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The determinants of corporate board size and composition: An empirical analysis ☆

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Abstract

Using a unique panel dataset that tracks corporate board development from a firm's IPO through 10 years later, we find that: (i) board size and independence increase as firms grow and diversify over time; (ii) board size—but not board independence—reflects a tradeoff between the firm-specific benefits and costs of monitoring; and (iii) board independence is negatively related to the manager's influence and positively related to constraints on that influence. These results indicate that economic considerations—in particular, the specific nature of the firm's competitive environment and managerial team—help explain cross-sectional variation in corporate board size and composition.

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Nonetheless, much of the variation in board structures remains unexplained, suggesting that idiosyncratic factors affect many individual boards' characteristics.

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1. Introduction

Corporate boards are the focus of many attempts to improve corporate governance. Shareholder advocates such as Institutional Shareholders Services, Inc. and the Council of Institutional Investors have called for US corporations to have smaller boards with greater outside representation, sentiments echoed by the National Association of Corporate Directors and The Business Roundtable.[1] Institutional investors such as TIAA-CREF have issued specific recommendations for how boards should be structured and run. Some of these recommendations were codified into law via the Sarbanes-Oxley Act of 2002, including, for example, a requirement that boards have audit committees that consist only of independent outside directors. The movement toward specific board guidelines, typically calling for greater outside representation, is also a characteristic of the Codes of Best Practice issued in many countries (see Denis and McConnell, 2003).

Yet despite the importance of corporate boards and the widespread call for their reform, financial economists have reached few definitive conclusions about the forces that drive board size and composition. This paper examines these forces empirically. To structure our tests, we group existing theories about corporate boards into three non-mutually exclusive testable hypotheses, which are summarized in Table 1.

The first hypothesis, which reflects the views of Fama and Jensen (1983), Coles, Daniel, and Naveen (2007), and Lehn, Patro, and Zhao (2005), implies that board structure is driven by the scope and complexity of the firm's operations. We call this the *scope of operations hypothesis*. The second hypothesis is that board size and composition are determined by the specific business and information environment in which the firm operates. We call this view—which borrows from ideas expressed by Demsetz and Lehn (1985) and Gillan, Hartzell, and Starks (2004), and is modeled by Raheja (2005) and Harris and Raviv (2007)—the *monitoring hypothesis*. The third hypothesis, reflecting work by Hermalin and Weisbach (1998) and Baker and Gompers (2003), implies that board composition results from a negotiation between the firm's CEO and its outside board members. We call this the *negotiation hypothesis*.

As illustrated in Table 1 and developed further in Section 2, each of these hypotheses yields testable predictions about the forces that shape board size, composition, or both. We test these predictions using hand-collected data from a panel of 1,019 firms that went public between 1988 and 1992, which we track for periods of up to 10 years. Our tests exploit the panel nature of the data and control for the endogeneity of board size and composition.

Our dataset differs from those of previous empirical investigations into corporate boards because it focuses on young companies. This presents both advantages and disadvantages.

[1]See The Business Roundtable (1997), National Association of Corporate Directors (2001), and Institutional Shareholder Services, Inc. (2003).

Table 1
Predictions of the economic hypotheses

This table summarizes the empirical predictions of the three alternative hypotheses tested in this paper with regard to the size of the board (Number of Directors) and independence of the board (Proportion of Independent Directors). The "Scope of Operations Hypothesis" argues that boards grow in response to the increasing net benefits of monitoring and specialization of board members that accompany a firm's growth. The "Monitoring Hypothesis" argues that board size reflects a tradeoff between the firm-specific benefits of increased monitoring and the costs of such monitoring. The "Negotiation Hypothesis" argues that corporate boards reflect the outcome of a negotiation between the CEO and outside board members. *Firm Size* is the natural log of the market value of equity. *Firm age* is the number of years since the IPO. *Number of Business Segments* is the number of operating segments in the company. *Free Cash Flow* is defined as (Earnings + Depreciation − Capital Expenditures)/Total Assets. *Industry Concentration* is the Herfindahl index of industry sales using data on Compustat-listed firms. *Takeover Defense* (*G-Index*) is measured as the firm's number of takeover defenses plus the number of state antitakeover laws that apply to the firm. *Market-to-Book* is the log of the book value of debt plus the market value of equity divided by total assets. *High R&D* is a dummy variable equal to one for firms in the top quartile of R&D expenditures relative to firm size. *Return Variance* is the variance of the firm's daily stock returns measured over the prior 12-month period. *CEO Ownership* is the ownership percentage of the CEO, as a fraction of shares outstanding. *CEO Tenure* is the number of years the CEO has been with the firm. *Outside Director Ownership* is the ownership percentage of the independent directors, as a fraction of shares outstanding. *Venture Capital Presence* is a dummy variable equal to one for venture-backed IPOs. *Carter-Manaster Underwriter Rank* is the ranking of the lead IPO underwriter.

	Number of Directors	Proportion of Independent Directors
For the Scope of Operations Hypothesis		
Firm Size	+	+
Firm Age	+	+
Number of Business Segments	+	+
For the Monitoring Hypothesis		
Measures of private benefits		
Free Cash Flow	+	+
Industry Concentration	+	+
Takeover Defense (*G*-index)	+	+
Measures of monitoring costs		
Market-to-Book Ratio	−	−
High R&D	−	−
Return Variance	−	−
CEO Ownership	−	−
For the Negotiation Hypothesis		
Measures of insiders' influence		
CEO Tenure		−
CEO Ownership		−
Measures of constraints *on insiders' influence*		
Outside Director Ownership		+
Venture Capital Presence		+
Carter-Manaster Underwriter Rank		+

One advantage is that the data address a concern voiced by Hermalin and Weisbach (2003) that most research on corporate boards has been limited to large, established companies. A second advantage is that the 10-year data period allows us to measure the evolution of corporate boards as firms mature. A third advantage is that, as Baker and Gompers (2003) argue, the time surrounding the initial public offering is a particularly rich setting for

studying board issues because it is a time of significant change in the firm's governance. Also, as Gertner and Kaplan (1996) point out, firms undertaking a public offering are more likely to choose value-maximizing governance features than already-public firms because the selling insiders directly bear the financial effects of such features. A disadvantage of our data, however, is that it excludes firms that have been public for more than 10 years. If the forces that drive board structure differ between young and old firms, our results might not generalize to firms that have been public for a long time. Lehn, Patro, and Zhao (2005) study firms that survive a long period of public trading.

Our results provide at least some support for all three hypotheses. In particular:

(i) Measures of the scope and complexity of the firm's operations—including firm size, firm age, and the number of the firm's business segments—are positively related to both board size and the proportion of independent outsiders on the board. This indicates that as companies grow, boards grow in response to the increasing net benefits of monitoring and specialization by board members.

(ii) Board size is positively related to measures of the private benefits available to insiders—including industry concentration and the presence of takeover defenses—and negatively related to proxies for the cost of monitoring insiders, including the market-to-book ratio, the firm's R&D expenditure, the return variance, and CEO ownership. This is consistent with arguments forwarded by Gillan, Hartzell, and Starks (2004), Raheja (2005), and Harris and Raviv (2007) that board size reflects a tradeoff between the firm-specific benefits of increased monitoring and the costs of such monitoring. Contrary to these arguments, however, we find no evidence that the proportion of independent board members is related to the costs and benefits of monitoring.

(iii) The proportion of independent outsiders is negatively related to measures of the CEO's influence—including the CEO's share ownership and job tenure—and positively related to constraints on such influence, including the ownership of outside directors, the presence of a venture capitalist, and the reputation of the firm's investment bank at the time of its IPO. This supports Hermalin and Weisbach's (1998) theory that corporate boards reflect the outcome of a negotiation between the CEO and outside board members. Furthermore, the evidence indicates a significant degree in persistence in the bargaining outcome, as the CEO's bargaining power at the time of the IPO helps explain board composition even several years after the IPO.

Overall, these results indicate that board size and composition vary across firms and change over time to accommodate the specific growth, monitoring, and managerial characteristics of the firm. Even considering all three hypotheses together, however, our empirical tests leave much of the cross-sectional variation in board size and composition unexplained. Thus, while economic hypotheses help explain board structure, there remains a large idiosyncratic or unexplained component to board structure.

The rest of this paper is organized as follows. In Section 2 we discuss related research on corporate boards and develop the three hypotheses about board size and independence. Section 3 describes the characteristics of corporate boards at the time of the IPO for our sample of 1,019 firms going public from 1988–1992, and describes the evolution of these firms' boards and ownership structures over the next 10 years. Section 4 describes our empirical procedures to test the three main hypotheses, and Section 5 reports the results. Section 6 examines the economic importance of the effects we measure, and Section 7 concludes. In Appendix A we report on several sensitivity tests that probe the robustness of the results with regard to our empirical methods and choice of proxies.

2. The determinants of board size and independence

2.1. The scope of operations hypothesis

Fama and Jensen (1983) propose that the way a firm is organized depends on the scope and complexity of its production process: larger or more complex processes lead to larger and more hierarchical firms. The firm's board, in turn, has the job of ratifying and monitoring senior managers' decisions. It follows that the information requirements of more complex operations tend to require larger boards.

This view, which we call the *scope of operations hypothesis*, is also consistent with arguments made by Lehn, Patro and Zhao (2005) and Coles, Daniel, and Naveen (2007). It implies that a firm growing into new product lines or new geographical territory will seek new board members to help oversee managers' performance. As a firm grows, or simply survives as a public entity, its demands for specialized board services are also likely to grow. As Bhagat and Black (1999) and Agrawal and Knoeber (2001) argue, new directors might have specialized knowledge that applies to the new growth areas. Boards of larger or more diverse firms also can increase their demands for new board members as such tasks as succession planning, compensation, and auditing are assigned to committees rather than handled by the board as a whole. The scope of operations hypothesis is also consistent with results reported by Denis and Sarin (1999) and Yermack (1996) that suggest that board size is positively related to firm size.

In addition to affecting board size, the scope and complexity of a firm's operations can affect the board's composition. Crutchley, Garner, and Marshall (2004) and Lehn, Patro, and Zhao (2005) argue that larger firms demand more outside directors because their large size gives rise to more significant agency problems. Using a similar argument, Anderson, Bates, Bizjak, and Lemmon (2000) and Coles, Daniel, and Naveen (2007) argue that diversified firms deploy more independent directors to monitor their wider scope of operations. These arguments imply that outside directors do in fact provide monitoring services, a notion that is supported by the empirical findings of Borokhovich, Parrino, and Trapani (1996), Mayers, Shivdasani, and Smith (1997), and others.

Thus, as shown in Table 1, the views that we summarize as the scope of operations hypothesis predict that both board size and the proportion of independent outsiders on the board are positively related to the scope and complexity of the firm's operations. In empirical tests, we use three measures of the firm's scope and complexity: the firm's size, age, and number of business segments. The scope of operations hypothesis implies that all three measures will be positively related to board size and the proportion of independent outsiders.

2.2. The monitoring hypothesis

Boards also might reflect the specific monitoring requirements of the firm's business activity. We call this the *monitoring hypothesis*. Versions of the monitoring hypothesis are expressed in several papers on board and ownership structure. Demsetz and Lehn (1985) propose that the noisiness of a firm's operating environment will affect monitoring costs, a notion that Gillan, Hartzell, and Starks (2004) use to argue that boards will monitor less in noisy environments. Lehn, Patro, and Zhao (2005) argue that high-growth firms will have small boards with a high proportion of insiders because their costs of monitoring are high.

Coles, Daniel, and Naveen (2007) argue that the proportion of inside directors will be positively related to the firm's R&D expenditures because outside board members are ineffective in monitoring firms with high growth potential. Linck, Netter, and Yang (2007) argue that firms facing greater information asymmetry will have smaller and less independent boards because of the higher costs of monitoring.

These ideas are formalized and expanded in theoretical models of board structure developed by Raheja (2005) and Harris and Raviv (2007). In these models, board members offer monitoring services that become less effective as the board gets larger because of free-riding problems. The *net* benefits of extra monitoring increase with managers' opportunities to consume private benefits, but decrease with the cost of monitoring. Thus, optimal boards will employ large numbers of outside directors, and be larger in overall size, when managers' private benefits are high and the cost of monitoring is low. That is, both board size and the proportion of outside directors are positively related to managers' private benefits and negatively related to the cost of monitoring. Note that the monitoring hypothesis does not imply that larger or more independent boards should be related to firm performance. Rather, it implies that the tradeoff between the costs and benefits of adding a board member depends on the firm's characteristics.

As indicated in Table 1, we use three measures of managers' potential private benefits to test the monitoring hypothesis: the firm's free cash flow, a Herfindahl measure of industry concentration, and a variation of Gompers, Ishii, and Metrick's (2003) *G*-index of the extent to which managers are insulated from the market for control by firm and state-level takeover defenses. We use four variables to measure the cost of monitoring: the log of the market-to-book ratio, a measure of high R&D expenditures, the variance of the firm's daily stock return, and CEO ownership. The rationales for each of these proxy variables and the details of the measures are explained in Section 5.2.

2.3. The negotiation hypothesis

Hermalin and Weisbach (1998) propose a model in which board structure is the outcome of a negotiation between the CEO and outside directors. In this model, CEOs that generate surpluses for their firms—that is, for whom good substitutes are unavailable—wield considerable influence with their outside directors. CEOs use their influence to capture some of these surpluses by placing insiders and affiliated outsiders in open board positions. We refer to this argument as the *negotiation hypothesis*.

Kieschnick and Moussawi (2004) introduce a variation of the negotiation hypothesis and argue that board independence shrinks with managers' influence and grows with institutional investor influence. Stated more generally, the negotiation hypothesis implies that the proportion of outsiders on the board will be negatively related to the CEO's influence and positively related to constraints on the CEO's influence.

As shown in Table 1, we use two measures of the CEO's influence in our empirical tests: the CEO's job tenure and the CEO's stock ownership.[2] Measures of constraints on this influence include outside directors' stock ownership, a dummy variable that represents the presence of a venture capital investor at the time of the IPO, and the Carter and Manaster

[2]Note that the monitoring hypothesis also implies a negative relation between board independence and CEO ownership. We interpret evidence of such a relation as consistent with both the negotiation and monitoring hypotheses.

(1990) ranking of the reputation of the firm's investment banker at the time of its IPO. The negotiation hypothesis implies that board independence will be negatively related to the first two measures and positively related to the latter three. Appendix A reports on robustness tests that examine additional proxies, including the presence and holdings of outside blockholders.

3. Description of the data

3.1. Firm characteristics at the IPO

Our sample is based on all industrial firms that went public in US markets from 1988 through 1992. To be included in the sample, the IPO must involve common stock offered at a minimum price of $1.00 per share and issued through a firm-commitment underwriting agreement. In addition, the firm must be incorporated in the US at the offer date and be identified on the Center for Research in Security Prices (CRSP) daily tape as having been listed within 3 months of the offer date. These criteria yield a sample of 1,019 IPOs, which explicitly excludes IPOs by financial institutions, real estate investment trusts, and closed-end mutual funds. We then collect board and ownership data on all sample firms at the IPO and at 1, 4, 7, and 10 years after the IPO. Data at the IPO come from the offering prospectuses, and data for subsequent years come from proxy statements. These data allow us to track the evolution in board structure over time.

Panel A of Table 2 reports on the sample size from the time of the IPO until 10 years later. Many of the 1,019 IPO firms from the 1988–1992 period were delisted over time, with only 422 remaining as independent publicly traded firms 10 years after their IPOs. The annual number of firms going public increases during the 1988–1992 period, although the percentage of firms that are delisted is roughly equal across each year's cohort of IPO firms.

The reasons for the delistings are summarized in Panel B of Table 2. Very few—only 0.6%—are delisted within 1 year of the IPO. Greater proportions are delisted by year 4 relative to the IPO year. But the majority of delistings (67%) occur after year 4. Most of the delisted firms (63%) are acquired by other firms. An additional 36% are delisted because they no longer meet listing requirements. Only two firms are classified by CRSP as having liquidated.

The firms in our sample are small, averaging $150.2 million in equity value at the IPO. As a basis of comparison, the mean equity value in Denis and Sarin's (1999) sample of seasoned firms is $434.6 million. Compared to Denis and Sarin's sample, our IPO firms also have a lower mean debt-to-total assets ratio (35% vs. 56%) and higher expenditures on research and development compared to total assets (11% vs. 1.58%). These averages are consistent with the stereotype of many firms at the IPO stage: they are relatively small, financed significantly by equity capital, and actively engaged in research and development activities.

In the tables that follow we use data from all surviving firms in any given year relative to the IPO. We also recalculate our tests using data only from the 422 firms that survive through year 10. The results of such tests are virtually identical to those reported below in the tables. Thus, the changes over time that we report below do not reflect a change in the composition of the sample, but rather the general trends in ownership and board structure as firms mature from the IPO stage.

Table 2
Sample size and changes over time
This table shows the sample distribution of 1,019 firms undergoing an IPO between 1988 and 1992. The data are partitioned by the year the firm goes public, and the tables below give the number of firms with data available in years 1, 4, 7, and 10 relative to the year of the IPO.

Panel A. Sample distribution by IPO year

	Year from IPO				
IPO Year	**IPO**	**Year 1**	**Year 4**	**Year 7**	**Year 10**
1988	111	107	81	67	51
1989	116	114	94	73	52
1990	113	112	96	75	49
1991	286	285	243	178	128
1992	393	389	309	220	142
Total	1,019	1,007	823	613	422

Panel B. Reasons given by CRSP for delistings (by year of delisting)

	Year from IPO				
Reason for delisting	**Year 1**	**Year 4**	**Year 7**	**Year 10**	**Total Delistings**
Merger	3	119	137	121	380 (37%)
Exchange	0	0	1	0	1 (0%)
Delisted by Exchange	3	71	71	69	214 (21%)
Liquidation	0	0	0	2	2 (0%)
Delistings by Year	6	190	209	192	597 (59%)
No Proxy Available	*6*	*0*	*1*	*0*	

3.2. Leadership characteristics and ownership at the IPO and over time

Panel A of Table 3 reports on the evolution of ownership for the IPO firms. Officers and directors own a mean of 52% of their firm's stock and CEOs own 16%, on average, right after the IPO. The corresponding averages from Denis and Sarin's sample of seasoned firms are 16% and 7%, respectively. Ownership by officers and directors declines steadily over the 10-year period from 52% at the IPO to 25% 10 years later (but still substantially higher than the 16% found by Denis and Sarin). Average CEO ownership also drops steadily over time, from 16% after the IPO to 7% 10 years later (similar to the 7% found by Denis and Sarin for seasoned firms). Ownership by officers follows a similar decline, from 26% after the IPO to 14% at year 10. Ownership by outside directors also declines steadily over the period, from 26% to 11%. Interestingly, ownership by 5% blockholders remains fairly steady over time at about 30%, as does the number of blockholders (an average of roughly three blockholders per firm).

Panel B of Table 3 reports CEO characteristics using data on all surviving firms at each year of the analysis. The average CEO is 48 years old at the IPO, with 8 years of tenure with the firm. For 43% of firms conducting IPOs, the CEO is also the founder. By year 10 only 21% of the CEOs are firm founders. The percentage of CEOs who also serve as

Table 3
Evolution of ownership, CEO characteristics, and board structure over time

This table shows the evolution of ownership, CEO characteristics, and board structure following the IPO. Panel A shows the evolution of ownership for IPO firms. Panel B provides means for characteristics of CEOs for a sample of 1,019 IPO firms occurring from 1988–1992 from the year they go public through 10 years later. Panel C provides information on the board structure of the firms at the IPO and afterwards. *Ownership by Officers and Directors* represents the percent of total shares held by officers and directors. *Ownership by CEO* represents the percent of total shares held by the CEO. *CEO tenure* is the number of years the executive has been in the position of CEO. *CEO is Founder* is a dummy variable equal to one if the CEO is a founder of the firm. *CEO is Chairman* is a dummy variable equal to one if the CEO is also the current chairman of the board of directors. *CEO Turnover* is a dummy variable equal to one if the CEO has changed since the previous data collection period. *Percent Outside Directors* shows the percentage of board members who are not employees of the firm. *Percent Affiliated* shows the percentage of the board who are grey directors, while *Percent Unaffiliated* shows the percentage of the board who have no other affiliations with the firm. *Percent Original Directors Remaining* is the percent of the directors on the board at the IPO who are still on the board after 1, 4, 7 years, and 10 years after the IPO.

Panel A. Evolution of ownership for IPO firms

	Year from IPO				
	IPO	**Year 1**	**Year 4**	**Year 7**	**Year 10**
Ownership by Officers & Directors	52%	45%	34%	28%	25%
Ownership by CEO	16%	14%	10%	8%	7%
Ownership by Officers	26%	23%	18%	15%	14%
Ownership by Outside Directors	26%	22%	16%	12%	11%
Ownership by 5% Blockholders	31%	30%	28%	29%	29%
Number of 5% Blockholders	2.9	3.0	2.9	3.0	3.2

Panel B. Characteristics of CEOs of IPO firms over time

	Year from IPO				
	IPO	**Year 1**	**Year 4**	**Year 7**	**Year 10**
CEO Age	48	49	51	53	54
CEO Tenure	8	9	10	10	12
CEO is Founder	43%	42%	33%	25%	21%
CEO is Chairman of the Board	60%	63%	64%	62%	60%
CEO Turnover		6%	30%	25%	30%

Panel C. Board structure for IPO firms over time

	Year from IPO				
	IPO	**Year 1**	**Year 4**	**Year 7**	**Year 10**
Number of Directors	6.21	6.74	6.98	7.17	7.52
Percent Outside Directors	62%	65%	69%	71%	74%
Percent Affiliated	5%	5%	7%	7%	5%
Percent Unaffiliated	56%	60%	62%	64%	69%
Percent Original Directors Remaining		90%	67%	51%	42%

chairman of the board is fairly constant over time, ranging from 60% to 64% of firms. CEO turnover ranges from 6% in the first public year to almost 10% per year in later years (30% of all firms experience CEO turnover between year 1 and year 4, with 25% between

year 4 and year 7, and 30% between year 7 and year 10, for an average of almost 10% of firms experiencing CEO turnover each year over these periods).

Panel C of Table 3 reports on the board structure for firms at IPO and afterwards. We follow the convention in the literature of labeling directors as insiders if they are currently employees of the firm; affiliated outsiders if they have substantial business relations with the firm, are related to insiders, or are former employees; and independent outsiders if they are neither insiders nor affiliated outsiders. The average number of directors increases steadily after the IPO, starting at 6.21 in the year of the IPO and rising to 7.52 by year 10. These numbers are similar to those reported by Mikkelson, Partch, and Shah (1997), who find that the board grows from an average of six members at the IPO to seven members 10 years later. Even after 10 years, however, the mean number of directors remains smaller than the mean of 9.35 reported by Denis and Sarin or the 9.44 reported by Gillan, Hartzell, and Starks (2004) for samples of generally more seasoned firms. This result suggests that corporate boards continue to grow as a firm ages beyond 10 years.

The increase in board size reflects primarily the addition of independent outside board members, the proportion of whom grows steadily until it reaches 69% by year 10. The proportion of affiliated outsiders stays roughly constant over time, while the proportion of insiders decreases steadily to 26% by year 10. Thus, the proportion of outside representation on these firms' boards increases as they age. For seasoned firms, Denis and Sarin find that 39% are insiders, 20% are affiliated outsiders, and 40% are independent outsiders. Consistent with these findings, Gillan, Hartzell, and Starks (2004) report that the mean proportion of independent outsiders in their sample of large firms from 1997–2000 is 59%. Panel C of Table 3 also provides data on the proportion of original board members remaining with the firm. In the first year, 90% of the original board members remain with the firm. This figure declines to 67% by year 4, 51% by year 7, and 42% by year 10.

To summarize, several patterns emerge about firms' leadership structure at the time of their IPOs and in the following 10 years. CEO and insider stock ownership tends to be much greater for firms at the time of their IPOs than for seasoned corporations. IPO firms have smaller boards, on average, than seasoned firms. The proportion of insiders is roughly equal across the two samples, but firms at the time of their IPOs have a significantly greater percentage of independent outsiders. Given that firms at the IPO stage have great incentive to maximize firm value, these results indicate that small boards with a majority of independent outside directors tend to be optimal for these firms. Thus, even though agency problems in the IPO firms might be small because managers own large amounts of stock, these firms rely heavily upon independent outside directors.

In the years after the IPO, ownership by officers and directors falls, presumably as share ownership becomes more widely diffused. The number of directors increases, although not to as high a level as observed in older, seasoned firms. Firms at the IPO stage have a higher proportion of independent outsiders on their boards than do typical seasoned corporations, and this proportion increases over time.

4. Empirical methods

In the following sections we estimate multivariate regressions using panel data methods to test the scope of operations, negotiation, and monitoring hypotheses. Our primary tests are robust regressions with clusters, in which observations are clustered by firm and the

covariance matrix is estimated using the Huber (1964) or White (1980) estimator. This method allows us to exploit information in both the cross-sectional and time-series nature of the data while still controlling for the serial correlation that is observed in each firm's time series of observations.

We use two strategies to control for the fact that board size and composition are endogenous to the firm's competitive environment. First, we include industry fixed effects in all regression models. The rationale for industry fixed effects is that they control for the underlying economic environment that might jointly determine board size and independence. Firms in the same industry face similar production technologies and market conditions—the very things that give rise to the endogeneity problem in the first place. In these tests, we use Fama and French (1997) industry groupings, although the results are not substantially different when we use alternative industry definitions, such as those examined by Kahle and Walkling (1996), or when we omit the industry controls altogether.

Our second strategy to control for endogeneity is to introduce instrumental variables for board size and the proportion of independent outsiders. In these tests, the instrumental variables are these variables' lagged values. For example, for firm *j*'s observation at year 10 relative to the IPO, the instrumental variable for board size is firm *j*'s board size at year 7 (because we have data for years 0, 1, 4, 7, and 10). We include instrumental variables for board size in the tests for board independence, and for board independence in the tests for board size. It turns out, however, that including these instruments, or additional instruments for other variables that plausibly could be endogenous, does not affect the results substantially.

In Appendix A we report on a number of sensitivity tests that probe our central results regarding the choice of empirical model, the proxy variables used, and our treatments for endogeneity. For example, we estimate systems of simultaneous equations that explicitly endogenize board size and independence. We also report on two alternate tests that explicitly recognize the attenuation bias that results from the use of multiple proxy variables to test each hypothesis. All tests yield similar inferences.

In Table 4 we provide a pairwise correlation matrix of all our explanatory variables, and we discuss issues of multicollinearity in Section 5 below.

5. Empirical results

5.1. The scope of operations hypothesis

As summarized in Table 1, we use firm size, firm age, and diversification as measures of the scope and complexity of a firm's operations. The scope of operations hypothesis predicts that board size and the proportion of independent directors are positively related to all three measures. Firm size is measured as the natural log of the market value of equity as of each fiscal year-end. (Results are similar when the book value of assets is used to measure firm size.) Age is calculated as the number of years since the firm's IPO. When age is calculated as the current year minus the year of incorporation, the empirical results are qualitatively unchanged. The number of business segments reported by the firm, as carried by Compustat, is used to measure diversification.

As additional controls, we include a dummy variable equal to one for firms that made an acquisition during the previous period; lagged return on assets (ROA) as measured by

Table 4
Correlation matrix

This table provides pairwise correlations. *Firm Size* is the natural log of the market value of equity as of each fiscal year-end. *Firm Age* is the number of years since the IPO. *Nseg* is the number of business segments. *Cashflow* is free cash flow, defined as (Earnings + Depreciation–Capital Expenditures)/Total Assets. *Ind_Herf* is the Herfindahl index of industry sales using data on Compustat-listed firms. *Gindex* is measured as the firm's number of takeover defenses plus the number of state antitakeover laws that apply to the firm. *Mkt_Bk* is the log of the book value of debt plus the market value of equity divided by total assets. *HighRD* is a dummy variable equal to one for firms in the top quartile of R&D expenditures relative to firm size. *Retvar* is the variance of the firm's daily stock returns measured over the prior 12-month period. *CEOp* is the ownership percentage of the CEO, as a fraction of shares outstanding. *CEO_ten* is the number of years the CEO has been with the firm. *Outown* is the ownership percentage of the independent directors, as a fraction of shares outstanding. *VCdum* is a dummy variable equal to one for venture-backed IPOs. *Carter* is the Carter-Manaster ranking of the lead IPO underwriter. *p*-values are given in parentheses.

	Firm Size	Firm Age	Nseg	Cashflow	Ind_Herf	Gindex	Mkt_Bk	HighRD	Retvar	CEOp	CEO_ten	Outown	VCdum
Firm Age	0.20												
	(0.00)												
Nseg	0.16	0.48											
	(0.00)	(0.00)											
Cashflow	0.23	−0.02	0.03										
	(0.00)	(0.39)	(0.11)										
Ind_Herf	−0.05	0.04	0.06	−0.01									
	(0.03)	(0.07)	(0.00)	(0.68)									
Gindex	0.12	0.02	0.04	0.07	−0.05								
	0.00)	(0.27)	(0.07)	(0.00)	(0.02)								
Mkt_Bk	0.42	−0.11	−0.12	−0.15	−0.03	−0.04							
	(0.00)	(0.00)	(0.00)	(0.00)	(0.13)	(0.04)							
HighRD	−0.04	0.003	−0.10	−0.32	0.01	−0.11	0.35						
	(0.04)	(0.88)	(0.00)	(0.00)	(0.71)	(0.00)	(0.00)						
Retvar	−0.37	0.12	0.03	−0.24	0.01	−0.10	−0.08	0.15					
	(0.00)	(0.00)	(0.10)	(0.00)	(0.50)	(0.00)	(0.00)	(0.00)					
CEOp	−0.20	−0.15	−0.08	0.07	−0.03	−0.01	−0.09	−0.18	0.01				
	(0.00)	(0.00)	(0.00)	(0.00)	(0.15)	(0.63)	(0.00)	(0.00)	(0.73)				
CEO_ten	0.13	0.14	0.12	0.18	−0.01	0.12	−0.11	−0.20	−0.12	0.25			
	(0.00)	(0.00)	(0.00)	(0.00)	(0.77)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			
Outown	−0.03	−0.20	−0.07	−0.02	0.02	−0.06	−0.07	−0.11	0.03	−0.25	−0.12		
	(0.13)	(0.00)	(0.00)	(0.45)	(0.26)	(0.00)	(0.00)	(0.00)	(0.11)	(0.00)	(0.00)		
VCdum	0.01	−0.01	−0.07	−0.17	0.001	−0.10	0.25	0.47	0.09	−0.22	−0.24	−0.14	
	(0.65)	(0.54)	(0.00)	(0.00)	(0.95)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
Carter	0.40	0.005	0.03	0.10	−0.03	0.14	0.02	0.05	−0.14	−0.14	0.04	0.05	0.20
	(0.00)	(0.83)	(0.10)	(0.00)	(0.09)	(0.00)	(0.25)	(0.01)	(0.00)	(0.00)	(0.04)	(0.01)	(0.00)

operating income divided by total assets in the previous period; and dummy variables for firms with dual-class shares and for firms that went public in reverse leveraged buyouts or equity carveouts. The results are not significantly affected, however, when any of these control variables are excluded from the sample.

The results of the regressions testing the scope of operations hypothesis are reported in Table 5. In Panel A, the number of directors on the board is the dependent variable, and

Table 5
Tests of the scope of operations hypothesis

Estimated coefficients from multiple regressions using pooled data from 1,019 firms for years 1, 4, 7, and 10 after the firms' IPOs. The dependent variable in Panel A is the number of board members. The dependent variable in Panel B is the proportion of the board that consists of independent (non-affiliated) board members. *Firm Size* is the natural log of the market value of equity as of each fiscal year-end. *Firm Age* is the number of years since the IPO. *Number of Business Segments* is the number of operating segments in the company. *Lag* (*Proportion of Independent Directors*) is the percent of independent directors on the board in the previous period. *Lag* (*Number Directors*) is the number of directors on the board in the previous period. *Dummy for Previous Merger* is equal to one for firms that completed an acquisition during the previous period. *Lag* (*ROA*) is the return on assets, measured as operating income over total assets in the previous period. All regressions include industry fixed effects, controlling for industry using Fama and French (1997) industry classifications. Standard errors are computed using robust methods (alternately called the Huber or White estimator) in which observations are clustered by firm. *p*-values are given in parentheses.

Panel A. Number of board members as the dependent variable

	Model 1	**Model 2**	**Model 3**	**Model 4**
Variables Used to Test the Scope of Operations Hypothesis:				
Firm Size	0.416			0.397
	(0.000)			(0.000)
Firm Age		0.065		0.005
		(0.000)		(0.711)
Number of Business			0.095	0.060
Segments			(0.000)	(0.002)
Control Variables:				
Lag (Proportion Independent Directors)	1.039	1.311	1.332	0.931
	(0.000)	(0.000)	(0.000)	(0.001)
Dummy for Previous Merger	1.044	1.092	1.139	1.028
	(0.000)	(0.000)	(0.000)	(0.000)
Lag (ROA)	−0.311	0.064	0.054	−0.309
	(0.014)	(0.668)	(0.716)	(0.015)
Dummy for Previous Reverse LBO	0.095	0.426	0.383	0.084
	(0.526)	(0.006)	(0.016)	(0.582)
Dummy of Equity Carve-Out	0.292	0.301	0.274	0.294
	(0.169)	(0.192)	(0.241)	(0.176)
Dummy for Dual Class	0.545	0.690	0.716	0.542
	(0.045)	(0.024)	(0.022)	(0.050)
Constant	5.531	6.709	6.583	5.343
	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted R^2	0.25	0.16	0.16	0.25
Wald Test for the Joint Significance of the Scope of Operations Hypothesis Variables:			*F*-statistic (*p*-value)	56.0 (0.000)

Table 5 (*continued*)

Panel B. Proportion of independent directors on the board as the dependent variable

	Model 1	Model 2	Model 3	Model 4
Variables used To Test The Scope Of Operations Hypothesis:				
Firm Size	0.011			0.009
	(0.001)			(0.008)
Firm Age		0.007		0.006
		(0.000)		(0.000)
Number of Business Segments			0.006	0.001
			(0.000)	(0.390)
Control Variables:				
Lag (Number of Directors)	0.012	0.012	0.013	0.010
	(0.000)	(0.000)	(0.000)	(0.001)
Dummy for Previous Merger	0.023	0.022	0.025	0.016
	(0.162)	(0.205)	(0.143)	(0.338)
Lag (ROA)	−0.045	−0.036	−0.033	−0.044
	(0.000)	(0.003)	(0.006)	(0.000)
Dummy for Previous Reverse LBO	0.074	0.082	0.081	0.076
	(0.000)	(0.000)	(0.000)	(0.000)
Dummy of Equity Carve-Out	0.037	0.039	0.034	0.036
	(0.032)	(0.022)	(0.050)	(0.038)
Dummy for Dual Class	−0.037	−0.037	−0.032	−0.037
	(0.075)	(0.077)	(0.126)	(0.083)
Constant	0.476	0.478	0.484	0.459
	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted R^2	0.19	0.20	0.19	0.20
Wald Test for the Joint Significance of the Scope of Operations Hypothesis Variables:			*F*-statistic	19.8
			(*p*-value)	(0.000)

the lagged value of the proportion of independent outsiders is included as an instrumental variable to control for endogeneity. In Models 1–3, each of the measures of firm scope is entered separately, and all three are positively and significantly related to board size. These results are consistent with the scope of operations hypothesis.

In Model 4, all three measures are included together. This, however, almost surely biases the estimated coefficients toward zero because, as reported in Table 4, all three measures are positively correlated. This attenuation bias results from estimating one structural coefficient with multiple proxies. Noting this bias, Lubotsky and Wittenberg (2007) argue that "Putting multiple proxies in the regression may likely result in many insignificant individual coefficients." Even with such a bias, however, firm size and the number of business segments remain significantly related to board size. A Wald test of the joint significance of the three measures is significant at the 1% level. These results indicate that board size is indeed correlated with the scope and complexity of the firm's operations.

Panel B of Table 5 reports results when the proportion of independent outsiders is the dependent variable. As reported in Models 1–3, the coefficients for all three measures of scope and complexity are positive and significant at the 1% level when each is entered separately. When all are entered together, as in Model 4, the coefficients all are positive,

and those for firm size and age remain statistically significant. A Wald test for the joint significance of the three variables has a p-value of less than 0.01. Overall, these results support the scope of operations hypothesis, which holds that corporate boards increase in size and independence as firm operations grow, mature, and become more complex.

Although not the focus of our study, the results for the control variables yield further insight into the forces that shape corporate boards. Recent merger activity, for example, is associated with larger boards, most likely as representatives from the acquired firm's board are added to the merged firm's board. And the proportion of insiders is negatively related to lagged ROA, indicating that firms respond to poor operating performance by increasing the proportion of outsiders on the board.

5.2. The monitoring hypothesis

We use seven different variables to test the monitoring hypothesis. The first three measure managers' opportunities for private benefits. Free cash flow is measured as the firm's earnings plus depreciation minus capital expenditures, all divided by assets. Industry concentration is the Herfindahl index of industry sales using data on Compustat-listed firms. Takeover defenses are measured using a variation of Gompers, Ishii, and Metricks (2003) G-index. In our variation, G is the firm's number of takeover defenses plus the number of state antitakeover laws that apply to the firm as of its IPO year. The takeover defenses and state antitakeover laws are those defined and tracked by Field and Karpoff (2002).

The rationale for free cash flow is provided by Jensen's (1986) argument that free cash flow generates agency conflicts, as managers have incentives to use it for private benefits rather than to create shareholder wealth. The rationale for industry concentration is that, as Gillan, Hartzell, and Starks (2004) argue, managers of firms with market power could be subject to less market discipline and are better able to extract private benefits than managers of firms in highly competitive industries. Likewise, higher levels of the G-index indicate a greater amount of insulation from the external market for control and a greater opportunity for managers to extract private benefits.[3] We reason that managers' opportunities to extract private benefits increase with all three of these measures, increasing the net benefits of increased board monitoring. The monitoring hypothesis predicts that board size and independence are positively related to these three variables.

We use four variables to measure the cost to outsiders of monitoring the firm's managers. The log of the market-to-book ratio is defined as the natural log of the ratio of the sum of the book value of debt and the market value of equity to the book value of assets. High R&D is a dummy variable that is set equal to one for firms whose R&D expenditures as a percentage of assets ranks in the upper quartile of the sample. The stock return variance is the variance of the daily logarithmic stock return measured over the prior 12-month period. The CEO's share ownership is measured as the proportion of the firm's currently outstanding shares owned by the CEO. The monitoring hypothesis predicts that board size and independence are negatively related to these four variables.

[3]Reverse causality is a potential issue here, as managers with large private benefits may encourage the firm's directors to adopt many takeover defenses. For our purposes, however, any reverse causality is not a problem, since we simply seek a variable that is correlated with, and hence provides a measure of, managers' potential to extract private benefits.

The rationale for the first three measures is similar. Firms with high log market-to-book ratios or high research and development expenses tend to have significant growth opportunities, which are more costly for outsiders to monitor and verify than are assets in place. Similarly, the cost of monitoring managers is likely to increase with the volatility of the firm's stock price, because volatility reflects background uncertainty about the firm's prospects and performance and increases the difficulty of judging managers' performance.[4]

The rationale for CEO ownership is that, as Demsetz and Lehn (1985) and Himmelberg, Hubbard, and Palia (1999) argue, the CEO can hold a large ownership stake to mitigate the agency problem that arises from a costly monitoring environment. Thus, although CEO ownership might not directly increase the costs of monitoring, its endogenous correlation with monitoring costs makes it a reasonable proxy for such costs.[5]

The empirical results for board size are reported in Table 6. In Models 1–7, each of the seven explanatory measures is entered separately. As predicted, board size is positively and significantly related to free cash flow, industry concentration, and the takeover defense *G*-index, and negatively related to R&D expenditures, the return variance, and CEO ownership. The coefficient for the log market-to-book ratio, however, is statistically insignificant. When all seven variables are entered simultaneously, as in Model 8, the coefficients for industry concentration, the takeover defense *G*-index, R&D expenditures, stock return variance, and CEO ownership remain statistically significant at the 5% level or better.

We also estimate a model that includes all seven variables for the monitoring hypothesis plus the three variables used to test the scope of operations hypothesis. The results are reported as Model 9. The majority of coefficients are similar to those from other models. The market-to-book ratio becomes negative and significant as predicted by the monitoring hypothesis. The coefficients for free cash flow and firm age, however, switch signs and are not consistent with the monitoring and scope of operations hypotheses, respectively. Such sign switches could be a symptom of the multicollinearity that results from including multiple proxy variables for each hypothesis. In addition, the instability of the free cash flow coefficient could reflect Jensen's (1993) argument that smaller boards can help ameliorate agency costs, particularly when free cash flow is large. This argument implies that, even if the monitoring benefits of additional board members increase with free cash flow, the coordination and free-riding costs increase even faster. That is, free cash flow serves as a proxy for the cost of monitoring as well as the benefits of monitoring. If this is the case, high free cash flow could lead a firm to decrease, rather than increase, its board size.

In calculating the Wald test statistics of joint significance for the monitoring and scope of operations variables from Model 9, we omit free cash flow and firm age. The Wald statistics for the joint significance of the remaining coefficients are significant at the 1% level.

[4]Similar arguments and measurements are made by Yermack (1995), Smith and Watts (1992), Bizjak, Brickley, and Coles (1993), Gaver and Gaver (1993), Kole (1997), Klein (1998), Brick and Chidambaran (2005), Lehn, Patro, and Zhao (2005), and Coles, Daniel, and Naveen (2007).

[5]We thank the referee for pointing out this effect of CEO ownership. This prediction also is consistent with Raheja's (2005) model, which predicts a negative relation between CEO ownership and board size and independence because higher managerial ownership decreases private benefits to insiders by better aligning their incentives with those of the shareholders.

Table 6
Tests of the monitoring hypothesis: predictions for board size

Estimated coefficients from multiple regressions using pooled data from 1,019 firms for years 1, 4, 7, and 10 after the firms' IPOs. The dependent variable is the number of board members. *Free Cash Flow* is defined as (Earnings + Depreciation−Capital Expenditures) scaled by Total Assets. *Industry Concentration* is measured as the Herfindahl index of industry sales using data on Compustat-listed firms. *Takeover Defense* (*G-index*) is measured as the firm's number of takeover defenses plus the number of state antitakeover laws that apply to the firm. *Ln* (*Market-to-Book*) is the log of the book value of debt plus the market value of equity, divided by total assets. *High R&D* is a dummy variable for firms in the top quartile of R&D expenditures relative to firm size. *Return Variance* is the variance of the firm's daily stock returns measured over the prior 12-month period. *CEO Ownership* is the proportion of the firms' outstanding shares owned by the CEO. *Firm Size* is the natural log of the market value of equity as of each fiscal year-end. *Firm Age* is the number of years since the IPO. *Number of Business Segments* is the number of operating segments in the company. *Dummy for Previous Merger* is equal to one for firms that completed an acquisition during the previous period. *Lag* (*ROA*) is the return on assets, measured as operating income over total assets in the previous period. All regressions include industry fixed effects, controlling for industry using Fama and French (1997) industry classifications. Standard errors are computed using robust methods (alternately called the Huber or White estimator) in which observations are clustered by firm. *p*-values are given in parentheses.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**
Variables Used to Test the Monitoring Hypothesis:									
Free Cash Flow	0.445							0.120	−0.537
	(0.007)							(0.494)	(0.003)
Industry		3.123						2.685	1.436
Concentration		(0.007)						(0.025)	(0.215)
Takeover Defense			0.100					0.082	0.045
(*G*-index)			(0.000)					(0.000)	(0.035)
Ln (Market-to-Book)				0.041				0.036	−0.622
				(0.608)				(0.657)	(0.000)
High R&D					−0.568			−0.591	−0.481
					(0.000)			(0.000)	(0.001)
Return Variance						−80.546		−71.35	−10.95
						(0.000)		(0.000)	(0.367)
CEO Ownership							−2.054	−2.120	−1.394
							(0.000)	(0.000)	(0.000)
Variables Used to Test the Scope of Operations Hypothesis:									
Firm Size									0.514
									(0.000)
Firm Age									−0.029
									(0.043)
Number of Business Segments									0.038
									(0.033)

Control Variables:									
Lag (Proportion	1.507	1.466	1.423	1.518	1.624	1.469	1.072	1.108	0.636
Indep. Directors)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.020)
Dummy for	1.172	1.194	1.178	1.161	1.139	1.164	1.172	1.165	1.014
Previous Merger	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lag (ROA)	−0.059	0.068	0.004	0.090	−0.016	−0.036	0.130	−0.204	−0.435
	(0.694)	(0.643)	(0.975)	(0.550)	(0.915)	(0.799)	(0.408)	(0.186)	(0.002)
Dummy for	0.378	0.412	0.392	0.400	0.291	0.338	0.344	0.159	−0.135
Previous Reverse LBO	(0.016)	(0.008)	(0.010)	(0.011)	(0.072)	(0.027)	(0.029)	(0.313)	(0.377)
Dummy for Equity	0.307	0.287	0.323	0.307	0.342	0.288	0.227	0.281	0.267
Carve-Out	(0.188)	(0.215)	(0.158)	(0.187)	(0.140)	(0.140)	(0.333)	(0.224)	(0.237)
Dummy for Dual	0.708	0.719	0.701	0.723	0.703	0.702	0.941	0.881	0.606
Class	(0.021)	(0.018)	(0.022)	(0.019)	(0.022)	(0.018)	(0.002)	(0.002)	(0.026)
Constant	6.980	6.357	6.718	6.933	6.918	7.163	7.666	7.083	5.644
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted R^2	0.15	0.15	0.16	0.15	0.16	0.16	0.18	0.22	0.30
Wald Test for the Joint Significance of the Monitoring Hypothesis Variables (in Model 9):								*F*-statistic	15.0
								(*p*-value)	(0.00)
Wald Test for the Joint Significance of the Scope of Operations Hypothesis Variables (in Model 9):								*F*-statistic	71.1
								(*p*-value)	(0.00)

Tests of predictions of the monitoring hypothesis for board independence are summarized in Table 7. For brevity, Table 7 reports results from a single regression in which all seven measures are entered simultaneously. Also included are the variables used to test the scope of operations hypothesis. Board independence is negatively related to the

Table 7
Tests of the monitoring hypothesis: predictions for board independence

Estimated coefficients from multiple regressions using pooled data from 1,019 firms for years 1, 4, 7, and 10 after the firms' IPOs. The dependent variable is the proportion of the board that consists of independent board members. *Free Cash Flow* is defined as (Earnings + Depreciation − Capital Expenditures) scaled by Total Assets. *Industry Concentration* is measured as the Herfindahl index of industry sales using data on Compustat-listed firms. *Takeover Defense* (*G-index*) is measured as the firm's number of takeover defenses plus the number of state antitakeover laws that apply to the firm. *Ln*(*Market-to-Book*) is the log of the book value of debt plus the market value of equity, divided by total assets. *High R&D* is a dummy variable for firms in the top quartile of R&D expenditures relative to firm size. *Return Variance* is the variance of the firm's daily stock returns measured over the prior 12-month period. *CEO Ownership* is the proportion of the firms' outstanding shares owned by the CEO. *Firm Size* is the natural log of the market value of equity as of each fiscal year-end. *Firm Age* is the number of years since the IPO. *Number of Business Segments* is the number of operating segments in the company. *Lag*(*Number of Directors*) is the number of directors on the board in the previous period. *Dummy for Previous Merger* is equal to one for firms that completed an acquisition during the previous period. *Lag* (*ROA*) is the return on assets, measured as operating income over total assets in the previous period. Regression includes industry fixed effects, controlling for industry using Fama and French (1997) industry classifications. Standard errors are computed using robust methods (the Huber or White estimator) in which observations are clustered by firm. *p*-values are given in parentheses.

	Coefficient (*p*-value)
Variables Used to Test the Monitoring Hypothesis:	
Free Cash Flow	0.009 (0.592)
Industry Concentration	−0.055 (0.629)
Takeover Defense (*G*-index)	0.001 (0.745)
Ln(Market-to-Book)	−0.021 (0.018)
High R&D	0.048 (0.001)
Return Variance	−1.172 (0.476)
CEO Ownership	−0.217 (0.000)
Variables Used to Test the Scope of Operations Hypothesis:	
Firm Size	0.008 (0.067)
Firm Age	0.004 (0.002)
Number of Business Segments	0.002 (0.246)
Control Variables:	
Lag (Number of Directors)	0.007 (0.022)
Dummy for Previous Merger	0.023 (0.208)
Lag (ROA)	−0.040 (0.001)
Dummy for Previous Reverse LBO	0.070 (0.000)
Dummy for Equity Carve-Out	0.026 (0.136)
Dummy for Dual Class	−0.014 (0.573)
Constant	0.595 (0.000)
Adjusted R^2	0.24
Wald Test for the:	***F*-statistic (*p*-value)**
Joint Significance of the Monitoring Hypothesis Variables	7.5 (0.000)
Joint Significance of the Scope of Operations Hypothesis Variables	10.9 (0.000)

market-to-book ratio and CEO ownership (significant at the 5% level), but the other coefficients are not statistically significant and the R&D level has a positive coefficient, which is inconsistent with the monitoring hypothesis. The Wald test for the monitoring variables, excluding the High R&D variable, indicates that the monitoring hypothesis does help explain the cross-sectional variation in board independence. As reported in Table 8, however, the monitoring hypothesis variables jointly are significant at only the 10% level when variables for the negotiation hypothesis are included.

Table 8
Tests of the negotiation hypothesis: predictions for board independence

Estimated coefficients from multiple regressions using pooled data from 1,019 firms for years 1, 4, 7, and 10 after the firms' IPOs. The dependent variable is the proportion of the board that consists of independent (non-affiliated) board members. *CEO Tenure* is the number of years that the CEO has been with the firm. *CEO Ownership* is the proportion of the firms' outstanding shares owned by the CEO. *Outside Director Ownership* is the proportion of the firms' outstanding shares owned by the independent directors. *Dummy for Venture Backing* is a dummy variable equal to one if a venture capital investor owned an equity stake at the IPO. *Carter-Manaster Underwriter Rank* is the ranking of the lead IPO underwriter. *Firm Size* is the natural log of the market value of equity as of each fiscal year-end. *Firm Age* is the number of years since the IPO. *Number of Business Segments* is the number of operating segments in the company. *Free Cash Flow* is defined as (Earnings + Depreciation − Capital Expenditures) scaled by Total Assets. *Industry Concentration* is measured as the Herfindahl index of industry sales using data on Compustat-listed firms. *Takeover Defense* (*G-index*) is measured as the firm's number of takeover defenses plus the number of state antitakeover laws that apply to the firm. *Ln* (*Market-to-Book*) is the log of the book value of debt plus the market value of equity, divided by total assets. *High R&D* is a dummy variable for firms in the top quartile of R&D expenditures relative to firm size. *Return Variance* is the variance of the firm's daily stock returns measured over the prior 12-month period. *Lag*(*Number of Directors*) is the number of directors on the board in the previous period. *Dummy for Previous Merger* is equal to one for firms that completed an acquisition during the previous period. *Lag* (*ROA*) is the return on assets, measured as operating income over total assets in the previous period. All regressions include industry fixed effects, controlling for industry using Fama and French (1997) industry classifications. Standard errors are computed using robust methods (alternately called the Huber or White estimator) in which observations are clustered by firm. *p*-values are given in parentheses.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Variables Used to Test the Negotiation Hypothesis:							
CEO Tenure	−0.002					−0.001	−0.002
	(0.000)					(0.182)	(0.007)
CEO Ownership		−0.242				−0.168	−0.115
		(0.000)				(0.000)	(0.003)
Outside Director			0.141			0.101	0.156
Ownership			(0.000)			(0.000)	(0.000)
Dummy for Venture				0.111		0.085	0.089
Backing				(0.000)		(0.000)	(0.000)
Carter-Manaster					0.019	0.007	0.004
Underwriter Rank					(0.000)	(0.022)	(0.296)
Variables Used to Test the Scope of Operations Hypothesis:							
Firm Size							0.006
							(0.172)
Firm Age							0.008
							(0.000)
Number of Business							0.002
Segments							(0.144)

Table 8 (*continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Variables Used to Test the Monitoring Hypothesis:							
Free Cash Flow							−0.002
							(0.912)
Industry							−0.053
Concentration							(0.617)
Takeover Defense							0.003
(G-index)							(0.134)
Ln (Market-to-Book)							−0.013
							(0.146)
High R&D							0.025
							(0.085)
Return Variance							−3.239
							(0.042)
Control Variables:							
Lag (Number of	0.014	0.011	0.014	0.014	0.011	0.010	0.005
Directors)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.081)
Dummy for Previous	0.039	0.033	0.030	0.028	0.031	0.038	0.025
Merger	(0.033)	(0.063)	(0.097)	(0.084)	(0.081)	(0.031)	(0.159)
Lag (ROA)	−0.031	−0.031	−0.024	−0.027	−0.051	−0.029	−0.028
	(0.011)	(0.011)	(0.050)	(0.018)	(0.000)	(0.019)	(0.019)
Dummy for Previous	0.084	0.068	0.071	0.085	0.063	0.063	0.065
Reverse LBO	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dummy for Equity	0.039	0.030	0.011	0.078	0.046	0.043	0.027
Carve-Out	(0.028)	(0.079)	(0.531)	(0.000)	(0.011)	(0.016)	(0.125)
Dummy for Dual	−0.031	−0.008	−0.044	−0.014	−0.042	−0.007	−0.015
Class	(0.135)	(0.730)	(0.037)	(0.489)	(0.047)	(0.751)	(0.524)
Constant	0.557	0.616	0.502	0.505	0.503	0.566	0.504
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted R^2	0.18	0.21	0.20	0.25	0.20	0.27	0.31
Wald Test for the Joint Significance of the Negotiation Hypothesis Variables (Model 7): *F*-statistic (*p*-value)							31.6 (0.000)
Wald Test for the Joint Significance of the Scope of Operations Hypothesis Variables (Model 7): *F*-statistic (*p*-value)							20.2 (0.000)
Wald Test for the Joint Significance of the Monitoring Hypothesis Variables (Model 7): *F*-statistic (*p*-value)*							1.9 (0.096)

*Note that High R&D is excluded from *F*-test and CEO Ownership is included under the negotiation hypothesis here.

5.3. The negotiation hypothesis

As summarized in Table 1, we use two sets of variables to test whether the composition of the board reflects a negotiation between the CEO and outside board members. CEO job tenure and CEO share ownership measure the CEO's influence in the negotiation. CEO tenure is the number of years in which the CEO has held a position with the firm. CEO ownership is the fraction of outstanding shares owned by the CEO. Outside director ownership, venture capital investment, and investment bank reputation measure the

constraints on the CEO's influence. Outside director ownership is the percent of outstanding shares owned by independent outside directors. The venture capital dummy variable is set to one if a venture capital investor owned an equity stake at the IPO, and investment bank reputation is measured by the bank's Carter-Manaster rank at the time of the firm's IPO. The negotiation hypothesis predicts that board independence is negatively related to CEO job tenure and ownership, and positively related to outside director ownership, venture capital investment, and investment bank reputation.

The results are reported in Table 8. In Models 1–5, each of the five measures is included separately. All five are significantly related to board independence in the predicted direction, providing support for the negotiation hypothesis.

In Model 6, all five measures are included together. Once again, this introduces an attenuation bias in the coefficient estimates due to the multicollinearity of the proxy variables (see the correlations in Table 4). Nevertheless, all variables except CEO tenure remain significantly related to board independence in Model 6. Model 7 also includes the regressors used to test the scope of operations and monitoring hypotheses. All five measures used to test the negotiation hypothesis have the predicted signs, and all but the Carter-Manaster rank are statistically significant. The Wald test indicates that the five variables are jointly significant at the 1% level. Overall, these results provide strong support for the negotiation hypothesis.

In Model 7, the variables used to test the scope of operations hypothesis have the same sign as the results reported in Table 5, Panel B (although only firm age is significant); the Wald test indicates joint significance of these three variables. Only return variance and CEO ownership have the predicted and significant signs for the monitoring hypothesis variables, and the High R&D measure has the wrong sign, similar to the results in Table 7. We run a Wald test for the monitoring hypothesis, but exclude CEO ownership (since it was included in the negotiation hypothesis) and High R&D (since it has the incorrect sign). The Wald test for the remaining monitoring hypothesis variables is not significant (p-value = 0.096). Overall, we interpret the data as providing support for both the scope of operations and negotiation hypotheses but little support for the monitoring hypothesis regarding board independence.

Note that two of our measures, the venture capital dummy and the Carter-Manaster rank, are measured at the time of the IPO. Baker and Gompers (2003) argue that the IPO is a particularly ripe time to investigate the negotiation hypothesis. This is because many firms' boards undergo significant changes around the IPO, and any negotiating influence that a CEO has will come into play at such times. Our results indicate that such measures of influence *at the time of the IPO* are useful in explaining board independence even in the years after the IPO. In tests not shown here, we test the negotiation hypothesis separately for each year in our sample. In these tests, we find that CEO tenure, the venture capital dummy, and ownership by outside directors, *when measured at the IPO*, are significant in explaining board independence even 7 years later! CEO tenure at the IPO is significant at the 1% level in explaining the proportion of outside directors even 10 years later. This evidence implies that a CEO's influence at the time of the IPO affects the board's composition in future years.

5.4. Discussion

Alchian (1950) argues that firm characteristics that facilitate success tend to survive the competitive process. This implies that board size and composition adapt endogenously to

facilitate firm success, and that boards tend to be structured efficiently. Many of our results are consistent with this view. In particular, both board size and independence reflect the scope and complexity of the firm's operations, and board size is sensitive to the benefits and costs of monitoring managers.

The interpretation of the negotiation hypothesis, however, is ambiguous. As Hermalin and Weisbach (1998) argue, the CEO's influence over board composition could be part of his or her compensation for generating quasi-rents for the firm. This is consistent with the view that boards tend to be structured efficiently, and with Brick, Palia, and Wang's (2005) finding that firm value is unrelated to board independence, which they interpret as indicating that board independence is endogenous to the firm's environment. An alternate view, however, is that powerful CEOs pack their boards for personal gain and at shareholder expense. That is, CEOs' influence on their boards might reflect a cost of agency rather than an efficient form of compensation.

The results in Tables 6 and 7 can be used to shed some light on these competing interpretations of the negotiation hypothesis. If boards are structured to facilitate managers' extraction of private benefits at shareholder expense, board monitoring should be low particularly when the opportunity for private benefits is high. That is, board size and independence should be negatively related to managers' opportunities to consume private benefits. The results in Tables 6 and 7, however, fail to support this view. With one exception, the proxies for managers' opportunities to consume private benefits are positively or insignificantly related to board size and board independence. The exception is the negative coefficient for cash flow in Model 9 of Table 6. But, as discussed previously, this coefficient estimate is sensitive to the model specification.

Overall, we interpret these results as consistent with the view that board size and independence reflect endogenous and efficient adjustments to the firm's operating environment. This interpretation, however, must be qualified on two accounts. First, the results are inconsistent with the monitoring hypothesis with regard to board independence. This undermines the view that board independence reflects a balancing of the benefits and costs of monitoring senior managers. And second, much of the cross-sectional variation in board size and independence remains unexplained. The adjusted *R*-squares for our most inclusive models in Tables 6 and 8, for example, are only 0.30 and 0.31. The low explanatory power could be due to imperfect proxies or improperly specified models. Alternatively, it could reflect a large idiosyncratic component to board composition that our hypotheses do not capture.

6. The magnitude of impacts on board size and independence

The data indicate that board size and independence depend on proxies for the firm's scope of operations, the CEO's influence and constraints on such influence, the opportunities for private benefits, and the cost of monitoring managers. But just how large are these effects?

To investigate this question, we use the coefficients estimated in Tables 5–8 to fit values for board size and independence when all regressors are set at their mean values. For each regressor that is significantly related to board size or independence, we then perturb that regressor by one standard deviation—leaving all other regressors at their mean values—to calculate the predicted change for the dependent variable.

The results are summarized in Table 9. Using fitted values from Model 1 in Table 5A, a one-standard-deviation increase in firm size predicts a 0.70 increase in the number of board members. Using coefficients from Model 2 in Table 5A, a one-standard-deviation increase in the years since the firm's IPO increases board size by 0.21 members, and (using coefficients from Model 3) a one-standard-deviation increase in the number of business segments increases board size by 0.22 members. Thus, among the three measures used to investigate the scope of operations hypothesis, perturbations in firm size have the largest impact on board size.

Among the measures used to investigate the monitoring hypothesis, perturbations in industry concentration, the takeover *G*-index, R&D intensity, the return variance, and CEO ownership have the largest impact on the predicted number of board members. A one-standard-deviation increase in CEO ownership is associated with a decrease in board size of 0.41 members, while a one-standard-deviation increase in the takeover *G*-index predicts an increase in board size by 0.25 members, and a one-standard-deviation increase

Table 9
Economic impact of variables for the three hypotheses in Tables 5–8

This table reports on the economic impact of each variable used to test the three hypotheses in Tables 5–8. Specifically, coefficient estimates from Tables 5–8 are used to fit values for board size and independence when all regressors are set at their mean values. We then perturb each key explanatory variable by one standard deviation—leaving all other regressors at their mean values—to calculate the predicted change in the dependent variable. The numbers indicate the effect of a one-standard-deviation change in the explanatory variable on board size (measured in # of people) or the proportion of independent board members (measured in percentage points). Results are reported for each key explanatory that, when isolated, is significantly related to board size (or independence).

	Board Size (# of people)	Board Independence (change in %)
Tests of the Firm Scope of Operations Hypothesis:		
Firm Size	0.70	1.79%
Firm Age	0.21	2.36%
Number of Business Segments	0.22	1.33%
Tests of the Monitoring Hypothesis:		
Free Cash Flow	0.12	(a)
Industry Concentration	0.23	(a)
Takeover Defense (*G*-index)	0.25	(a)
Market-to-Book	(a)	(a)
High R&D	−0.25	1.94%
Return Variance	−0.25	(a)
CEO Ownership*	−0.41	n/a*
Tests of the Negotiation Hypothesis:		
CEO Tenure	n/a	−1.89%
CEO Ownership	n/a	−4.83%
Outside Director Ownership	n/a	3.15%
Venture Capital Backing	n/a	5.42%
Carter-Manaster Ranking	n/a	2.92%

*For tests of board independence, CEO ownership is included under the negotiation hypothesis. For tests of board size, CEO ownership is included under the monitoring hypothesis, as there is no prediction for board size under the negotiation hypothesis. (a) Coefficient not significant in regression, so economic significance not computed.

in either R&D intensity or return variance predicts a decrease in board size by 0.25 members. A one-standard-deviation increase in industry concentration predicts an increase of 0.23 members on the board.

The third column in Table 9 reports on the perturbation tests when board independence is the dependent variable. A one-standard-deviation increase in firm size predicts an increase in the proportion of independent board members of 1.8 percentage points, while the number of years since the IPO predicts an increase of 2.4 percentage points. A one-standard-deviation increase in the number of business segments predicts an increase of 1.3 percentage points. For the negotiation hypothesis, a one-standard-deviation increase in CEO tenure decreases the proportion of independent directors by 1.9 percentage points, while a one-standard-deviation increase in CEO ownership decreases the proportion of independent directors by 4.8 percentage points. A one-standard-deviation increase in outside director ownership, venture capital backing, and the Carter-Manaster ranking predict increases of 3.2, 5.4, and 2.9 percentage points in the proportion of independent directors, respectively. As mentioned earlier, the variables for the monitoring hypothesis have minimal impact on board independence. Only two of the seven variables tested are significant when entered separately (not shown in Table 8)—the R&D measure and CEO ownership (note however, CEO ownership is included under the negotiation hypothesis). A one-standard-deviation increase in the R&D measure predicts a 1.9 percentage point increase in the proportion of independent directors.

Overall, these results indicate that many factors contribute to board size and independence. Firm size has the largest impact on board size, and the presence of venture capital backing has the largest impact on board independence, but such other characteristics as CEO ownership, firm age, the number of business segments, the presence of a takeover defense, R&D intensity, and stock return variance also are important economically as well as statistically.

7. Conclusion

We examine the development of corporate boards during the first 10 years after a firm's IPO. We find that firms average three fewer directors at IPO than do large, seasoned firms (6.2 vs. 9.4). These new firms add an average of 0.13 board members per year during the 10 years after the IPO. This moves their boards closer in size to those for large seasoned firms, but after ten years the average board remains relatively small (7.5 vs. 9.4). Boards of these IPO firms have a majority (56%) of independent outsiders, and continue to add independent outsiders such that, 10 years later, 69% are independent outsiders. The increase in the proportion of independent outsiders occurs even as one important type of outsider—venture capital investors—tends to leave the board.

We then use these data to test for the forces that shape corporate boards. Much of the cross-sectional variation in board size and independence is idiosyncratic, as the *R*-squares of our empirical models do not exceed 0.31. Nonetheless, several persistent patterns are robust to alternate model specifications. In particular, we find that: (i) larger, more seasoned, and more diverse firms have larger and more independent boards; (ii) firms in which managers' opportunities to consume private benefits are large, or in which the cost of monitoring managers is small, have larger boards; and (iii) firms in which managers have substantial influence and in which the constraints on managerial influence are weak, have less independent boards.

These results indicate that board size and independence are shaped by a broad combination of firm-specific and managerial characteristics—exactly what we expect if board composition is the endogenous result of a competitive process. To the extent board structure is endogenous, most firms' boards are tailored to suit their unique competitive environment. Simple rules or guidelines to reform board governance, such as limits on board size or insider representation, therefore are unlikely to enhance value for most firms.

Appendix A. Alternative tests of the hypotheses

This appendix reports the results of several tests that probe the robustness of the results reported in Tables 5–8 with regard to the estimation procedure and the choice of proxy variables.

A.1. A binomial test

In Tables 5–8 we introduce different proxy variables sequentially, following a common form of presentation when more than one proxy variable is used to test a hypothesis (e.g., Brickley, Linck, and Coles, 1999). This avoids the attenuation bias from introducing multiple proxies for a single hypothesis. But it also risks introducing omitted variable biases. To examine whether such biases affect our results, we conduct two alternative tests.

In the first test we estimate a series of regressions in which each hypothesis is represented by a single proxy variable. There are, in total, three proxy variables for the scope of operations hypothesis, five for the negotiations hypothesis, and seven for the monitoring hypothesis. Both the scope of operations and monitoring hypotheses yield predictions for board size. Each proxy for the scope of operations (say, firm size) is thus paired with each of the seven proxies for the monitoring hypothesis in seven separate tests of both hypotheses. In all, this implies $3 \times 7 = 21$ separate regressions for board size. Since all three hypotheses yield predictions about board independence, there are a total of $3 \times 5 \times 7–3 = 102$ unique combinations of proxies testing all three hypotheses together. (The reason that the number is not $3 \times 5 \times 7 = 105$ is that one variable, CEO ownership, is used as a proxy for both the negotiation and monitoring hypotheses.)

The results are summarized in Table A1. For tests of board size, firm size appears in seven separate regressions (one for each of the proxies for the monitoring hypothesis). The firm size coefficient is positive and significant at the 1% level in all seven regressions. The same is true for the firm age variable in all seven of the regressions in which it is used as the proxy for the scope of operations hypothesis, and also for the number of business segments in all seven of its regressions. Under the null hypothesis that none of the three proxies is related to board size, the likelihood that 21 out of 21 coefficients would be significant at the 1% level is $(0.01)^{21} = 10^{-42}$. We conclude that the observance of 21 significant coefficients is not due to chance, and reject the null in favor of the scope of operations hypothesis.

Likewise, the coefficients for the monitoring hypothesis are significant at the 1% level in 13 out of the 21 regressions and two are significant at the 5% level (with the predicted signs). Under the null hypothesis that none of the seven proxies is significantly related to board size (and assuming independence), the likelihood of observing 13 or more significant coefficients is 1.9×10^{-21}, which is very close to zero. Thus, this binomial test also indicates that the monitoring hypothesis helps explain board size.

The results for tests of board independence are in Panel B of Table A1. The results strongly support the scope of operations and negotiation hypotheses. For example, all of the coefficients to test the negotiation hypothesis are significant at the 1% level. Under the null hypothesis that none of the negotiation hypothesis proxies is related to board independence, the likelihood of observing 102 or more significant coefficients is $(0.01^{102}) = 10^{-204}$. In contrast, only 28 of the 102 proxies for the monitoring hypothesis variables are significantly related to board independence, and most of these are for CEO ownership and the High R&D variable. Thus, the monitoring hypothesis does not, in general, explain board independence. These results are qualitatively the same as those summarized in Tables 5–8.

A.2. Principal components tests

In a second alternate test, we use principal components to transform the group of proxy variables for each hypothesis into a smaller number of factors that contain the same

Table A1
A Binomial test based on coefficients in which each hypothesis is represented by one proxy variable

This table summarizes the results of 21 separate regressions for Panel A and 102 regressions for Panel B. In each regression, one unique proxy represents each of the three main hypotheses. There are, in total, three different proxy variables used for the scope of operations hypothesis, seven for the monitoring hypothesis, and five for the negotiation hypothesis (used only to explain board independence). The entries in the table report the number of regressions in which a given proxy variable's coefficient is significant at the 1%, 5%, or 10% level. Thus, for example, in Panel A the firm size coefficient is significant at the 1% level in all seven regressions in which firm size is included. Control variables are included in all regressions but not shown. All variables are defined in Table 8.

Panel A: Number of board members as the dependent variable

Panel A provides tests on board size, in which 21 unique regressions are run. One example of such a regression includes firm size to represent the scope of operations hypothesis and free cash flow to represent the monitoring hypothesis. Another regression includes firm size and industry concentration. In all, firm size is included in seven regressions, whereby each regression sequentially also includes one of the monitoring proxies. Likewise, each monitoring hypothesis proxy is included three times, whereby each one sequentially is paired with one of the scope of operations proxies. The cells show the number of regressions in which each regressor is significant. The total number of regressions that include each variable is given in the far right column.

Explanatory Variables	Number of Coefficients Significant at Each Level: 1%	5%	10%	Not Significant	# Regressions Including Variable
Variables Used to Test the Scope of Operations Hypothesis:					
Firm Size	7	0	0	0	7
Firm Age	7	0	0	0	7
No. of Business Segments	7	0	0	0	7
Variables Used to Test the Monitoring Hypothesis:					
Free Cash Flow	1	1	0	1	3
Industry Concentration	0	1	0	2	3
Takeover Defense (G-index)	3	0	0	0	3
Ln (Market-to-Book)	1	0	0	2	3
High R&D	3	0	0	0	3
Return Variance	2	0	0	1	3
CEO Ownership	3	0	0	0	3

Table A1 (*continued*)

Panel B: Proportion of independent directors on the board as the dependent variable

Panel B provides tests on board independence, in which 102 unique regressions are run, each including one proxy variable per hypothesis. When testing for board independence, we include three different hypotheses: we examine three different proxies for the scope of operations hypothesis, five proxies for the negotiation hypothesis, and seven proxies for the monitoring hypothesis (note that CEO ownership is used as a proxy for both the negotiation and monitoring hypotheses, leaving a total of $3 \times 5 \times 7-3 = 102$ unique combinations, each representing one regression). One example of such a regression includes firm size to proxy for the scope of operations hypothesis, CEO tenure to proxy for the negotiation hypothesis, and free cash flow to proxy for the negotiation hypothesis. Another example is a regression that includes firm size for the scope of operations hypothesis, CEO ownership for the negotiation hypothesis, and free cash flow for the monitoring hypothesis. Thus, we sequentially include one proxy for each hypothesis until all combinations are exhausted, leaving a total of 102 different regressions. The cells below show the number of regressions in which the coefficient for a given proxy variables is statistically significant. The total number of regressions run for each variable is given in the far right column. (Control variables are included but not shown.)

Explanatory Variables	Number of Coefficients Significant at Each Level:				# Regressions Including Variable
	1%	5%	10%	Not Significant	
Firm Size	16	11	0	7	34
Firm Age	34	0	0	0	34
No. of Business Segments	34	0	0	0	34
Variables Used to Test the Monitoring Hypothesis:					
Free Cash Flow	0	0	1	14	15
Industry Concentration	0	1	1	13	15
Takeover Defense (G-index)	0	0	0	15	15
Ln (Market-to-Book)	4	1	0	10	15
High R&D	11	1	0	3	15
Return Variance	1	1	1	12	15
CEO Ownership[a]	12	0	0	0	12
Variables Used to Test the Negotiation Hypothesis:					
CEO Tenure	21	0	0	0	21
CEO Ownership[a]	18	0	0	0	18
Outside Director Ownership	21	0	0	0	21
Dummy for Venture Backing	21	0	0	0	21
Carter-Manaster Ranking	21	0	0	0	21

[a]CEO ownership regressions run for both the negotiation and monitoring hypotheses. For regressions where CEO ownership was chosen simultaneously for both hypotheses, CEO ownership entered the regression only once and was counted toward the negotiation hypothesis (three occurrences).

information as the original proxy variables. The first principal component for the scope of operations hypothesis, for example, is the linear combination of the three variables used to test this hypothesis (firm size, firm age, and the number of business segments) that accounts for the highest proportion of their variance. The second principal component is the orthogonal linear combination of the three proxy variables that explains the highest proportion of the remaining variation.

Following the practice originally proposed by Kaiser (1960), we use all principal components whose eigenvalues exceed one (i.e., that have more explanatory power than

any one of the original proxies by itself). This gives us a single factor for the scope of operations hypothesis, three different factors for the negotiation hypothesis, and four factors for the monitoring hypothesis.

The results from the principal components tests are summarized in Table A2. Panel A shows the eigenvectors for each variable included in each factor with eigenvalues over one.

Table A2
Principal components analysis

Panel A provides results from principal components analysis (PCA) used to transform the proxy variables for each hypothesis into a smaller number of factors. For each hypothesis, the first factor is the linear combination of variables used to test the hypothesis accounting for the highest proportion of their variance, while the second factor is the orthogonal linear combination of the variables explaining the highest proportion of the remaining variation. We include only factors with eigenvalues exceeding one. In Panel A, we show the factors determined by PCA, the eigenvectors associated with each variable, and the proportion of variation explained by each factor. In Panels B and C we use these factors as explanatory variables in regressions of board size and independence.

Panel A: Factors derived for each hypothesis from principal components analysis

	Hypothesis:				
	Scope of Ops	**Negotiation**		**Monitoring**	
	Factor 1	**Factor 1**	**Factor 2**	**Factor 1**	**Factor 2**
Scope of Operations Hypothesis					
Ln (Total Assets)	0.388				
Firm Age	0.662				
No. of Business Segments	0.641				
Proportion Explained	*53%*				
Negotiation Hypothesis					
Insiders' Influence:					
CEO Tenure		0.707			
CEO Ownership[a]		0.707			
Proportion Explained		*63%*			
Outsiders' Influence:					
Outside Director Ownership		−0.296	0.847		
Dummy for Venture Backing		0.736	−0.093		
Carter-Manaster Ranking		0.610	0.523		
Proportion Explained		41%	35%		
Monitoring Hypothesis					
Private Benefits:					
Free Cash Flow				0.633	0.431
Industry Concentration				−0.338	0.901
Takeover Defense (*G*-index)				0.697	0.045
Proportion Explained				*37%*	*33%*
Monitoring Costs (including CEO Ownership):					
Ln (Market-to-Book)				0.611	−0.282
High R&D				0.681	0.168
Return Variance				0.079	0.944
CEO Ownership[a]				−0.396	0.041
Proportion Explained				*48%*	*35%*
Monitoring Costs (excluding CEO Ownership):					
Ln (Market-to-Book)				0.690	−0.300
High R&D				0.717	0.163
Return Variance				0.096	0.940
Proportion Explained				*45%*	*35%*

Table A2 (*continued*)

Panel B: Regression of board size using principal components factors from panel A

Panel B provides results of robust regressions of board size using the principal components factors from Panel A above as explanatory variables for the scope of operations and monitoring hypotheses (the monitoring hypothesis factors here include CEO ownership). Control variables are defined in Table 8. Standard errors are computed using the White estimator in which observations are clustered by firm. *p*-values are given in parentheses.

Explanatory Variable	Coefficient (*p*-value)
Scope of Operations Hypothesis:	
Scope of Operations Factor	0.316 (0.000)
Monitoring Hypothesis:	
Private Benefits Factor #1	0.189 (0.001)
Private Benefits Factor #2	−0.070 (0.418)
Monitoring Costs Factor #1	−0.020 (0.714)
Monitoring Costs Factor #2	−0.232 (0.000)
Control Variables:	
Lag (Proportion Independent Directors)	1.089 (0.000)
Dummy for Previous Merger	1.144 (0.000)
Lag (ROA)	−0.303 (0.049)
Dummy for Previous Reverse LBO	0.243 (0.124)
Dummy for Equity Carve-Out	0.332 (0.155)
Dummy for Dual Class	0.635 (0.038)
Constant	7.034 (0.000)
Adjusted R^2	0.22

Panel C: Regression of board independence using principal components factors from panel A

Panel C provides results of robust regressions of board independence using the principal components factors from Panel A above as explanatory variables for the scope of operations, monitoring, and negotiation hypotheses (the monitoring hypothesis factors here exclude CEO ownership). Control variables are defined in Table 8. Standard errors are computed using the White estimator in which observations are clustered by firm. *p*-values are given in parentheses.

Scope of Operations Hypothesis:	
Scope of Operations Factor	0.019 (0.000)
Monitoring Hypothesis:	
Private Benefits Factor #1	0.004 (0.481)
Private Benefits Factor #2	−0.005 (0.532)
Monitoring Costs Factor #1	0.001 (0.894)
Monitoring Costs Factor #2	−0.002 (0.617)
Negotiations Hypothesis:	
Insiders' Influence Factor	−0.030 (0.000)
Outsiders' Influence Factor #1	0.026 (0.000)
Outsiders' Influence Factor #2	0.029 (0.000)
Control Variables:	
Lag (Number of Directors)	0.005 (0.102)
Dummy for Previous Merger	0.029 (0.101)
Lag (ROA)	−0.044 (0.001)
Dummy for Previous Reverse LBO	0.059 (0.000)
Dummy for Equity Carve-Out	0.026 (0.154)
Dummy for Dual Class	−0.018 (0.423)
Constant	0.613 (0.000)
Adjusted R^2	0.28

[a]CEO ownership is included in both the negotiation and monitoring hypotheses. For regressions testing board independence, we use monitoring costs without CEO ownership (since CEO ownership enters in through the negotiations hypothesis). For tests of board size, we use monitoring costs with CEO ownership since the negotiation hypothesis is not used.

Panel B contains the regression results for board size using the relevant factors for each hypothesis as exogenous variables, as well as the control variables used in Tables 5–8. Panel C contains similar regression results for board independence.

As shown in Panel A, the scope of operations hypothesis has one factor, which is a linear combination of firm size, firm age, and the number of business segments. There are three factors for the negotiation hypothesis—one factor measuring insiders' influence, which is a combination of CEO tenure and ownership, and two factors measuring outsiders' influence, a combination of outside director ownership, venture capital backing, and underwriter rank. The monitoring hypothesis is captured by four factors—two measuring private benefits, which are combinations of free cash flow, industry concentration, and the *G*-index, and two factors measuring monitoring costs, which are combinations of market-to-book, R&D expenditures, return variance, and CEO ownership (note: CEO ownership is not included in tests that also contain the negotiation hypothesis).

As shown in Panel B, the scope of operations principal component is positively related to board size (the coefficient equals 0.32 with a *t*-statistic of 9.58). Board size also is significantly positively related to the first private benefits principal component and significantly negatively related to second cost of monitoring principal component (the other two monitoring hypothesis factors are insignificant). These results are consistent with those reported previously: board size is positively related to the scope and complexity of the firm's operations. It also is positively related to managers' opportunities to extract private benefits and negatively related to the cost of monitoring managers.

In Panel C, the proportion of independent board members is negatively related to the insiders' influence factor and positively related to the scope of operations principal component and also to the two outsiders' influence factors of the negotiation hypothesis. These outsiders' influence factors reflect primarily the constraints on managers' influence, as represented by the percent of outside directors' shareholdings, the presence of a venture capital investor at the IPO, and the Carter-Manaster ranking of the firm's lead underwriter at its IPO. These results are also similar to those reported previously: board independence is positively related to the scope and complexity of the firm's operations and also to the constraints on managers' influence, as implied by the negotiation hypothesis.

A.3. Simultaneous equations estimation

The tests reported in Tables 5–8 control for the endogeneity of board size and independence using industry controls and instrumental variables. Another method to control for endogeneity is to specify a structural model that explicitly endogenizes board size and independence, and to estimate the structural model using simultaneous (two-stage) equation methods. The results of such an approach are provided in Table A3.

We model board size in Panel A of Table A3. In the first stage we create an instrument for board independence that is used in the second stage, where board size is the endogenous variable. To identify the structural model, we need at least one variable related to board independence but not board size. We use the negotiation hypothesis variables: CEO tenure, outside director ownership, venture backing, and the Carter-Manaster underwriter rank as our identifying variables. As argued previously, we expect each of these variables to affect board independence but not necessarily board size.

We model board independence in Panel B of Table A3. In the first stage we create an instrument for board size that is used in the second stage, where board independence is the endogenous variable. To identify the structural model, we use a dummy variable that equals one if the firm has acquired another company (“Dummy for Previous Merger”). We reason that new board members can join the board from the acquired firm, which would affect board size. However, it is not clear whether these new board members would be insiders or outsiders of the acquiring firm.

Table A3
Two-stage least squares regressions

Estimated coefficients from two-stage least squares regressions using pooled data from 1,019 firms for years 1, 4, 7, and 10 after the firms' IPOs. We use a two-stage approach to control for possible endogeneity between board size and board independence. In Panel A, we create an instrument for board independence (the fitted value from the first stage regression), which then is utilized as an independent variable for the second stage, in which board size is the endogenous variable. In Panel B, we create an instrument for board size (the fitted value from the first stage regression), which then is utilized as an independent variable for the second stage, in which board independence is the endogenous variable. All variables are defined in Table 8. Standard errors are computed using the White estimator in which observations are clustered by firm. *p*-values are given in parentheses.

Panel A: Number of board members as the dependent variable

	First-Stage	Second-Stage
Exogenous Variables:	***Endogenous Variable:*** **Board Independence**	**Endogenous Variable: Board Size**
Instrument for Board Independence		0.084 (0.946)
Variables Used to Test the Scope of Operations Hypothesis:		
Firm Size	0.008 (0.017)	0.516 (0.000)
Firm Age	0.008 (0.000)	−0.028 (0.073)
Number of Business Segments	0.002 (0.161)	0.045 (0.016)
Variables Used to Test the Monitoring Hypothesis:		
Free Cash Flow	−0.005 (0.744)	−0.524 (0.008)
Industry Concentration	−0.055 (0.640)	1.266 (0.300)
Takeover Defense (*G*-index)	0.003 (0.017)	0.040 (0.074)
Ln (Market-to-Book)	−0.015 (0.038)	−0.626 (0.000)
High R&D	0.024 (0.030)	−0.451 (0.014)
Return Variance	−3.280 (0.006)	−8.477 (0.533)
CEO Ownership	−0.125 (0.000)	−1.436 (0.002)
Variables Used to Test the Negotiation Hypothesis:		
CEO Tenure	−0.002 (0.000)	
Outside Director Ownership	0.157 (0.000)	
Dummy for Venture Backing	0.087 (0.000)	
Carter-Manaster Ranking	0.004 (0.120)	
Control Variables:		
Dummy for Previous Merger	0.024 (0.240)	0.958 (0.000)
Lag (ROA)	−0.030 (0.017)	−0.436 (0.003)
Dummy for Previous Reverse LBO	0.064 (0.000)	−0.119 (0.530)
Dummy for Equity Carve-Out	0.028 (0.037)	0.291 (0.208)
Dummy for Dual Class	−0.011 (0.462)	0.556 (0.047)
Constant	0.127 (0.124)	7.156 (0.000)
Adjusted R^2	**0.29**	**0.29**

Panel B: Proportion of independent directors on the board as the dependent variable

	First-Stage	Second-Stage
Exogenous Variables:	***Endogenous Variable:*** **Board Size**	***Endogenous Variable:*** **Board Independence**
Instrument for Board Size		0.026 (0.175)
Variables Used to Test the Scope of Operations Hypothesis:		
Firm Size	0.551 (0.000)	−0.006 (0.573)
Firm Age	−0.014 (0.329)	0.008 (0.000)
Number of Business Segments	0.047 (0.011)	0.001 (0.541)
Variables Used to Test the Monitoring Hypothesis:		
Free Cash Flow	−0.519 (0.006)	0.008 (0.678)
Industry Concentration	0.516 (0.701)	−0.069 (0.531)
Takeover Defense (*G*-index)	0.044 (0.004)	0.002 (0.342)
Ln (Market-to-Book)	−0.652 (0.000)	0.002 (0.919)
High R&D	−0.294 (0.018)	0.031 (0.061)
Return Variance	−13.258 (0.330)	−2.937 (0.076)
Variables Used to Test the Negotiation Hypothesis:		
CEO Ownership	−1.120 (0.000)	−0.096 (0.027)
CEO Tenure	−0.011 (0.024)	−0.001 (0.042)
Outside Director Ownership	0.852 (0.000)	0.135 (0.000)
Dummy for Venture Backing	−0.351 (0.000)	0.096 (0.000)
Carter-Manaster Ranking	−0.018 (0.544)	0.005 (0.219)
Control Variables:		
Dummy for Previous Merger	0.941 (0.000)	
Lag (ROA)	−0.367 (0.010)	−0.021 (0.163)
Dummy for Previous Reverse LBO	−0.155 (0.148)	0.068 (0.000)
Dummy for Equity Carve-Out	0.005 (0.975)	0.028 (0.135)
Dummy for Dual Class	0.422 (0.011)	−0.022 (0.378)
Constant	4.030 (0.000)	0.351 (0.014)
Adjusted R^2	**0.28**	**0.27**

The simultaneous equations generate statistically weaker results than in any of our other tests. In Table A3, for example, firm age, industry concentration, and return variance are not significantly related to board size (Panel A), and firm size, the number of business segments, and the Carter-Manaster rank of the underwriter are not significantly related to board independence (Panel B). Overall, however, the simultaneous equation models support the results reported in Tables 5–8. Board size and independence generally increase with the scope of the firm's operations. Consistent with the negotiation hypothesis, board independence also decreases with the CEO's influence and increases with constraints on such influence. Consistent with the monitoring hypothesis, board size generally increases with the benefits to monitoring managers and decreases with the cost of such monitoring.

A.4. Panel data robustness checks

Our data consist of a cross-sectional, time-series panel. In the main tests we control for lack of independence among observations from the same firm by estimating robust regressions with clusters based on firms. An alternative test procedure is to use a random-effects

GLS model. This procedure, however, yields results that are qualitatively identical to those reported in Tables 5–8. We also estimate year-by-year cross-sectional regressions and calculate Fama and MacBeth (1973) regression coefficients. Having only a short time series that consists of four years (years 1, 4, 7, and 10 relative to the IPO year), the Fama and MacBeth coefficients sometimes have higher significance levels than those reported in Tables 5–8, but the point estimates are similar.

A.5. Alternate control variables, instrumental variables, and proxy variables

In another set of sensitivity tests we include additional control variables that might affect board size and independence, such as debt-to-total assets, sales growth, the CEO's age, whether or not the CEO is the chairman, and whether or not the CEO is the company founder. We also include instrumental variables for some of the regressors that could be endogenous to board size and independence, such as CEO ownership, CEO tenure, the firm's takeover defense *G*-index, and outside director ownership. (As discussed in Section 4, the endogeneity of some of the proxy variables does not raise inference problems in our context, since we test for correlations rather than causation.) The large majority of the results are unaffected by these additional controls. The statistical significance of some variables, including firm age and the number of business segments, decreases in some specifications. For example, CEO tenure is no longer significant when we add additional CEO control variables to Model 7 of Table 6, but this is due to a high correlation between CEO tenure and CEO age.

Two sensitivity tests yield noteworthy results. First, we find that outside director ownership is significantly related to board independence. This is consistent with Raheja's (2005) model, which implies that board size is positively related to outside director ownership because it increases the incentive for outsiders to monitor projects. Second, in some model specifications the proportion of shares held by 5% blockholders who also have a representative on the board is positively related to both board size and board independence. This indicates that when blockholders obtain board representation, they do so by increasing board size rather than displacing other board members. This result also supports Kieschnick and Moussawi's (2004) argument that outside blockholders constrain the CEO's ability to place insiders on the board.

Finally, we examine whether the results are sensitive to our industry definitions or our specific controls for endogeneity. Using Compustat industry definitions rather than Fama and French industries does not affect the results. Eliminating industry controls altogether increases the statistical significance of some coefficients, but does not change our overall inferences. Likewise, eliminating the instrumental variables (e.g., lagged board independence in the board size regressions) increases the significance of some coefficients. If anything, our controls for endogeneity tend to control away some of the very relations we seek to test. The fact that most of these relations are statistically significant even when the controls are included, as reported in the tables, indicates that these are not artifacts of our model specifications.

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