (not reported here) on all the control variables generally are similar to those in Yermack. More important, as in Yermack (1996), we find that Q decreases in board size. Panel A of Fig. 2

[7]For all models in Table 3, we repeat the analysis including a dummy variable indicating whether the firm acquired another firm in the current or previous year. This is because boards of acquiring firm could be temporarily large until any restructuring or refocusing activity is completed. Our main results remain. The coefficient estimates indicate that recently merged firms have boards that are 4–6% larger.

[8]For robustness, we use two alternative proxies for the CEO's retirement age. (1) As in Baker and Gompers (2003), we form an indicator variable that equals one if the CEO is over 60 years old and equals zero otherwise. (2) Because Weisbach (1988) suggests that voluntary resignations are more likely when the CEO is between 64 and 66 years of age, we form an indicator variable that equals one if the CEO's age is in this range and equals zero otherwise. The regression results for both board size and board composition are robust to including either of these dummy variables instead of the continuous variable for CEO age.

[9]The independent variables are log(board size), fraction of insiders, number of business segments, firm size, contemporaneous, 1-year lagged, and 2-year lagged return on assets, intangible assets, CEO ownership, and year and two-digit SIC dummies.

Table 4
Do high-research and development (R&D) firms have higher fraction of insiders on the board?

The dependent variable is the fraction of insiders on the board. R&D dummy equals one if the firm's R&D intensity is greater than the 75th percentile value and zero otherwise. Absolute values of t-statistics based on robust standard errors are reported in parentheses, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Dependent variable: Insider fraction	
Independent variables	Model 1 OLS	Model 2 Median
R&D dummy	−0.015***	−0.007
	(3.7)	(1.3)
Firm size	−0.011***	−0.010***
	(9.2)	(5.8)
Leverage	−0.033***	−0.030**
	(3.2)	(2.3)
Log(firm age)	−0.008***	−0.006**
	(4.6)	(2.4)
Log(CEO tenure)	0.001	−0.000
	(1.3)	(0.2)
Log(CEO age)	0.060***	0.073***
	(4.8)	(4.6)
CEO ownership	0.006***	0.008***
	(14.2)	(15.9)
Risk	0.005***	0.005***
	(3.5)	(2.8)
ROA	0.059	0.084*
	(1.6)	(1.8)
ROA_{t-1}	0.011	0.053
	(0.3)	(1.0)
ROA_{t-2}	0.052	0.050
	(1.6)	(1.2)
Free cash flow	−0.022	−0.045
	(−0.8)	(−1.2)
Intangible assets	0.024**	0.008
	(2.4)	(0.6)
Intercept, industry and year dummies	Yes	Yes
Number of observations	6,510	6,510
R^2	24%	14%

illustrates the estimated relation between board size and Q, where board size is on the x-axis and predicted Q on the y-axis. Predicted Q is based on the estimated regression coefficients with the control variables held at the means.

6.1. Effect of board size on Q: complex versus simple firms

Based on the extensive literature on the ostensible determinants of Q, we augment Yermack's specification with leverage, stock-return volatility, and R&D (see Morck, Shleifer, and Vishny, 1988; McConnell and Servaes,1990; Yermack, 1996; Himmelberg, Hubbard, and Palia, 1999; Demsetz and Villalonga, 2001; Coles, Lemmon, and Meschke, 2006). Our specification for investigating Hypothesis 3 is

$$Q = \beta_0 + \beta_1 Log(Board\ \ Size) + \beta_2 Log(Board\ \ Size) \times ADVICE\ \ dummy + \gamma\ \ Fraction\ \ Insiders + \delta\ \ ADVICE\ \ dummy + Controls, \tag{1}$$

β_1 captures the effect of board size on Q for simple firms. β_2 is the incremental effect of board size on Q for complex firms, while $\beta_1 + \beta_2$ is the total effect of board size on Q for complex firms. As per Hypothesis 3, both β_2 and $\beta_1 + \beta_2$ should be positive.

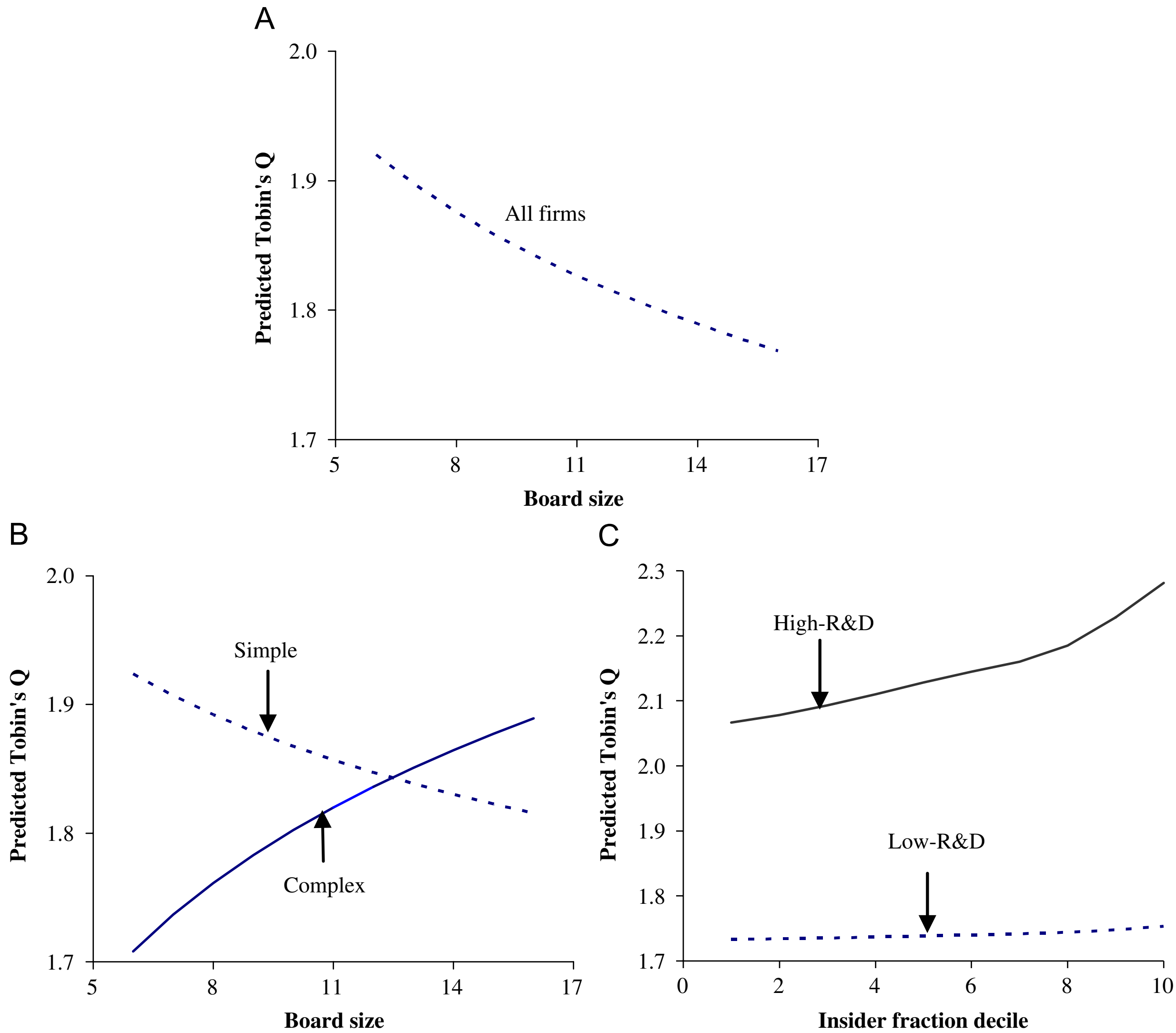

Fig. 2. Effect of board structure on Tobin's Q for different types of firms. The predicted Tobin's Q is along the y-axis and board structure is along the x-axis. Panel A is based on a specification similar to Yermack, 1996 (see footnote 9). Panels B and C are based on Model 1 of Table 5 and Model 1 of Table 6. Tobin's Q is the ratio of market value of assets to book value of assets. In Panel B, complex (simple) firms are those with high (low) advising needs. Specifically, these firms have factor scores that are above (below) median values, where the factor score is computed based on business segments, firm size, and leverage. In Panel C, high (low) R&D firms are those whose research and development (R&D) intensity is greater (less) than the 75th percentile values. Firms are categorized into ten deciles based on the fraction of insiders on the board, where decile one (ten) consists of firms with the lowest (highest) fraction.

Table 5 reports the results for the above specification. In Model 1, we find that the coefficient on board size is significantly negative ($\beta_1 = -0.110$; $p = 0.05$). β_2 is significantly positive (0.295, $p<0.01$), implying that the negative effect of board size on Q for simple firms is more than offset for complex firms. The effect of board size on Tobin's Q for complex firms is positive and significant ($\beta_1+\beta_2 = 0.185$; $p<0.01$; see last row of Table 5). For complex firms, therefore, Q is increasing in board size, even after controlling for the insider fraction. These results are consistent with Hypothesis 3 that complex firms with high advising requirements, both relative to simple firms and in absolute terms, benefit from having a larger board.

The coefficient of 0.185 ($\beta_1+\beta_2$) indicates that if the board size increases by one (by about 10%, given the average board size of 10.4), Q increases by 1.6% relative to the mean Q of a complex firm. Similarly for a

Table 5
Does Tobin's Q increase in board size and the number of outsiders on the board for complex firms?

Tobin's Q is defined as the ratio of market value to book value of assets. We compute a factor score based on number of business segments, firm size, and leverage. ADVICE dummy equals one if this factor score is greater than the median value and zero otherwise. R&D dummy equals one if the firm's research and development (R&D) intensity is greater than the 75th percentile value and zero otherwise. Absolute values of t-statistics based on robust standard errors are reported in parentheses, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

		Dependent variable: Tobin's Q			
Independent variables		Model 1 OLS	Model 2 Median	Model 3 OLS	Model 4 Median
Log(board size)	β_1	-0.110^{**}	-0.024		
		(2.0)	(0.8)		
Log(board size) × ADVICE dummy	β_2	0.295^{***}	0.176^{***}		
		(4.4)	(4.3)		
Log(outsiders)	β_3			-0.089^{*}	-0.003
				(1.8)	(0.1)
Log(outsiders) × ADVICE dummy	β_4			0.242^{***}	0.144^{***}
				(4.4)	(4.6)
Insider fraction		0.187^{**}	0.152^{***}	0.209^{*}	0.234^{***}
		(2.1)	(3.0)	(1.9)	(4.1)
ADVICE dummy		-0.744^{***}	-0.430^{***}	-0.560^{***}	-0.322^{***}
		(4.7)	(4.5)	(4.9)	(4.9)
R&D dummy		0.393^{***}	0.239^{***}	0.396^{***}	0.242^{***}
		(13.7)	(15.6)	(13.7)	(17.0)
Risk		0.146^{***}	0.074^{***}	0.147^{***}	0.073^{***}
		(13.0)	(12.7)	(13.0)	(13.5)
ROA		6.774^{***}	5.674^{***}	6.756^{***}	5.638^{***}
		(25.2)	(44.1)	(25.1)	(47.1)
ROA_{t-1}		1.351^{***}	1.243^{***}	1.357^{***}	1.207^{***}
		(4.2)	(7.8)	(4.2)	(8.1)
ROA_{t-2}		0.955^{***}	1.075^{***}	0.957^{***}	1.143^{***}
		(3.6)	(8.2)	(3.7)	(9.4)
Intangible assets		1.154^{***}	0.795^{***}	1.150^{***}	0.781^{***}
		(17.0)	(20.4)	(17.0)	(21.5)
CEO ownership		0.003	0.001	0.002	0.001
		(0.9)	(0.7)	(0.9)	(1.0)
Intercept, industry and year dummies		Yes	Yes	Yes	
Number of observations		6,794	6,794	6,791	6,791
R^2 (Pseudo-R^2)		55%	33%	55%	33%
F-test: effect of board size on Q for complex firms		$\beta_1+\beta_2=0.185^{***}(p<0.01)$	$\beta_1+\beta_2=0.152^{***}$ $(p<0.01)$		
F-test: effect of outsiders on Q for complex firms				$\beta_3+\beta_4=0.153^{***}(p<0.01)$	$\beta_3+\beta_4=0.141^{***}(p<0.01)$

simple firm, the coefficient of -0.110 for board size (β_1) indicates that if board size increases by one, Q decreases by 0.6%. In contrast, Yermack (1996) reports that when board size doubles, Q decreases by 1%. The economic significance of the board size effect in complex firms is large in dollar terms because complex firms are considerably bigger compared with simple firms (mean book assets of $10.9 billion versus $1.6 billion). An increase in board size by one implies an increase of $285 million in firm value for complex firms compared with a decrease of $20 million for simple firms.

Here and throughout this section, economic significance is similar if we use median assets and median board structure instead of the corresponding means. Our results on control variables are generally consistent with the prior literature. We obtain similar results using median regressions (Model 2) instead of OLS.

Fig. 2 (Panel B) provides a graphical representation of the empirical support for Hypothesis 3. We plot predicted Q on board size, where predicted Q is based on the coefficient estimates from Model 1 of Table 5, with control variables held at their means. Q increases with board size in complex firms but decreases with board size in simple firms.

6.2. Effect of number of outsiders on Q: complex versus simple firms

We argue earlier that complex firms stand to benefit from having more directors on the board because CEOs of complex firms have a greater need for advice and expertise. Such advice is more likely to be provided by outside directors, so we expect the positive relation between board size and Q to be driven by the number of outsiders on the board. Consequently, in Model 3, we replace log(board size) with log(outsiders).

The coefficient on the interaction of log(outsiders) and ADVICE (β_4) is significantly positive, implying that, in complex firms, having more outsiders adds value relative to simple firms. The overall effect of outsiders on Q is positive ($\beta_3+\beta_4=0.153$) and significant ($p<0.01$) for complex firms. In economic terms, when the number of outsiders increases by one, firm value increases by \$290 million for complex firms but decreases by \$21 million for simple firms. Thus the impact of outsiders on Q is similar to the impact of board size on Q. These results support our hypothesis that increasing board size, specifically adding outsiders, does not necessarily detract from firm value. To the contrary, it could even add value in complex firms. Results are similar using median regressions (Model 4).[10]

6.3. Effect of insider fraction on Q: high-R&D versus low-R&D firms

We next study the effect of insider fraction on Q for high-R&D versus low-R&D firms, using the specification

$$Q = \chi_0 + \chi_1 Fraction\ \ Insiders + \chi_2\ \ Fraction\ \ Insiders \times R\&D\ \ dummy + \delta\ \ Log(Board\ \ Size) + \gamma\ \ R\&D\ \ dummy + Controls, \quad (2)$$

χ_1 captures the effect of insider fraction on Q for low-R&D firms. χ_2 is the incremental effect of the insider fraction on Q for high-R&D firms, while $\chi_1+\chi_2$ is the total effect of insider fraction on Q for high-R&D firms. Per Hypothesis 4, both χ_2 and $\chi_1+\chi_2$ should be positive.

The results are presented in Table 6. In Model 1, the coefficient on the fraction of insiders is statistically insignificant, suggesting that Q is independent of board composition for low-R&D firms. The coefficient on the interaction term is positive ($\chi_2=0.552$, $p=0.02$), indicating that Tobin's Q is more positively related to the fraction of insiders in high-R&D firms compared with low-R&D firms. The sum of the coefficients on the fraction of insiders and the interaction term is significantly positive ($\chi_1+\chi_2=0.609$, $p<0.01$). In R&D-intensive firms Tobin's Q increases in the fraction of insiders on the board.

Model 1 indicates that, for high-R&D firms, if the fraction of insiders increases by 0.10, which on the average board is equivalent to replacing one outsider with one insider, firm value increases by \$263 million. The median regression (Model 2) yield similar inferences.

Panel C of Fig. 2 plots predicted Q (based on Model 1 of Table 6) on insider fraction decile for high-R&D versus low-R&D firms. Control variables are held at their means. Because insider fraction is a continuous variable, unlike board size, for simplicity in characterizing the data we use deciles instead of the insider fraction. Decile 1 (Decile 10) contains firms with the lowest (highest) insider fraction. We find that, for high-R&D firms, Q increases with the fraction of insiders on the board. In contrast, the relation is flat for low-R&D firms.

[10] Although our findings in Models 3 and 4 of Table 5 are consistent with our hypothesis, it is premature to conclude that the association between Q and board size is driven by outsiders. This is because, if we hold the fraction of insiders constant, any increase in the number of outsiders requires a corresponding increase in insiders. In Section 7.2, we provide several robustness tests that support the hypothesis that it is outside directors that drive the association between board size and Q in complex firms.

Table 6
Does Tobin's Q increase in the fraction of insiders on the board for high-R&D firms?

Tobin's Q is defined as the ratio of market value to book value of assets. R&D dummy equals one if the firm's research and development (R&D) intensity is greater than the 75th percentile value and zero otherwise. We compute a factor score based on number of business segments, firm size, and leverage. ADVICE dummy equals one if this factor score is greater than the median value and zero otherwise. Absolute values of t-statistics based on robust standard errors are reported in parentheses, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

		Dependent variable: Tobin's Q			
Independent variables		Model 1 OLS	Model 2 Median	Model 3 OLS	Model 4 Median
Insider fraction	χ_1	0.057	0.071	0.052	0.076
		(0.6)	(1.1)	(0.6)	(1.2)
Insider fraction × R&D dummy	χ_2	0.552**	0.567***	0.518**	0.603***
		(2.4)	(4.6)	(2.3)	(5.3)
Log(board size)	χ_3	0.035	0.074***	−0.102*	−0.008
		(0.9)	(2.8)	(1.8)	(0.3)
Log(board size) × ADVICE dummy	χ_4			0.286***	0.161***
				(4.3)	(3.7)
R&D dummy		0.283***	0.127***	0.281***	0.115***
		(5.3)	(4.0)	(5.3)	(3.9)
ADVICE dummy		−0.064***	−0.026**	−0.723***	−0.397***
		(3.6)	(2.0)	(4.6)	(3.9)
Risk		0.148***	0.071***	0.145***	0.073***
		(13.0)	(10.6)	(12.8)	(11.8)
ROA		6.771***	5.732***	6.774***	5.654***
		(25.1)	(38.9)	(25.1)	(41.4)
ROA_{t-1}		1.360***	1.206***	1.358***	1.300***
		(4.2)	(6.6)	(4.2)	(7.6)
ROA_{t-2}		0.953***	1.046***	0.943***	1.049***
		(3.6)	(7.0)	(3.6)	(7.6)
Intangible assets		1.166***	0.821***	1.164***	0.806***
		(17.2)	(18.3)	(17.1)	(19.4)
CEO ownership		0.003	0.001	0.003	0.001
		(1.2)	(0.6)	(1.0)	(0.4)
Intercept, industry and year dummies		Yes	Yes	Yes	Yes
Number of observations		6,794	6,794	6,794	6,794
R^2 (Pseudo-R^2)		55%	33%	55%	33%
F-test: effect of insider fraction on Q for high-R&D firms		$\chi_1+\chi_2=0.609^{***}$ ($p<0.01$)	$\chi_1+\chi_2=0.638^{***}$ ($p<0.01$)	$\chi_1+\chi_2=0.570^{***}$ ($p<0.01$)	$\chi_1+\chi_2=0.679^{***}$ ($p<0.01$)
F-test: effect of board size on Q for complex firms				$\chi_3+\chi_4=0.184^{***}$ ($p<0.01$)	$\chi_3+\chi_4=0.153^{***}$ ($p<0.01$)

Finally, Models 3 and 4 report OLS and median results for specifications that include both ADVICE and R&D interaction terms. The results are similar. Also, if we replace log(board size) with log(outsiders) in Models 3 and 4, we get similar results.

7. Additional robustness checks and tests of alternative explanations

In this section, we discuss results using a simultaneous equations approach to estimating the relation between board structure and Q. We report results from several additional robustness checks.

7.1. Controlling for endogeneity

In our regressions of Q, we use board size, board composition, and CEO ownership as independent variables. Prior literature, however, indicates that all of these variables, in turn, are determined by Q

(see Demsetz and Lehn, 1985; Hermalin and Weisbach, 1988; Smith and Watts, 1992; Bizjak, Brickley, and Coles, 1993; Bhagat and Black, 1999; Core and Guay, 1999; Denis and Sarin, 1999; Coles, Lemmon, and Meschke, 2006). We address this endogeneity problem using several approaches.

First, we estimate simultaneous equations in Q, board size, fraction of insiders, and CEO ownership, using three-stage least squares (3SLS) regressions.[11] This is similar to Bhagat and Black (2001) who estimate Tobin's Q, board composition, and CEO ownership using 3SLS. Table 7 reports the parameter estimates. We find that the results are generally consistent with our hypotheses. Column 1 presents the results on the determinants of Tobin's Q. The coefficient on the interaction term of board size with ADVICE and that on the interaction term of insider fraction with R&D dummy are both highly significant. The effect of board size on Q for firms that have large advisory needs ($\eta_1+\eta_2$) is significantly positive. We find, however, that the effect of insider fraction on Q for high-R&D firms ($\eta_3+\eta_4$) is insignificant.

The board size results (Column 2) confirm that firms with high advisory needs have larger boards. The third column presents the results for insider fraction. In our OLS regressions in Table 5, we did not find our expected positive relation between R&D intensity and fraction insiders. The 3SLS results, however, indicate that high-R&D firms have a higher insider fraction, per Hypothesis 2. The final column presents results for CEO ownership. Consistent with prior research, we find that CEO ownership increases with Q and CEO tenure and decreases with firm size.

While our results are qualitatively similar under 3SLS, this method could be subject to specification error. Thus, we use two other approaches to address endogeneity. Following Hermalin and Weisbach (1991), we use lagged (instead of contemporaneous) values of board size and fraction of insiders (and their corresponding interaction terms) in regressions of Q on structure (as in Tables 5 and 6). Following Dahya, Dimitrov, and McConnell (2007) and Rajgopal and Shevlin (2002), we use lagged values of Q as the dependent variable. In both cases, our results are similar to those reported here.[12]

7.2. Is it outsiders that contribute to higher Q in complex firms?

In Table 5 we find that, holding the fraction of insiders constant, Q is positively related to number of outside directors. Based on this, we conclude that the board size effect is driven by outsiders. The problem, however, is that if we hold the fraction of insiders constant, any increase in the number of outsiders requires a corresponding increase in insiders. If the association between Q and the number of insiders is identical to the association between Q and the number of outsiders, then our conclusion might be premature. While this problem is mitigated to some extent by our use of log-transformed variables, there is no ideal specification that is free from this or a similar difficulty. On the surface, it appears that regressing Q on the number of outsiders (and the associated interaction term) while controlling for both the fraction of insiders and the number of insiders would solve the problem, but such a specification is internally inconsistent. Changing the number of outsiders must change one of these control variables, so controlling for both (holding both constant) makes no sense.

We use three specifications to verify that it is the number of outsiders (not the number of insiders or the fraction of outsiders) that drives the increase in firm value in complex firms. First, in Model 3 of Table 5 we replace log(outsiders) with log(insiders).

$$Q = \eta_0 + \eta_1 Log(Insiders) + \eta_2 Log(Insiders) \times ADVICE\ \ dummy \\ + \lambda\ \ ADVICE\ \ dummy + \delta\ \ Fraction\ \ Insiders + Controls. \tag{3}$$

[11] Investment policy (R&D intensity, diversification), financing policy (leverage), and stock-return volatility (risk) all arise endogenously (see, for example, Coles, Daniel, and Naveen, 2006). Also, the interaction terms that include board size and board composition are effectively endogenous. Because specification error is more likely to be propagated throughout a large system of equations, we exclude the corresponding equation.

[12] Another method to potentially control for endogeneity is to include firm fixed effects. Fixed effects, however, are not appropriate in our case because most of the variation arises in the cross section instead of in the time series. In our sample, the correlation between board size (composition) and its lagged value is 91% (86%). See Hermalin and Weisbach (1991) and Zhou (2001) for similar arguments.

Table 7
Effect of board structure on Tobin's Q: three-stage least squares

A simultaneous system of equations is estimated in which the dependent variables are Tobin's Q, log(board size), insider fraction, and Chief Executive Officer (CEO) ownership. Tobin's Q is defined as the ratio of market value to book value of assets. We compute a factor score based on number of business segments, firm size, and leverage. ADVICE dummy equals one if this factor is greater than the median value and zero otherwise. R&D dummy equals one if the firm's research and development (R&D) intensity is greater than the 75th percentile value and zero otherwise. Absolute values of t-statistics are reported in parentheses, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Independent variables		Tobin's Q	Log (board size)	Insider fraction	CEO ownership
Tobin's Q			0.459***	−10.952***	0.440***
			(16.7)	*(8.7)*	*(2.6)*
Log(board size)	η_1	−0.334		0.696*	
		(1.2)		(1.9)	
Log(board size) × ADVICE dummy	η_2	1.280***			
		(5.7)			
Insider fraction	η_3	−7.988***	−0.946***		
		(2.8)	(11.4)		
Insider fraction × R&D dummy	η_4	7.860***			
		(3.2)			
ADVICE dummy		−3.158***	0.114***		
		(6.0)	(12.4)		
R&D dummy		−1.415***	−0.196***	4.755***	
		(2.6)	(11.7)	(8.4)	
Risk		0.164***	−0.099***	1.505***	0.006
		(10.9)	(16.4)	(8.2)	(0.1)
ROA		6.994***	−2.880***	68.365***	−2.096
		(25.0)	(13.7)	(8.7)	(1.3)
ROA_{t-1}		1.505***	−0.675***	13.465***	0.126
		(4.4)	(5.1)	(8.3)	(0.1)
ROA_{t-2}		0.819***	−0.413***	7.315***	2.015*
		(3.0)	(3.9)	(7.9)	(1.8)
Intangible assets		1.427***	−0.543***	11.275***	
		(12.1)	(12.0)	(8.5)	
CEO ownership		0.120***		1.186***	
		(3.8)		(7.8)	
Log(CEO tenure)			−0.019***	−0.327***	0.555***
			(6.7)	(6.9)	(19.3)
Log (CEO age)			0.321***	−6.175**	
			(8.1)	(8.3)	
Log(firm age)			0.064***	−0.069**	
			(12.5)	(2.4)	
Free cash flow			−0.279***	0.174	
			(3.4)	(0.8)	
Firm size				0.915***	−0.554***
				(9.7)	(14.2)
Leverage				−9.719***	
				(10.3)	
Intercept, industry, and year dummies		Yes	Yes	Yes	Yes
Number of observations		5,790	5,790	5,790	5,790
F-test for Tobin's Q regression		$\eta_1+\eta_2=0.946^{***}$ ($p<0.01$); $\eta_3+\eta_4=-0.128$ ($p=0.79$)			

This specification has the same interpretation problem, but in reverse, because increasing the number of insiders leads to an increase in the number of outsiders as we hold the fraction the same. If, in our original specification (reported in tables), insiders were driving the increase in firm value, then η_2 in the current specification should be positive. This coefficient, however, is not significant, suggesting that our results in Model 3 of Table 5 are not driven by insiders.

Second, starting with Model 3 of Table 5, we eliminate the fraction of insiders and instead use the logarithm of the number of insiders and the corresponding interaction term with ADVICE:

$$Q = \omega_0 + \omega_1 Log(Outsiders) + \omega_2 Log(Outsiders) \times ADVICE\ \ dummy + \omega_3 Log(Insiders) + \omega_4 Log(Insiders) \times ADVICE\ \ dummy + \lambda\ \ ADVICE\ \ dummy + Controls. \quad (4)$$

The coefficient on log(Outsiders), ω_2, continues to be significantly positive. Now, however, ω_4 also has explanatory power, but in terms of economic significance ω_4 is small compared with ω_2.

With the above specification, one problem is that, holding the number of insiders constant, as the number of outsiders increases, so does the fraction of outsiders. To show that it is the number, and not the fraction, of outsiders that is driving our results, we estimate

$$Q = \kappa_0 + \kappa_1 Log(Fraction\ \ Outsiders) + \kappa_2 Log(Fraction\ \ Outsiders) \times ADVICE\ \ dummy + \lambda\ \ ADVICE\ \ dummy + \delta\ \ Log(Board\ \ Size) + Controls. \quad (5)$$

We find that κ_2 is statistically insignificant. Thus, it appears that it is not the fraction of outsiders that drive our results. Overall, the results from these three models suggest that it is the number of outsiders, not the number of insiders or the fraction of outsiders, that drives the results in Table 5.

7.3. *Could unexplained nonlinearities in the Q-board structure relation drive our results?*

Lipton and Lorsch (1992) suggest that eight or nine members is about the right size for the corporate board. Thus, we regress Q on a quadratic in board size. The idea is similar to that which gives rise to the literature on the relation between Q and managerial ownership. For example, McConnell and Servaes (1990) find an inverted-U-shaped relation between Q and ownership. One interpretation of the McConnell and Servaes result is that Q increases in ownership as managerial incentives become better aligned with shareholder interests but, at some point, at the maximum, the marginal costs of managerial entrenchment just overcome and then overtake the marginal benefits of alignment (e.g., see Stulz, 1988). Perhaps something similar is manifested in the data between Q and board size.

In contrast, as it turns out, in our data the Q-board size relation is U-shaped. The results are given below with the t-statistics given in parentheses.

$$Q = \text{intercept} \underset{(-2.6)}{- 0.063 Board\ \ Size} \ \underset{(2.8)}{+0.003(Board\ \ Size)2} \ \underset{(1.8)}{+0.152 Insider\ \ \ Fraction} + Controls. \quad (6)$$

The linear term in board size is significantly negative ($p<0.01$) and the quadratic term is significantly positive ($p<0.01$). This result appears inconsistent with the notion that a medium-size board, reflecting a balance between benefits and costs, is optimal. If we take the results at face value, the smallest and largest boards are associated with higher Q, and such boards could represent value-maximizing board structure.

This result bears further examination. The U-shaped relation is consistent with our parameter estimates (Table 5), with complex firms driving the positively sloped segment and simple firms driving the negatively sloped segment of the quadratic relation (see Fig. 3). Our transaction costs story would also predict a U-shape (see Panel B of Fig. 1). Nonetheless, while the quadratic parameter estimates are consistent with our advising hypothesis, an alternative explanation could apply. For example, it is possible that the relation between Q and board size is U-shaped for reasons not captured by our empirical design; complex firms have bigger boards and simple firms have smaller boards for reasons unrelated to firms' advising needs; and the effects of omitted exogenous variables place complex (simple) firms on the upward- (downward-) sloping segment of the estimated U-shape. That is, the nonlinearity hypothesis is that the Q-board size relation is negatively sloped for simple firms and positively sloped for complex firms, but this relation has nothing to do with firm complexity and associated advising requirements.

What is required is a specification that accommodates nonlinearity and also allows for a test of whether the (nonlinear) association between Q and board size differs for complex versus simple firms. The nonlinearity hypothesis is that the Q-board size relation is unaffected by firm complexity. Thus, for both simple and

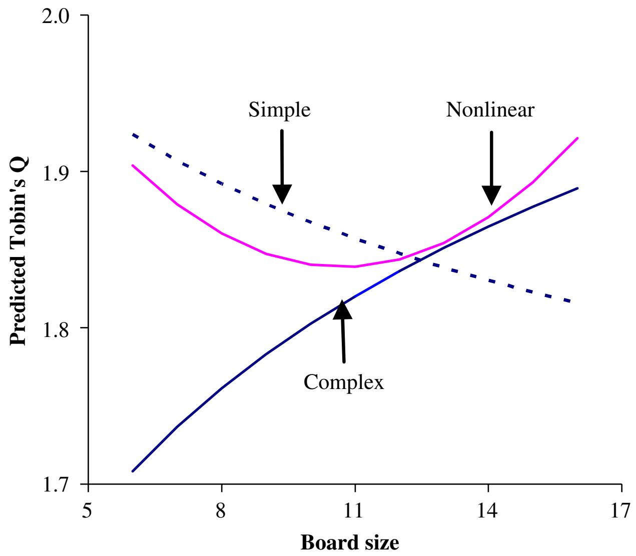

Fig. 3. Nonlinearity versus advising hypothesis. The figure shows the predicted Q based on Eq. (6) (nonlinearity hypothesis) and the predicted Q based on Model 1 of Table 5 as a function of board size (advising hypothesis). The U-shaped relation is consistent with our parameter estimates (Model 1 of Table 5), with complex firms driving the positively sloped segment and simple firms driving the negatively sloped segment of the quadratic relation.

complex firms, we should observe an identical U-shaped relation between Q and board size. Our advising hypothesis, in contrast, predicts that the relation between Q and board size differs by type of firm. To test this, we estimate the following specification.

$$Q = \theta_0 + \theta_1 Board\ Size + \theta_2\ Board\ Size^2 + \theta_3 Board\ Size \times ADVICE + \theta_4 Board\ Size^2 \times ADVICE + \gamma\ ADVICE + \delta\ Fraction\ Insiders + Controls. \quad (7)$$

The nonlinearity hypothesis predicts that $\theta_3 = 0$ and $\theta_4 = 0$.

We find that $\theta_3 = 0.141$ ($p<0.01$) and $\theta_4 = -0.005$ ($p = 0.02$). These results indicate that there are statistically significant differences between simple and complex firms even when the specification accommodates for the possibility of a nonlinear relation between Q and board size. We also find $\theta_1 = -0.075$ ($p = 0.05$) and $\theta_2 = 0.003$ ($p = 0.07$), estimates that are consistent with the U-shape for simple firms.

Based on the models that give rise to our advising hypotheses, a stronger prediction would be a positive derivative for complex firms over their domain of board sizes. The relevant derivative is $\theta_1+\theta_3+2(\theta_2+\theta_4)$ $Board\ Size = 0.066 - 0.004 Board\ Size$, which is positive for any *Board Size* less than 16.5. Only 4% of complex firms have boards with 17 or more members. For simple firms, we expect a negative derivative over their domain of board sizes. The relevant derivative is $\theta_1 + 2\theta_2 Board\ Size = -0.075 + 0.006 Board\ Size$, which is negative for any *Board Size* less than 12.5. Only 9% of simple firms have 13 or more members. For the most part, Q is increasing (decreasing) in board size for complex (simple) firms, even based on a functional form that accommodates a U-shaped relation between Q and board size arising from other forces. These results provide further support for our advising hypothesis.[13]

7.4. Using continuous measures of ADVICE and R&D

We use indicator variables, ADVICE dummy and R&D dummy, to represent advising requirements and R&D intensity. This allows us to easily (and graphically) present the economic impact of these variables.

[13] This approach yields similar results when we use logarithm of board size (not board size) and when we include the ADVICE dummy in the regression specifications.

We now replace the two indicator variables by their corresponding continuous values. Our main results in Tables 3–6 continue to hold. In particular, we find that board size increases in firm complexity while fraction of insiders is negatively related to R&D (the latter result is opposite to our prediction, but consistent with our results in Table 4). We find that the coefficient on the interaction term of log(board size) with firm complexity is significantly positive. Also, based on the coefficient estimates, we find that Q increases in board size for complex firms. The same is true when we use number of outsiders instead of board size.

The coefficient on the interaction term of insider fraction with R&D is significantly positive in the median regression. Based on the coefficient estimates, we find that Q increases in insider fraction for high-R&D firms. In contrast, the OLS coefficients are statistically insignificant.

7.5. Using individual components of ADVICE

We use ADVICE dummy, an indicator variable based on a factor score in which the underlying components are number of business segments, log(sales), and leverage. For robustness, we replace our ADVICE dummy with three indicator variables, DIVERSE, FIRMSIZE, and DEBT. DIVERSE equals one if the firm has more than one business segments and equals zero otherwise. FIRMSIZE equals one if the firm has above-median sales in a year and equals zero otherwise. DEBT equals one if the firm has above-median leverage ratio in a year and equals zero otherwise. In the board size regressions (Table 3) we find, as expected, that the coefficients on all three variables are significantly positive. Firms that are diversified, large, and high-debt have 18% bigger boards and 26% more outsiders. Next, we repeat the Q regressions (Table 5) using these indicator variables. The results indicate that Q increases in board size and in number of outsiders for firms that are larger, diversified, or have high debt.

7.6. Alternative definitions of ADVICE dummy and high-R&D

Throughout the paper, we use log(sales) as a proxy for firm size. Further, our ADVICE variable is based on log(sales), leverage, and number of segments. Our results are robust to using, instead, log(assets) as a measure of firm size. Similarly, for high-R&D firms, we use the 75th percentile as a cutoff. Our main results are robust to using the 80th percentile as the cutoff. Because only 40% of the population has positive R&D, the 80th percentile can be considered as the median for the firms with positive R&D.

7.7. Excluding finance and utility firms

Our sample includes finance and utility firms, as in Himmelberg, Hubbard, and Palia (1999), Demsetz and Villalonga (2001), and Coles, Lemmon, and Meschke (2006). Some studies such as Yermack (1996), however, exclude these firms. Our results in Tables 3–6 generally are the same when we drop these firms, although the sample size is now about 15% smaller. One exception is that the coefficient on the interaction of R&D dummy with insider fraction in Table 6 is now significant only at the 15% level in the OLS regressions (although it continues to remain significant in the median regressions).

7.8. Subsample analysis

We have no reason to expect the coefficients on control variables in the Q regression to differ systematically depending on whether the firm is simple or complex and whether the firm is high-R&D or low-R&D. Hence, we use interaction terms to capture the effect of complexity and R&D-intensity on the Q-board structure relation. Nevertheless, we replicate Table 5 for subsamples of complex firms and simple firms. Similarly, we replicate Models 1 and 2 of Table 6 for subsamples of high-R&D and low-R&D firms. We obtain similar inferences.

7.9. Using industry-adjusted values

As in Gompers, Ishii, and Metrick (2003a, b), we use an alternative measure of our dependent variable, namely industry-adjusted Q. This is computed as Q net of its industry (two-digit SIC) median for that year.

All results are considerably stronger when we use this measure. Moreover, we get similar results when regressing industry-adjusted Q on all the explanatory variables themselves adjusted by industry medians. As before, we use ADVICE and R&D dummies, but now we compute them based on industry median and industry 75th percentile values respectively. All our results in Tables 3–5 remain similar. In Table 6, we get weaker results for high R&D firms in the OLS regressions, but median regression results are as before. The results for R&D could be weaker because we are now effectively classifying firms with even marginally positive R&D as high R&D firms (because industry 75th percentiles are zero for 62% of industries).

7.10. Corrected standard errors

We implement the procedure of Fama and MacBeth (1973) to address the potential bias in standard errors resulting from contemporaneous residuals being correlated across firms for the OLS regressions. We estimate ten cross-sectional regressions, one for each year in our sample. The Fama and MacBeth coefficient is the time-series average of the coefficients across the ten regression estimates. The p-value is based on the standard deviation of the ten coefficient estimates. The Fama and MacBeth results are similar in both statistical and economic dimensions to the results reported in the tables.

For the OLS regressions, we also use bootstrap techniques to generate standard errors. We generate one thousand bootstrapped samples of the same size as our original sample. This is done by sampling both the independent and dependent variables jointly with replacement from the original sample. The one thousand regression coefficients from the bootstrapped samples are used to estimate the standard error. The results are almost identical to those reported in the tables.

We also correct for any form of clustering of standard errors within firms, including serial correlation (we employ the CLUSTER(firm) option in STATA). Our results are the same.

8. Conclusion

We examine both the reasoning and data behind the conventional wisdom that smaller and more independent boards are better. In contrast, we argue that certain classes of firms are likely to benefit from larger boards and boards with more insider representation. Complex firms such as those that are diversified across industries, large in size, or have high leverage are likely to have greater advising requirements. Hence, these firms are more likely to benefit from a larger board of directors, particularly from outside directors who possess relevant experience and expertise. Furthermore, firms for which the firm-specific knowledge of insiders is relatively important, such as R&D-intensive firms, are likely to benefit from greater representation of insiders on the board.

Our empirical results are consistent with these hypotheses. We find that complex firms, which have greater advising requirements, have larger boards with more outside directors. The relation between Tobin's Q and board size is U-shaped, which, at face value, suggests that either very small or very large boards are optimal. This relation, however, is driven by differences between complex and simple firms. Tobin's Q increases (decreases) in board size for complex (simple) firms and this relation is driven by the number of outside directors. We find weak evidence that R&D-intensive firms, for which the firm-specific knowledge of insiders is relatively important, have higher fraction of insiders on the board. For these firms, Q increases with the fraction of insiders on the board.

At the very least, our empirical results call into question the existing empirical foundation for prescriptions for smaller, more independent boards. Moreover, our estimated specifications likely represent part of the true relation between performance and board structure. Such an interpretation can be supported by two styles of model. One model allows for the possibility that transactions costs are negligible, the central idea being that the estimated relation between performance and board structure in the data represents the envelope of value-maximizing organization forms. This model illustrates how rules and regulations prohibiting large boards and a high fraction of insiders on the board could destroy value. This is consistent with arguments in Gillan, Hartzell, and Starks (2003) and Bainbridge (2003) that regulatory actions applying one-size-fits-all criteria can damage some firms. The other model relies on a transaction cost-based departure from optimal board structure. In this case, the data on performance and board structure represent a segment of the objective function that firms would maximize in the absence of transaction costs. Based on this model with significant transaction costs, if changes in economic institutions and regulations can help firms avoid some of the costs of changing board structure (so as to enhance performance and value), such regulation could benefit shareholders.

Our study speaks to the call by Hermalin and Weisbach (2003) for a better understanding of the relation between board size and corporate performance and to the appeal in McConnell (2002) for more research on the role of outsider directors. In the context of the recent scandals at Enron, WorldCom, and Qwest, as the role of boards in the governance of corporations comes under increased scrutiny, and as Congress, TIAA-CREF, CALPERS, the NYSE, Nasdaq, and others weigh in on governance, our findings assume particular significance. Our evidence casts doubt on the idea that smaller boards with fewer insiders are necessarily value-enhancing.

Appendix A. Alternative model of the Q-board structure relation

In Section 2.3, we propose a transaction costs-based model that gives rise to a relation between Q and board structure. Here we propose an alternative model that could yield similar predictions, even absent transaction costs.

The model has seven elements. (1) There are two types of firms, complex (for example, diversified) and simple (for example, focused). (2) In contrast to Section 2.3, firms within each type are not similar. Specifically, they are endowed with varying amounts of growth options (potentially positive net present value projects). (3) Growth options are of two types: for focused firms those options are relatively homogeneous, and for diversified firms, the options, coming from a variety of industries, are relatively heterogeneous. (4) The relative benefit of advising (e.g., from a larger board comprised primarily of outsiders) versus agility (e.g., from a smaller board with some insiders) differs based on the type of growth options (homogenous or heterogeneous).

(5) For firms with homogeneous growth options, the value gain from rapid decision making and industry-specific human capital increases in the level of growth options. For example, if a focused firm is slow to innovate, it does not have the option (unlike a diversified firm) to reallocate resources to other segments. Also, focused firms tend to operate in rapidly changing industries, including biotech, and other high-R&D industries. In such industries a nimble board is relatively important, particularly as the firm with more growth opportunities exploits those opportunities to compete. In focused firms, the benefits of rapid action (from a smaller board) and industry-specific expertise (from inside directors) exceed the costs of less breadth of expertise.

(6) For firms with heterogeneous growth options, it is unlikely that the top management team has sufficient depth of expertise in each of the entire range of those options. Thus, as the extent of the various growth options increases, it is more important to have advice from a wider range of experts, implying a need for a larger board with more outside directors (at the expense of decision speed). Though nimble decision making can be important for complex firms, it is likely to be less critical than advising. (7) Higher growth options translate into higher Q as long as the firm chooses a board structure (with the right amount of agility or expertise or both) that ensures that the maximum value can be extracted from its endowment of growth options.

What do these assumptions yield? For complex firms, with heterogeneous growth options, as the extent of the growth options increases, so does the need for advice, so a bigger board with more outsiders are optimal (because outsiders are better at providing advice). More growth options also means higher Q. Thus, for complex firms, the trace of the individual firms' optima generates, in the data, a positively sloped relation between board size and Q. This relation appears to be driven by the number of outside directors. For simple firms, with homogeneous growth options, as the quantity of those growth options increases, a smaller board (for rapid decisions) with some insiders (deeper industry expertise) are optimal. Again, more growth options also implies higher Q. Thus, for simple firms, the individual firm optima trace a negatively sloped relation between board size and Q.

Fig. 4 represents how the data would look under this model. The dotted curves depict the objective function of three firms of each type (chosen arbitrarily). The triangles (squares) represent the maxima for simple (complex) firms. The downward (upward) sloping solid line represents the trace of the optima for simple

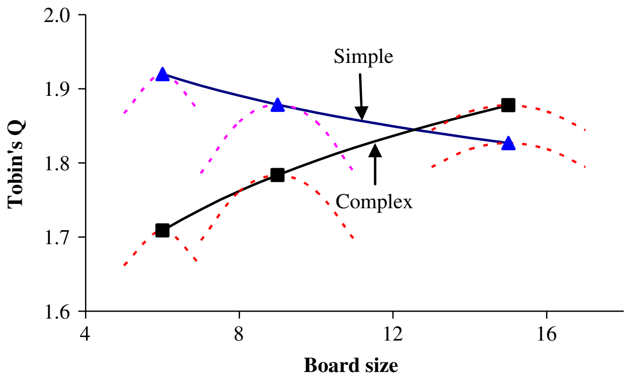

Fig. 4. Relation between Q and board structure as a collection of optima. This figure presents hypothetical data based on a model with no transaction costs. We use board size to illustrate our point although similar arguments could be made for board composition. In this world, there are two types of firms, simple and complex. While simple firms have homogeneous growth options, complex firms have heterogeneous growth options. Within each type, firms are endowed with different levels of growth options. Each firm chooses board size so as to maximize firm value that can be extracted given its growth options. The dotted curves depict the objective function of three firms (chosen arbitrarily) of each type. The triangles represent the maxima for simple firms and the squares represent the maxima for complex firms. The downward (upward) sloping solid line represents the trace of such optima for simple (complex) firms.

(complex) firms. The location of the objective function, which relates Q to board size for a given firm, depends on product market characteristics, industry characteristics, the set of governance mechanisms employed by the firm, and the nature and extent of available growth opportunities. For complex (simple) firms, moving to the right (left) on the horizontal axis represents an increase in heterogeneous (homogeneous) growth opportunities.

This simple model excludes some relevant aspects of the problem, including other governance characteristics such as managerial pay-performance sensitivity. Nonetheless, as our analysis demonstrates, there is empirical support for this model.

Our models are meant primarily to illustrate how two different approaches can support a significant relation in the data between performance and board size. A combination of our models also could be appropriate. In a combined model, the size of transaction costs would determine the extent of departures from the locus of value-maximizing combinations of Q and board size.

Appendix B. Variable definitions

This appendix defines the variables used in the study. Compustat data items are defined by their corresponding data item number. Stock return data are taken from the Center for Research on Security Prices (CRSP), accounting and operating segment data from Compustat, and board data from Compact Disclosure and Investor Research Responsibility Center (IRRC).

Tobin's Q = (data6–data60 + data199 × data25)/data6
Board size = Number of directors
Outsiders = Board size − insiders
Insider fraction = Insiders/board size
DIVERSE = 1 if number of business segments > 1; = 0 otherwise
Firm size = Log(sales) = Log(data12)
FIRMSIZE = 1 if firm size > median for that year; = 0 otherwise
Leverage = (data9 + data34)/data6
DEBT = 1 if leverage > median for that year; = 0 otherwise
R&D intensity = research & development expenditure to assets = Max(0,data46)/data6
R&D dummy = 1 if R&D intensity > 75th percentile for that year; = 0 otherwise

ADVICE = factor score computed based on business segments, firm size, and leverage
ADVICE dummy = 1 if ADVICE > median for that year; = 0 otherwise
Risk = Standard deviation of daily excess returns over the fiscal year
ROA = Return on assets = data13/data6
Intangible assets = 1 – net property, plant, and equipment to assets = 1 – (data8/data6)
Free cash flow = (data308–data19–data21)/data6
Firm age = number of years since first trading date on CRSP

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