A Learning-Based Approach to Evaluating Boards of Directors

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Abstract

Uncertainty about a firm's governance is reflected in its stock return volatility. A model of learning about director ability implies that the magnitude of the decline in volatility over a director's tenure is a function of his value impact. This paper uses this prediction from the theory to develop a learning-based approach to evaluating corporate boards. Its estimates suggest that directors have real value effects and that governance accounts for a substantial part of stock return volatility. I revisit the literature on boards using this novel framework and provide new evidence on attributes not previously studied. Among other findings, I show that the value of independent directors depends on the degree to which firms are insulated from the market for corporate control and that incoming directors on well compensated boards have more impact on firm value.

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Key Words: Board of directors, corporate governance, Bayesian learning, director turnover, director attributes, idiosyncratic volatility

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Introduction

Boards of directors are critical pillars in corporate governance. The board is legally responsible for governing the firm and protecting the interests of shareholders. Yet, there has been a debate going back to Smith (1776) and Berle and Means (1932) about whether boards of directors are monitors of, or are tools of management.[1] How does one measure whether boards of directors make a difference in the fortunes of a typical corporation? If they do make a difference, how can we quantify the extent to which boards affect value? Are there systematic patterns in effectiveness between certain kinds of boards?

These questions have been addressed to some extent, but the literature often yields conflicting evidence and lacks a unified framework. In this paper, I propose a novel approach to addressing these questions based on a theoretical model of learning. I develop a general method to assess how the market reacts to the appointments of new directors which relies on the idea that every time a director takes an action, it provides information about his quality that is incorporated into the stock price. As investors become more acquainted with their new board, they update their assessment of the board's quality to a lesser extent. The resolution of governance-related uncertainty leads to a decline in stock return volatility.

I first present a formal model of this process, based on Pastor and Veronesi (2003) as applied to management by Pan, Wang and Weisbach (2015). The model yields intuitive testable predictions which motivate the empirical analysis. First, if directors affect firm value, volatility should decline over their tenure, and it should decline more at the beginning of their tenure. Second, the extent of the decline depends on the extent to which directors participate in value creation. Indeed, the interplay between the extent to which a director's ability is uncertain and his marginal value is what affects the volatility of stock returns and drives the analysis. By controlling for *ex-ante* uncertainty, I can relate the magnitude of

[1] Smith (1776) wrote: "The Directors of [joint stock] companies, however, being the managers of other people's money rather than their own, it cannot be expected that they should watch over it with the same anxious vigilance [as owners]… Negligence and profusion, therefore, must always prevail, more or less, in the management of the affairs of such a company." ([1937] p.700). One hundred fifty-six year later, Berle and Means (1932) argued: "…control will tend to be in the hands of those who select the proxy committee and by whom, the election of directors for the ensuing period will be made. Since the proxy committee is appointed by existing management, the latter can virtually dictate their successors." (p. 87).

the decline in volatility with the marginal value of different kinds of directors. The model therefore provides a theoretical framework to assess which kinds of directors are more value relevant. Further, the model is useful to quantify the portion of volatility related to the uncertainty about the firm's governance.

I estimate this model using a sample of 25,355 directors and 2,297 firms, taken from the intersection of S&P 1,500 firms in BoardEx, CRSP and Compustat during the 2000-2012 period. The estimates indicate that when a director joins a board, stock return volatility spikes and then declines over time. This implies that learning about boards lowers volatility, presumably by reducing governance-related uncertainty. The decline provides empirical support for the assumption that investors expect board members to be a source of value creation. Controlling for determinants of volatility, the estimates imply that the resolution of uncertainty leads monthly idiosyncratic volatility to decline by about 3% over the first three years of tenure.

An important concern with this interpretation is the potential endogeneity of director appointments. In particular, firms could reshuffle their boards during times of crisis, when volatility tends to be high. I employ two strategies to address endogeneity concerns. First, I consider a sample of appointments specifically designed to satisfy the new board independence-listing requirement set by the stock exchanges in the early 2000s. Many firms had to initiate board changes to comply with these new requirements and these appointments are unlikely to coincide systematically with a time when the firm’s fundamental volatility is high. Second, I present results isolating directors appointed to replace a retiring board member. Restricting the sample to retiree replacements yields a sample of board turnovers that are likely exogenous to firm conditions. For these two samples of exogenous director appointments there is a distinct spike in volatility when new directors join, followed by a decline, suggesting that the pattern in the overall sample is not the result of the endogeneity of director appointments.

A series of additional tests confirm that the documented volatility patterns surrounding director appointments reflect investor learning about governance rather than some other factor. First, consistent with the idea that the decline in volatility subsequent to director appointments reflects learning, volatility declines over average board tenure for young boards but does not for mature boards. There is presumably

more uncertainty about the quality of young boards than there is about seasoned boards, which supports the idea that the decline in volatility reflects the resolution of this uncertainty. Second, I run the analysis using all firm-months instead of using the first years of director tenure to test the volatility-tenure relationship. The results indicate that volatility declines significantly over the first three years of director tenure, but does not outside this window. Third, the decline in volatility over the first three years is sharpest for a sample of directors for which *ex-ante* uncertainty is especially high compared to a sample of directors for which it is low. This exercise gives further credence to the idea that the decline in volatility indeed reflects learning about the ability of new directors. Fourth, tests excluding CEOs and controlling for CEO tenure show that investor learning about directors does not merely reflect learning about the CEO, but is an independent effect occurring due to director uncertainty. Finally, a matched sample confirms that the drop in volatility exceeds what would be observed for firms that do not experience the arrival of a new director. All these findings are consistent with the notion that the spike and subsequent decline in stock return volatility following director appointments reflect uncertainty about the value that the new directors are expected to generate for their firm.

The model has implications about the portion of overall volatility attributable to the uncertainty about the board. I use the methodology developed in Pan et al. (2015) based on the average decline in volatility, the average volatility at the time a new director joins and the average corporate dividend growth to show that when a director joins, the uncertainty about his ability accounts for about 9% to 14% of overall stock return volatility. These estimates indicate that when corporate directors join a board, governance-related uncertainty accounts for a substantial percentage of overall stock return volatility.

In the second part of this paper, I use the learning-based approach cross-sectionally to revisit part of the literature on corporate boards and to test new hypotheses on director and board attributes previously not examined in the literature. I use two different approaches to that end. The first relies on interaction variables to examine how some director, board or firm characteristics affect the volatility-tenure relationship. The second is based on the concept of learning slopes. Both approaches examine the

value impact differential of variables pertaining to the new director's position on the board, his personal characteristics, his area of expertise, as well as board and firm level attributes.

First, I focus on whether directors with different positions on the board have different importance, as measured by the decline in stock return volatility over their tenure. The results suggest that chairmen and members of the compensation and audit committees are expected to have significantly more impact on firm value than the average director, whereas members of nomination committees do not. Directors sitting on all three committees are especially valuable. These findings shed new light on the channels through which board members impact firm value. There is no evidence that independent directors have a stronger effect on value creation in general. However, consistent with evidence in Masulis, Ruzzier, Xiao and Zhao (2012) and Faleye, Hoitash and Hoitash (2012), independent directors with industry expertise do. In addition, investors expect independent directors joining "dictatorships", as characterized by their high G-index (see Gompers, Ishii and Metrick, 2003) to be more important. Accounting for endogeneity, Karpoff, Schonlau and Wehrly (2015) provide empirical evidence that a high G-index is significantly associated with a lower likelihood of takeover. Therefore, this indicates that when firms are highly insulated from the market for corporate control, independent directors and the monitoring services they provide are valuable. Hence, monitoring services by boards of directors may substitute for a firm's weak external governance mechanisms. This is consistent with findings in Gillan, Hartzell and Starks (2011) who report that powerful boards are substitute for the market for corporate control.

Second, I examine personal director attributes. The results show that female board members do not contribute to firm value as much as their male counterparts on average. There is however suggestive evidence that female directors are valuable when firms' monitoring needs are acute, which is consistent with evidence in Adams and Ferreira (2009) and Adams, Gray, and Nowland (2012). Director nationality is on average value irrelevant, although a foreign director joining an American only board is associated with lower marginal value. Whether the director is busy (i.e. sits on three or more boards) is value irrelevant for the average firm. However, busy directors are beneficial to young firms in need of advisory services. This result is in line with Field, Lowry and Mkrtchyan (2013). Director connections appear to

matter, although the effect is restricted to chairmen, for whom larger business networks are associated with higher marginal value. Directors with a background in human resources are associated with significantly lower contribution and there is weak statistical evidence that technology experts, directors with financial expertise, lawyers, directors with previous CEO experience and directors with board experience in the same industry have more value impact. The fact that relevant board experience is only marginally significant suggests that director skills are not easily transferable from one firm to another.

Third, I analyze the effect of board level attributes. Boards with powerful CEOs (i.e. CEOs with at least five years of tenure who cumulate the titles of CEO, President and Chairman of the board) are *de facto* potentially more entrenched. The results based on the learning-induced changes in volatility indicate that entrenched boards, as captured by CEO power, contribute less to firm value, consistent with Coles, Daniel and Naveen (2014), who find that co-opted boards are less effective monitors. Among other proxies, Coles, Daniel and Naveen (2015) use the percentage of directors with long tenures as a proxy for groupthink. The authors find that groupthink is detrimental for firm value in dynamic industries. Consistent with their finding, I find that groupthink is associated with decreased director participation to value creation. This result supports growing voices in the market for the need of board refreshment.[2] In addition, directors joining small boards affect value more than those joining large boards. Boards with a high Board Pay Slice, i.e. boards that compensate their directors generously relative to their CEO, play a larger role in value creation. This finding sheds new light on the role of director compensation. Incoming directors on gender-diverse boards are associated with a lower contribution to firm value. A possible interpretation of this result is that the monitoring role of the new director is discounted when a woman already sits on the board, as women are better monitors (see Adams and Ferreira, 2009 and Schwartz-Ziv, 2015).

Finally, I examine the effect of firm characteristics on the expected marginal value of directors. The findings indicate that investors consider directors on the boards of small firms to engage more in

[2] In a speech from April 2015, Patrick S. McGurn, executive vice president and special counsel at ISS stressed the importance of board refreshment in governance assessments.

value creating activities than the marginal director in large firms. Investors have higher expectations with regard to the contribution of new directors when their firm has recently performed poorly relative to the industry. The results also indicate that directors are more valuable in more complex, human capital-intensive industries, which corroborates the findings in Coles, Daniel and Naveen (2015) who show that groupthink is particularly detrimental in dynamic industries. In addition, incoming directors on firms with a higher G-index are associated with a significantly lower impact on firm value. This result implies that for the average firm (not necessarily "dictatorships" as defined in Gompers et al., 2003), market participants do not anticipate internal governance mechanisms to serve as a substitute for weaker external governance. Rather, when firms use more takeover defenses, investors seem to believe that the average director plays a limited role in value creation.

Next, I compute the learning slope for each director-firm pair, by estimating the average decline in volatility over the course of director tenure, over and above the variation in volatility predicted by firm level covariates and macroeconomic factors. I use these learning slopes as a metric to evaluate directors. Studying the determinants of learning slopes is a complementary approach to the interaction variables methodology described above. Both approaches are directly derived from the theoretical framework and both approaches yield similar results, which further supports the idea that the decline in volatility following director appointments ought to be the consequence of market learning.

This paper contributes to the literature in three ways. First, it provides a new methodological approach to assessing the extent to which boards of directors have real effects. Second, it provides an estimate of the overall importance of boards of directors on stock price movements when there is a board change. Finally, this paper applies this new approach to propose a unified framework to examine any director or board characteristic, thereby identifying which are value relevant. I confirm prior findings and test new hypotheses pertaining to characteristics previously not studied in the literature.

The paper continues as follows. Section 1 reviews the related literature. Section 2 introduces the theoretical framework and describes the econometric model and data. Section 3 presents empirical results for the volatility-director tenure relationship and estimates the proportion of volatility imputable to the

governance-related uncertainty. Section 4 uses the learning-based methodology cross-sectionally to measure the extent to which different types of directors and boards affect value. Section 5 concludes.

1. Related literature

Although the study of boards of directors holds a prominent place in corporate finance research, the literature leaves the question of the value of boards of directors unresolved, mainly due to endogeneity concerns, as highlighted in Adams, Hermalin and Weisbach (2010). Early empirical work on boards of directors focuses on how board characteristics affect firm profitability. One of the questions most often raised addresses the composition of the board and in particular whether more independent directors increases firm performance or value (e.g. Hermalin and Weisbach, 1991; Bhagat and Black, 2000). Much of the literature on boards examines the relationship between board characteristics and board actions. For example, researchers extensively study how board composition or size impact CEO turnover (Weisbach, 1988; Yermack, 1996; Wu, 2000), takeover probabilities (Shivdasani, 1993), or CEO compensation (Core et al., 1999). More recently, the literature has evolved to focus on the role of director networks and ties (Barnea and Guedj, 2007; Kuhnen, 2009; Fracassi and Tate, 2012). Finally, empirical studies have also looked at the dynamics of board composition (Shivdasani and Yermack, 1999; Baker and Gompers, 2000).

Theoretical work on boards of directors includes Hermalin and Weisbach (1998) who use a model of bargaining power between the board and the CEO, in which the structure of the board and its actions are derived endogenously. Harris and Raviv (2008) present a model that determines the optimal control of corporate boards as a function of the importance of insiders' and outsiders' information and the extent of agency problems.

A substantial part of the literature, reviewed in Yermack (2006), studies abnormal returns around director appointments. Recent articles using this methodology include Adams et al. (2012) who examine market reactions to female directors' appointments. They find that gender is value-relevant as on average, the market reacts positively to the appointment of female directors, particularly for firms that need more

monitoring. Masulis et al. (2012) show that appointments of independent directors with industry expertise are associated with a significant positive abnormal return, while appointments of independent director without industry expertise are not. Fich and Shivdasani (2006) find that the market reacts positively to the departure of busy directors.

Articles directly estimating the value of the board include Richardson, Tuna and Wysocki (2003), who use a sample of directors with multiple directorships and find evidence that supports the idea that directors are important in explaining firms' governance, financial, disclosure and strategic policy choices. Larcker et al. (2013) investigate the role of directors by studying the effects of social networks. Their findings suggest that corporate boards are important in shaping firm performance. Fernau (2013) finds that the variation in firm performance is partially attributable to director fixed effects and the study conducted by Schwartz-Ziv and Weisbach (2013) provides a rare opportunity to understand the workings of boards. Their analysis suggests that in addition to monitoring top executives, board members also do play an active management role when necessary.

In a recent innovative paper, Denis, Denis and Walker (forthcoming) build on the intuition in Hermalin and Weisbach (2014) and show that in addition to the monitoring and advising roles put forth in the literature, corporate boards also have an assessment responsibility: they have to learn about the quality of the CEO and his match with the firm. Using spinoff transactions to explore the formation of boards, the authors find that board composition depends on the need for CEO assessment. Their results provide empirical evidence that learning about managerial competence is an important determinant of the structure of corporate boards.

In this paper, the assessment activities are performed not by the board but by investors, who learn about new directors. Using a methodological approach based on a Bayesian learning model, this paper provides estimates of the value of directors and studies the value relevance of director attributes and board characteristics on firm value. The theoretical framework derived in this paper draws on the work by Harris and Holmström (1982), Murphy (1986), Gibbons and Murphy (1992), and Holmström (1999) in the context of learning about managerial ability. Using a sample of CEO turnovers, Pan et al. (2015)

implement the logic set up by Pastor and Veronesi (2003) to study learning about CEO ability. These two papers together lay the groundwork for the examination of the dynamics of stock return volatility following a change in the composition of the board.

2. A learning model of board quality: theoretical framework and empirical implementation

2.1. Bayesian learning

This section develops the theoretical framework of rational learning that motivates the empirical analysis in this paper. The learning model relies on the theoretical work of Pastor and Veronesi (2003). The setup is similar to the stylized model in Pan et al. (2015), which is altered here to accommodate a multi-director framework. It features market participants who update their beliefs about the ability of newly appointed directors. The model serves the purpose of characterizing the relationship between the uncertainty surrounding the appointment of new directors, director value and stock price volatility. The model generates the following predictions:

1) Volatility decreases in a convex manner over director tenure.
2) If director ability affects firm value, then return volatility increases with uncertainty about ability.
3) If director ability is uncertain *ex-ante*, then return volatility increases with the value impact of directors.

In the model, the ability of directors refers to their capacity to facilitate the generation of cash flows. When newly appointed directors join a board, their personal aptitude and capacity to influence this particular board are uncertain, as is the degree of complementarity between their expertise and that of current board members. The uncertainty surrounding the ability of new board members resolves over time as these parameters are gradually revealed to the market.

In the model, dividend growth follows a geometric Brownian motion:

$$\frac{dD_{it}}{D_{it}} = \left(\sum_{j=1}^{n} \alpha_j^i\right)dt + \sigma dW_t \qquad (1)$$

where D_{it} represents dividend for firm *i* at time *t*,

$\sum_{j=1}^{n} \alpha_j^i$ represents the sum of directors' unobserved abilities, which affects the average dividend growth rate,

σ represents dividend growth volatility.

Director *j* has the ability α_j^i to contribute to the generation of cash flows for firm *i*. This ability is unknown and unobservable but subject to learning. The ability of each director is assessed by investors over time. For each firm, the sum of directors' assessed abilities may be thought of as investors' assessment of the quality of the board. The ability of a director may depend on firm characteristics, i.e. the ability of a director on the board of firm A may differ from his ability on the board of firm B. For example, a director with relevant experience in an industry may contribute more to firm value on the board of a firm in that industry than on the board of a firm that operates in an industry in which he has no experience.

It is assumed that there is symmetric information (see Holmström, 1999; Gibbons and Murphy, 1992; Berk and Green, 2004 and Chung, Sensoy, Stern and Weisbach, 2012 for symmetric information about managers' abilities). Assuming that α_j^i follows a truncated normal distribution with prior mean $\theta_{j,0}^i$ and variance $\delta_{j,0}^{i2}$ and that director abilities are independent and identically distributed, individual assessed ability at time *t* is normally distributed:

$$\alpha_{j,t}^i \sim N\left(\theta_{j,t}^i, \delta_{j,t}^{i2}\right), \qquad \alpha_{j,t}^i < r \tag{2}$$

The sum of assessed abilities also follows a normal distribution:

$$\sum_{j=1}^{n} \alpha_{j,t}^i \sim N\left(\sum_{j=1}^{n} \theta_{j,t}^i, \sum_{j=1}^{n} \delta_{j,t}^{i2}\right) \tag{3}$$

Under these assumptions, Bayesian updating by market participants leads to posterior assessments of directors' ability (Pastor and Veronesi, 2003):

$$d\left(\sum_{j=1}^{n}\theta_{j,t}^{i}\right) \approx m_t\left[\frac{dD_{i,t}}{D_{i,t}} - \left(\sum_{j=1}^{n}\theta_{j,t}^{i}\right)dt\right] \quad (4)$$

$$with \quad m_t = \frac{\sum_{j=1}^{n}\delta_{j,t}^{i2}}{\sigma^2} = \frac{\sum_{j=1}^{n}\delta_{j,0}^{i2}}{\sigma^2+\left(\sum_{j=1}^{n}\delta_{j,0}^{i2}\right)t} \quad (5)$$

The revised assessment of ability is a function of two terms: m_t and the expression in brackets. Agents observe a higher-than-expected signal about the ability of a group of directors when $\left[\frac{dD_{i,t}}{D_{i,t}} - \left(\sum_{j=1}^{n}\theta_{j,t}^{i}\right)dt\right]$ is positive, and revise their expectations upwards accordingly. This revision depends on m_t, which is the ratio of uncertainty about directors to uncertainty about the firm's dividends. This implies that conditional on the realization of the signal, the larger the uncertainty about directors, the larger the revision of assessed ability. Therefore, the Bayesian learning framework predicts a positive relationship between the uncertainty about the ability of directors and the magnitude of the revision of assessed ability.

Bayesian updating generates posterior variance of the assessment of ability of the form:

$$\sum_{j=1}^{n}\delta_{j,t}^{i2} = \frac{\sigma^2\sum_{j=1}^{n}\delta_{j,0}^{i2}}{\sigma^2+\left(\sum_{j=1}^{n}\delta_{j,0}^{i2}\right)t} \quad (6)$$

The posterior variance of assessment of directors' ability $\sum_{j=1}^{n}\delta_{j,t}^{i2}$ does not depend on the realization of the signal but has a negative and convex relationship with *t*. Therefore, the model predicts a decreasing and convex learning curve: the uncertainty about ability dissipates over time and learning is faster at the beginning of director tenure. The revised variance $\delta_{j,t}^{2}$ is always smaller than the initial variance $\delta_{j,0}^{i2}$ and represents the uncertainty about parameter *θ*. Ability α_j^i is assumed constant for each director. As market participants learn about directors' ability, the uncertainty dissipates and eventually $\delta_{j,t}^{i2} \rightarrow 0$.

Timmermann (1993) shows that when agents do not know the true data-generating process for dividends, learning generates excess stock return volatility. Pastor and Veronesi (2003, 2009) formalize

this intuition and derive an approximation for return volatility, which is adapted in the context of this paper:

$$\text{Return Volatility} \approx \text{Dividend Growth Volatility} \times \left[1 + \left(\frac{\partial \log\left(\frac{\mathrm{P}}{\mathrm{D}}\right)_{\mathrm{t}}}{\partial\left(\sum_{j=1}^{n} \theta_{j,t}\right)}\right)\left(\frac{\sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right)t}\right)\right] \quad (7)$$

Equation (7) directly motivates the empirical analysis in this paper. In the above equation, $\frac{\partial \log\left(\frac{\mathrm{P}}{\mathrm{D}}\right)_{\mathrm{t}}}{\partial\left(\sum_{\mathrm{j}=1}^{\mathrm{n}} \theta_{\mathrm{j,t}}^{\mathrm{i}}\right)}$ represents the sensitivity of the $\log(\frac{P}{D})$ to the mean assessment of ability and can therefore be interpreted as the marginal return to directors' ability. $\left(\frac{\sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right)t}\right)$ is m_t, and can be interpreted as the ratio of uncertainty about directors to uncertainty about the firm's dividends (see Equation (5)). Equation (7) therefore implies that three components affect stock return volatility: fundamental volatility, *ex-ante* uncertainty about directors' ability and marginal return to ability (MRA). Equation (7) can be rewritten as:

$$Vol \approx \sigma\,(1 + MRA_t \times m_t) \quad (8)$$

If directors take actions that influence the generation of cash flows, then MRA>0. In that case, return volatility is positively related to the uncertainty about directors' ability *via* m_t. Note that we know from Equation (5) that m_t declines at a predetermined rate over time due to Bayes' rule and that this rate is faster for higher *ex-ante* levels of uncertainty about ability. This implies that after controlling for *ex-ante* uncertainty, cross-sectional analysis of declines in volatility provides estimates of directors' marginal value. In other words, the extent of the decline in volatility over director tenure depends on the marginal value of that director.

In sum, the model presented above implies that if directors do not engage in window-dressing but do in fact make a difference in the fortunes of the companies onto which boards they sit, then we should observe a decline in volatility over director tenure. Moreover, the decline should be more pronounced when directors are more value relevant. By exploiting the empirical analysis stemming from these predictions, this article offers a new methodological approach to evaluating corporate boards.

2.2. Empirical design

2.2.1. Regression model

The predictions from the learning model described in the previous section are tested using regression models that estimate the relation between the tenure of a newly appointed director and stock return volatility. The regression model is characterized by the following equation:

$$Vol_{i,t} = \beta_{1,k,i} + \beta_2 f(tenure_{i,j}) + \beta_3 X_{i,t} + \lambda_t + \varepsilon_{i,t} \quad (9)$$

where $\beta_{1,k,i}$ represents the board fixed effect for board k of firm *i*,

$f(tenure_{i,j})$ represents a function of director *j*'s tenure, allowing for a decreasing and convex relationship between volatility and tenure as predicted by the model,

$X_{i,t}$ represents a set of firm level control variables,

λ_t represents the calendar-month fixed effect.

The null hypothesis is that tenure and volatility are not related (H_0: β_2 is insignificant). The alternative hypothesis is that the governance-related component of stock return volatility decreases as the market learns about the ability of a director (H_1: β_2 is significantly negative).

Regressions include board fixed effects to account for unobservable board and director characteristics. For example, directors with higher ability may serve on larger firms and the dynamics of information sharing and groupthink may vary across different board compositions. Board fixed effects control for such time-invariant board and director characteristics. Regressions with board fixed effects thus estimate learning about director ability from the time-series variation in volatility within a particular composition of the board. In addition, all regressions include a month fixed effect to account for macroeconomic factors that affect the volatility of all firms. Standard errors are clustered at the firm level.

2.2.2. Data sources and descriptive statistics

The sample consists of 2,297 firms from the intersection of S&P 1,500 firms in BoardEx, CRSP and Compustat from 2000 to 2012. It comprises a total of 25,355 directors and 8,367 new director appointments.

I estimate the relationship between director tenure and stock return volatility in monthly regressions following director appointments using two measures of volatility. *Realized volatility* is the standard deviation of daily returns within a month. *Idiosyncratic volatility* is the standard deviation of the residuals of a Fama-French three-factor model as in Ang et al. (2006). Appendix A reports the definition of all variables.

Table 1 presents summary statistics. Panel A reports director and board summary statistics at the firm-year level. The average board consists of 9.4 directors, of whom 11% are women and 2% are not American. On average, 3% of board members have experience as CEO of a public company, 5% have previously served on the board of a firm in the same industry, and 12% have previously worked in a firm in the same industry. The average director is 60 years old and has been a director for eight years. On average, 78% of board members are independent, 34% sit on the nomination committee, while 43% sit on the compensation committee and 43% on the audit committee. Only 8% of board members sit on all three key committees. A board is "entrenched" if the CEO combines the titles of Chairman and President and has been in office for at least five years. Using this definition, about half of boards are considered entrenched. Coles, Daniel and Naveen (2015) use the percentage of directors with tenure greater than nine years as a proxy for groupthink. In this sample, about a third of board members are prone to groupthink. On average, 31% of board members are considered "busy", i.e. sit on three or more boards. The network of the average director comprises about 600 professional connections. *Board Pay Slice* is defined as the sum of independent directors' compensation over CEO total compensation, and averages 21%.[3]

Statistics for the two volatility measures and betas are reported at the firm-month level in Panel B of Table 1. Average monthly realized (idiosyncratic) volatility is 11.7% (8.6%). Firm level financial statistics are reported at the firm-year level in Panel C.

[Insert Table 1]

[3] This is consistent with figures for the average S&P500 firm which spent $2.2 million in 2012 in basic board compensation and $10.7 million on average to compensate its CEO. Source: http://www.bloomberg.com/news/2013-05-30/board-director-pay-hits-record-251-000-for-250-hours.html

3. Empirical relationship between volatility and director tenure

3.1. Full sample

The model implies that as the market learns about directors, its update of its assessment of their quality is reduced, and hence stock return volatility declines. This decline occurs presumably because governance-related uncertainty dissipates as investors become more acquainted with their board. Figure 1 graphs the relationship between monthly average idiosyncratic volatility and director tenure for three samples of newly appointed directors. In all three panels, the sample is restricted to directors who remain at least five years on the board. In Panel A, there are no other director appointments at least two years before and three years after the new director joins. In Panel B, there are no other director appointments at least one year before and one year after the new director joins. In Panel C, there is no restriction related to the arrival of other directors. For the three samples, volatility sharply increases at time zero, which corresponds to the arrival of new directors to the board.

This spike in volatility suggests that the arrival of a new director may be viewed as a positive shock to the uncertainty about future profitability. The higher uncertainty pushes up volatility through a mechanism described in Pastor and Veronesi (2003). The idea is that when there is a new director, the effect of any news is amplified as the market updates both the effect of the news and their assessment of the director's quality, and consequently their expectation of future events and their effect on firm value. This upswing is followed by a decline in volatility, as the uncertainty progressively resolves and investors no longer update their valuation of the firm according to their assessment of the new director's ability.

[Insert Figure 1]

Four functional forms of director tenure are specified to determine whether the empirical relation between volatility and director tenure is consistent with the theoretical framework: a quadratic regression model, a piecewise linear model, a logarithmic specification and a reciprocal specification. The convexity of the volatility-tenure relationship can be verified with all four specifications. Panel A of Table 2 presents regression results with the quadratic regression model for the three subsamples of newly appointed directors and for the two volatility measures. All regressions estimate the volatility-tenure

relation over the first five years of tenure. In Specifications 1 and 2, no other directors are appointed at least two years before and three years after the new director joins. In Specifications 3 and 4, no other directors are appointed at least one year before and one year after the new director joins. There is no restriction on the arrival of other directors in Specifications 5 and 6.

All regressions control for firm level factors that affect the firm's return volatility. The coefficient estimates for the control variables are significant in the expected direction. In addition, when the dependent variable is realized volatility, the regressions include the market beta, SMB beta and HML beta to control for factors that affect the volatility in average dividend growth.

In all specifications, the estimated coefficients on *Tenure* are negative and almost always highly statistically significant for both measures of volatility. As predicted by the model, volatility declines over the tenure of a newly appointed director. In addition, the coefficients on $Tenure^2$ are positive and always significant for idiosyncratic volatility, which indicates that volatility declines at a faster rate at the beginning of director tenure. Therefore, there is a negative and convex relationship between volatility and director tenure in the data, which is in line with the predictions of the learning model.

[Insert Table 2, Panel A]

Panel B of Table 2 reports results from piecewise linear regressions to characterize the volatility-director tenure relationship for the three samples of director appointments. The regressions include a knot at year one, and therefore allow for a different slope for the first year of tenure and for years two through five. There is a significant drop in volatility in the first year of a director's tenure for all three samples of director appointments. The splines corresponding to years 2 through 5 are statistically insignificant. The difference between the estimated coefficients on Tenure (year 1) and Tenure (year 2-5) is statistically significant at the 5% significance level. Confirming the results using the quadratic regressions, these patterns document a negative and convex relationship between volatility and director tenure and suggest that investors learn about director quality and update their valuation of the firm accordingly mostly during the first year.

[Insert Table 2, Panel B]

In Panel C of Table 2, I use two additional functional forms for director tenure to confirm the convexity of the relation with volatility. As before, in Specifications 1 and 2, no other directors are appointed at least two years before and three years after the new director joins. In Specifications 3 and 4, no other directors are appointed at least one year before and one year after the new director joins. There is no restriction on the arrival of other directors in Specifications 5 and 6. In Specifications 1, 3 and 5 (2, 4, 6), idiosyncratic volatility is regressed on the natural logarithm of one plus *Tenure* (minus one over one plus *Tenure*). The logarithmic and reciprocal functions of *Tenure* provide additional support for the hypothesized convexity of the volatility-tenure relationship.

The results in Table 2 indicate that investors behave according to the predictions of the Bayesian learning model when updating their assessment of a newly appointed director's ability. The evidence is robust across samples that vary with respect to the restriction period for the arrival of other directors. Although the magnitude of the coefficients varies, the conclusion is unchanged: there is a negative convex relationship between director tenure and stock return volatility. Since the restriction period does not alter the results, the remainder of the paper focuses on the larger sample with no restriction period, from which subsamples are studied in subsequent sections.

3.2. Samples of exogenous director appointments

A potential alternative interpretation for the results derived above is that firms may appoint new directors in times of crisis, when volatility is high. For example, poor firm performance may prompt the need to bring a fresh perspective on the board. In addition, board changes frequently occur concurrently with management turnover (see Hermalin and Weisbach, 1988 and Denis and Sarin, 1999), which may also coincide with a period of high volatility. It is therefore important to identify changes in board composition that are unlikely to occur as a response to corporate turbulences to ensure that the patterns documented in the previous section hold for exogenous director appointments.

3.2.1. Board independence requirement

The first sample of exogenous director appointments is constructed by selecting appointments that were specifically designed to ensure that the board would satisfy the new board independence requirements. Governance reforms in the early 2000s led the NASDAQ and NYSE exchanges to impose stricter listing requirements regarding the independence of corporate boards.

The introduction of new exchanges listing requirements has been used in the literature to study the effect of board structure on firm value (Wintocki, 2007; Duchin, Matsusaka and Ozbas, 2010), CEO compensation (Chhaochharia and Grinstein, 2009), and firm transparency (Armstrong, Core and Guay, 2014).

The sample of exogenous appointments is constructed by restricting appointments to those that resulted in the board complying with the new 50% independence requirement when it did not prior to that director's appointment. A director appointment therefore qualifies for this sample if the director joins the board between 2002 and 2005 and the firm previously did not comply with the 50% independence requirement. Because firms were required to make these board changes, the arrival of these directors is unlikely to systematically coincide with a time when fundamental volatility is particularly high.

Panel A of Figure 2 graphs the relationship between return volatility and director tenure for this exogenous sample. As in the full sample, volatility sharply increases after the appointment of a director and gradually declines. By construction, the sample consists of directors who join corporate boards between 2002 and 2005. Therefore, the upward trend beginning around year four coincides with the financial crisis. Panel B graphs the same relationship omitting 2008 and 2009.

[Insert Figure 2]

Specification 1 in Table 3 provides regression results for this exogenous sample of director appointments. The results are unaltered: volatility decreases over the tenure of newly appointed directors and does so at a decreasing rate.

[Insert Table 3]

In addition, to confirm that the documented relation between director tenure and volatility is not affected by the endogeneity of director appointments, I conduct a test using the full sample of director

appointments and perform a regression in which *Tenure* is interacted with *Exchange mandated appointment* which is a dummy variable equal to one for director appointments included in the sample of exogenous appointments designed to satisfy the new board independence listing requirements. The estimated coefficient on the interaction term is insignificant. This suggests that there is no significant difference in the volatility-tenure relationship between the full sample and this exogenous sample. Therefore, the results in the previous section are unlikely to be driven by the endogeneity of director appointments.

3.2.2. Retiree replacement

The second exogenous sample consists of newly appointed directors who replace retiring directors. To construct the retiree replacement sample, a new director is included if he joins the board within a month following the departure of a director who reached the maximum age requirement. Typically, firms require that their directors retire after they are 70 for insiders and 72 for outsiders. This sample is augmented with directors who served simultaneously on multiple boards and left all of their boards within three years[4]. These directors arguably left their boardrooms for reasons exogenous to the situation of one particular firm. For example, directors who retired due to health reasons before reaching the maximum age requirement would be included in this subsample.

Panel C of Figure 2 shows that the decline in volatility following director appointments for this subsample is very similar to the one using the full sample. In particular, there does not appear to be unusual volatility before the arrival of new board members, but rather volatility seems to spike upon their arrival. This is consistent with evidence in Fracassi and Tate (2012) who show that director retirements are typically not related to firm conditions. Therefore, the arrival of new directors appointed to replace retirees should not systematically coincide with a period of high volatility.

Specification 3 in Table 3 shows that the regression results derived with the full sample of director appointments continue to hold when the sample is restricted to retiree replacements. The

[4] Not including these directors does not affect the results.

estimated coefficients confirm the negative convex relationship between the tenure of directors and stock return volatility, even when limiting the sample to exogenous director appointments.

In Specification 4, *Tenure* is interacted with *Retiree replacement* in regressions that use the full sample. *Retiree replacement* is a dummy variable equal to one for director appointments included in the retiree replacement sample. As with the exchange listing requirements sample, there is no significant difference in the volatility-tenure relationship between the full sample and appointments of directors replacing retirees. This provides additional evidence that the results in the previous section are not driven by the endogeneity of director appointments.

3.3. Additional tests

The evidence presented above is consistent with learning-induced declines in volatility and supports the hypothesis that directors affect firm value. Importantly, this result is not the product of the potential endogeneity of director appointments. Follow-on tests are conducted to provide additional evidence that the ability of directors to create value for the firm is subject to learning by investors.

3.3.1. All firm-months and *ex-ante* uncertainty

In Panel A of Table 4, I perform regressions using all firm-months as opposed to restricting the sample to the first years of director tenure. *First 3 yrs* is a dummy variable equal to one for the first three years of tenure and is interacted with *Tenure* and with *ln(1+tenure).* The purpose of this exercise is to broaden the analysis to ensure that the relation between volatility and tenure is not inflated when the estimation is restricted to the first years of tenure.

Specifications 1 through 4 confirm the learning hypothesis. The coefficients on *Tenure*First 3 yrs* and *ln(1+tenure)*First 3 yrs* are negative and significant. Therefore, volatility declines significantly more over the first three years of tenure than over other periods. Note that the estimated coefficients on *Tenure* in Specifications 1 and 3 and on *ln(1+tenure)* in Specifications 2 and 4 are insignificant, which indicates that volatility does not significantly decrease over tenure outside the first three year window.

[Insert Table 4, Panel A]

Moreover, learning by market participants should be more important when prior uncertainty about the new director is high. This is an intuitive prediction from the model. To test whether the decline in volatility is reduced when the new director is well-known, I construct variables pertaining to the level of individuals' *ex-ante* uncertainty. *High uncertainty* is a dummy variable equal to one for directors who do not have previous board experience, have not been CEO of another firm and are less than fifty years old, and zero otherwise. *Low uncertainty* is a dummy variable equal to one for directors who have previous experience as CEO and have served on at least two boards, and zero otherwise.

Because the *ex-ante* uncertainty of a director is constant, regressions using the level of director *ex-ante* uncertainty include firm fixed effects rather than board fixed effects. Using triple interactions, Specifications 5 and 6 in Panel A of Table 4 show that while volatility declines significantly more over director tenure over the first three years of tenure for directors characterized by high *ex-ante* uncertainty, it does not when the director is well-known. This result provides further support for the hypothesis that the observed spike and subsequent decline in volatility upon the arrival of a new director indeed reflect learning by investors.

3.3.2. Young *vs.* seasoned boards

If the uncertainty surrounding the value that directors can generate for the firm dissipates over the course of their tenure, we should observe learning for younger boards but not for seasoned boards. Boards are categorized into terciles based on the average tenure of their members. Young (seasoned) boards are defined as those whose members' average tenure is in the first (third) tercile. Figure 3 graphs firm volatility as a function of average director tenure for young and seasoned boards in panels A and B, respectively. Figure 3 shows a distinct decline in volatility as young boards become more mature. In contrast, there is no apparent relation between average board tenure and volatility for seasoned boards.

[Insert Figure 3]

Specifications 1 and 3 in Panel B of Table 4 report regression results where the main independent variable is the average tenure of board members and Specifications 2 and 4 use the logarithm of one plus the average tenure of board members. While there is a clear negative convex relationship between firm

volatility and the average tenure of board members for young boards (Specifications 1 and 2), this relationship disappears for mature boards (Specifications 3 and 4).

This finding suggests that investors update their assessment of the potential for value creation by directors when they are relatively new, but no longer do so when their quality becomes well-known.

[Insert Table 4, Panel B]

3.3.3. Not a CEO effect

3.3.3.1. No CEO turnover

The literature (Hermalin and Weisbach, 1988; Denis and Sarin, 1999) shows that director appointments tend to cluster around CEO turnovers. Moreover, Pan et al. (2015) find a significant decline in stock return volatility following CEO turnovers. To ensure that director appointments that overlap with CEO turnovers do not drive the results, regression results excluding director appointments occurring within one year of a CEO turnover are presented in Specifications 1 and 2 in Panel C of Table 4. The negative convex relationship between director tenure and stock return volatility remains intact for this subsample of director appointments, which indicates that the results presented so far are not due to a CEO effect in disguise.

[Insert Table 4, Panel C]

3.3.3.2. Controlling for CEO tenure

An alternative way to ensure that the results are not driven by learning about the CEO is to control directly for CEO tenure in the regression model. Regression results presented in Specifications 3 and 4 in Panel C of Table 4 control for CEO tenure and show that CEO tenure has a negative relationship with stock return volatility. However, including CEO tenure in the regressions does not take away the significance of the director tenure variable, which confirms that the results are not driven by learning about the CEO. The only case for which including CEO tenure does take away the significance of director tenure is when the sample is restricted to CEOs with tenure of less than three years, which is when learning about the CEO is at its peak (see Pan et al., 2015). In that case, the effect of learning about CEO ability dominates the effect of learning about director ability, as expected.

3.3.4. Co-appointments

Panel D of Table 4 reports regression results for various subsamples of director appointments. The purpose of this exercise is to examine in more detail the relation between director appointments and stock return volatility. Specification 1 restricts the sample to director appointments not accompanied by another director appointment within a year. The director tenure variable is not significant for this subsample. Specification 2 uses a subsample of multiple (at least one other) director appointments within a year. In that case, the negative convex relationship between tenure and return volatility is highly significant. The sample used in Specification 2 is further divided into two subsamples. Specification 3 shows coefficient estimates for the sample of directors appointed with exactly one other director within a year, whereas Specification 4 shows results for directors with two or more co-appointments.

[Insert Table 4, Panel D]

The point estimates are sensitive to the number of co-appointments: the more directors join the board, the more uncertainty and the higher the impact on stock return volatility. Column 5 uses a subsample of directors appointed within a year of a CEO turnover. Not surprisingly, the associated estimated coefficient is much larger in absolute value: over three times larger than the one associated with a director appointed with exactly one other director. The fact that the decline in volatility is sensitive to the number of newly appointed directors gives further credence to the idea that the documented patterns reflect learning about directors.

3.3.5. Matched sample

The evidence provided so far documents a decline in volatility following the appointment of new directors. A matched sample test is performed to ascertain that the drop in volatility exceeds what would be observed in firms that do not experience the arrival of new directors. Firms are matched based on industry and size. Each firm belongs to one of ten industries based on the Fama-French ten-industry classification. Each firm in the treated group is assigned to a control firm, which is the closest in size (based on the firms' assets) and operates in the same industry as the treated firm. The control firm must

not experience a director appointment at least one year prior and one year after the appointment of a director in the treated firm.

Regressions similar to those in Table 2 are run for the matched sample. If the decline in volatility for the treated firms indeed reflects learning about incoming directors by market participants, we should not observe a systematic decline in volatility for the control firms. Results are reported in Panel E of Table 4. As expected, there is no decline in the stock return volatility of control firms following the appointment of directors on the board of treated firms.

[Insert Table 4, Panel E]

3.4. How much do directors matter?

Pan et al. (2015) estimate that at the time of a CEO turnover, the uncertainty surrounding the ability of the new CEO accounts for about a quarter of overall stock return volatility. This section uses Pan et al.'s estimate as a benchmark. CEOs undoubtedly have more impact on firm value than directors. But how much more is an open question. How do investors perceive the value relevance of directors with respect to that of the CEO?

The methodological approach in this paper allows estimating the percentage of overall volatility imputable to the uncertainty surrounding the ability of directors at the time of their appointment (δ_0/Vol_0). This section directly relies on the methodology derived in Pan et al. (2015), which is described here. It involves estimates of the average decline in volatility over director tenure, the average volatility in corporate dividends (σ) and the average volatility at the time directors joins (Vol_0).

From Equation 7, let $Vol' = \frac{Vol}{\sigma} - 1$ be the percentage excess volatility. Then, $Vol' = MRA_t m_t$, and the percentage change in excess volatility from time 0 to time t is $\frac{\Delta Vol'}{Vol'_0} = \frac{\Delta m}{m_0} + \frac{\Delta MRA}{MRA_0} \times \left(1 + \frac{\Delta m}{m_0}\right)$. The marginal return to ability is hypothesized constant over time, therefore, $\frac{\Delta Vol'}{Vol'_0} = \frac{\Delta m}{m_0}$. Then,

$\frac{\Delta m}{m_0} = \frac{1}{1+m_0 t} - 1 = \frac{\Delta Vol'}{Vol'_0} = \frac{\Delta Vol}{Vol_0} \times \frac{Vol_0}{Vol_0 - \sigma}$. When t = 3, the percentage of overall volatility attributable to the uncertainty about new directors, $\frac{\delta_0}{Vol_0} = \sqrt{\frac{1}{3}\left[\frac{1}{1-\frac{\Delta Vol'}{Vol'_0}} - 1\right]} \times \frac{\sigma}{Vol_0}$.

The average decline in idiosyncratic volatility over the first three years of tenure varies between 1.3% (Specification 1 in Panel C of Table 4 in which there is no CEO appointment overlap), and 3.3% (Specification 3 in Table 3 in which only directors replacing retiring directors are considered). The average volatility of corporate dividends (σ) is about 21% and the average idiosyncratic volatility at the time directors joins (Vol_0) is about 30%. Therefore, the uncertainty about new directors accounts for about 9% to 14% of return volatility at the time of director appointments. Excluding director appointments that occur within a year of a CEO turnover reduces this estimate by about 18% (from 10.8% to 8.8%).

Pan et al. (2015) find that the uncertainty about the CEO accounts for about 22% of overall return volatility at the time of CEO turnover. The authors however do not account for learning about directors, which may potentially affect their estimates of learning about the CEO, in particular when new directors join the board around CEO turnover.

The results indicate that governance-related uncertainty accounts for a substantial percentage of overall stock return volatility. Taken together, the findings derived in this section suggest that boards of directors are important contributors to firm value. These results have important implications in corporate governance inasmuch as they help us better understand the value of board members and provide an estimate of the overall importance of governance in corporations.

4. The effect of director and board characteristics on firm value

4.1. Prior empirical evidence on board and director characteristics

Hermalin and Weisbach (2003), Yermack (2006) and Adams, Hermalin and Weisbach (2010) provide surveys of the literature on boards of directors. One of the most studied features related to board

composition is the degree of board independence. Weisbach (1988) shows that CEO turnover is more sensitive to firm performance for more outsider-dominated boards. However, Hermalin and Weisbach (1991) and Bhagat and Black (2000) report no relation between the percentage of outside directors and firm value (as measured by Tobin's Q) or accounting measures of performance. On the other hand, Brickley, Coles and Terry (1994) find a positive association between the percentage of outside directors and announcement returns following the adoption of poison pills. Their findings are consistent with the hypothesis that outside directors act in the best interest of shareholders. Harris and Raviv (2008) propose a model in which insider-dominated boards may be optimal. Overall, the evidence in the literature on the value of independent directors is mixed.

Concerns about the size of corporate boards are described in Lipton and Lorsch (1992) and in Jensen (1993). Yermack (1996) and Wu (2000) provide detailed evidence that smaller boards are beneficial for firm value. These papers document that small boards are more likely to replace CEOs based on poor performance and that smaller boards are associated with increased CEO pay-for-performance.

A number of studies have examined the effect of CEO power on the ability of the board to perform its role. Hermalin and Weisbach (1998) argue that CEOs are likely to increase their bargaining power vis-à-vis the board over the course of their tenure, as their perceived ability is higher given that they repeatedly passed the replacement option test. Shivdasani and Yermack (1999) find that powerful CEOs, as measured by the extent to which they are involved in the board nomination process, are able to select less independent boards. Baker and Gompers (2000) find similar results when CEO power is proxied by CEO tenure. Coles et al. (2014) show that co-opted boards are less effective monitors, as evidenced by lower pay-for-performance and lower sensitivity of CEO turnover to performance.

The literature has also studied the effect of personal director attributes on either firm value or some measure of performance or board actions. In particular, a number of empirical studies examine the effect of director gender. The evidence on the value of female board members is mixed. Adams and Ferreira (2009) show that women are better monitors, although increased monitoring comes at the cost of lower firm performance. On the other hand, using data on mandatory announcements of director

appointments, Adams, Gray and Nowland (2012) find that investors value female directors more than their male counterparts and Schwartz-Ziv (2015) shows that gender-balanced boards are more active. In particular, she finds that a critical mass of at least three female directors on a board changes the board dynamics, especially in times when the CEO is being replaced. Using the 2003 law on female board representation in Norway, Ahern and Dittmar (2012) find that the imposed quota led to a drop in firm valuations and deterioration in operating performance.

While Masulis, Wang and Xie (2012) find that the presence of foreign directors reduces the board's monitoring activities, Daniel, McConnell and Naveen (2013) find that foreign directors are associated with increased firm value and that the effect comes from dissimilar directors on multinational corporations.

The amount of time an individual can commit to his role as director of a company has been shown to be value relevant. Researchers have studied the number of directorships and provided mixed evidence as to whether more current directorships are beneficial or detrimental to firm value. On the one hand, additional board seats bring experience and business connections that are potentially useful resources to be passed on to the firm's management. On the other hand, overly committed board members do not have time to be effective monitors or to truly understand the business. Their contribution to firm value is therefore potentially adversely affected. Ferris et al. (2003) report positive announcement returns to the appointments of busy directors. In contrast, Fich and Shivdasani (2006) find that investors react positively to the departure of busy directors, thus suggesting that busyness is not a desirable director attribute. Core et al. (1999) show that busy outside directors are associated with increased CEO compensation. Recently, Field, Lowry and Mkrtchyan (2013) shed some light on the subject by providing evidence that the firm's life cycle is an important factor to consider when examining the value effect of busy directors. The authors argue that while large established firms benefit relatively more from monitoring than advising services on the part of directors, young firms derive more value from their network and experience. In line with this argument, the authors show that busy directors are beneficial for

younger firms because they rely more on advising than monitoring, and detrimental for large corporations because they require the opposite.

Director networks have been the focus of several recent studies. Whereas networks may facilitate the transmission of information and be a source of value, they can also bring costly inefficiencies. Barnea and Guedj (2009) find that better connected directors are associated with higher CEO compensation, lower pay-for-performance and lower sensitivity of CEO turnover to firm performance. Kuhnen (2009) analyzes the effect of director connections for investor welfare in the mutual fund industry and finds evidence that the two effects of network ties (efficient information transfers and inefficient favoritism) balance out in her setting. Recently, Larcker et al. (2013) find that firms with more central boards earn higher risk-adjusted returns and higher future growth in ROA.

This succinct review of the literature on board attributes highlights that one characteristic of the way the literature traditionally studies boards of directors is to select a board or director attribute, analyze its effect on firm value or some measure of performance or board action and conclude that boards or directors with this attribute are better or worse than those without. In this paper, I use the learning-based approach to revisit part of this literature and offer new results based on attributes previously not studied. Specifically, I exploit the cross-sectional variation of the learning-induced changes in volatility following the arrival of new directors. The learning model (and in particular Equation 7) implies that a higher marginal return to ability is associated with larger stock return volatility. Therefore, examining the effect of firm, board and individual attributes on the volatility-tenure relationship is a convenient novel approach to studying the value impact of directors. A summary of the findings is included in Table 5, alongside a comparison with the results previously derived in the literature.

[Insert Table 5]

4.2. Cross-sectional analysis using the learning-based framework: interaction variables

The learning-based approach provides a new way to measure the expected contribution to firm value of different kinds of directors, as well as different kinds of boards. Equations (5) and (7) in Section

2 show that uncertainty about director ability decreases at a predetermined rate over time due to Bayes' rule, and that this rate is faster for higher *ex-ante* levels of uncertainty. Hence, after controlling for *ex-ante* uncertainty, cross-sectional analysis of declines in volatility provides estimates of directors' marginal value. In other words, the extent of the decline in volatility over director tenure is a function of the marginal value of that director. Panels A and B of Table 6 report regression results with interaction variables to document the effect of director attributes on the decline in volatility following director appointments. Controls for *ex-ante* uncertainty include director age, number of previous jobs, number of previous board seats and whether the director has experience as CEO of a public company.

4.2.1. Director attributes and firm value

4.2.1.1. Position on the board

In Specification 1 in Panel A, the coefficient estimate on *ln(1+Tenure)*Chairman* is negative and significant. This suggests that investors expect chairmen to be important elements of the board and have more impact on firm value than the average director. Although this result may partially be attributable to CEOs often cumulating the role of chairman, unreported tests show that removing CEOs from the sample does not alter the results.

[Insert Table 6, Panel A]

Specification 2 investigates the role of independent directors. The literature on director independence provides mixed evidence regarding the effect of independent directors on firm value. Researchers have therefore started looking at alternative settings (Choi et al., 2007) and alternative definitions of independence (Fracassi and Tate, 2012). In this sample, independent directors (as traditionally defined in the literature) are not expected to create more value, as evidenced by the positive significant coefficient on *ln(1+tenure)*Independent*. In fact, independent directors are associated with a smaller decline in volatility, suggesting that on average they have a smaller marginal contribution to firm value. Again, excluding CEOs from the sample does not alter the result. However, Specification 3 provides evidence that independent directors with industry expertise do have a stronger effect on value creation, consistent with evidence in Masulis et al. (2012) and Faleye et al. (2012). In addition,

Specification 4 shows that when the firm is insulated from the market for corporate control by using a high number of takeover defenses (i.e. the firm is a "dictatorship" as defined by its high G-index as in Gompers et al., 2003), independent directors are particularly important.

Specification 5 suggests that directors sitting on the compensation and audit committees are more important than the average director. This result indicates that decisions made by these two committees are expected to affect the value of the firm directly. In contrast, members of the nomination committee do not appear to have significantly more impact than the average director. Members of all three committees are associated with a much larger decline in volatility, about twice the magnitude of any single committee membership.

4.2.1.2. Personal attributes

Panel B reports the effect of personal attributes on the learning-induced decline in volatility. Adams and Ferreira (2009) show that female directors are better monitors. However, they find that the additional monitoring comes at the cost of lower firm performance, especially for well-governed firms which do not need extensive monitoring. The results from the learning-based approach suggest that for the average firm, female board members do not contribute to firm value as much as their male counterparts. Specifications 2 and 3 restrict the sample to a subset of firms with entrenched boards. For this subset of firms, women joining "dictatorships", as defined by their high G-index, do have more impact on firm value, although the estimated coefficient is only marginally significant. The same is true for women joining large firms. Overall, these results provide suggestive evidence that female directors are particularly valuable when the need for monitoring services is acute.

[Insert Table 6, Panel B]

Specification 4 shows that the nationality of incoming directors is value irrelevant on average. However, foreign directors joining a board composed exclusively of American directors are associated with significantly lower value impact, which could reflect high coordinating costs. These results on gender and nationality directly speak to the ongoing policy debate on board diversity. The evidence in this

paper suggests that on average, adding a woman or a director of a nationality other than American is not associated with increased expected impact on value creation.

The coefficient on *ln(1+tenure)*Large network* is negative but insignificant, which suggests that directors with large networks do not contribute significantly more to firm value on average. This supports the conclusion in Kuhnen (2009). The author analyzes the effect of director connections for investor welfare in the mutual fund industry and finds evidence that the two effects of network ties (efficient information transfers and inefficient favoritism) balance out in her setting. However, a triple interaction test indicates that a well-connected chairman is particularly valuable.

Busy directors (i.e. who simultaneously sit on at least three boards) are on average not associated with more or less impact on firm value. The literature on busy directors generally concludes that director busyness is detrimental for firm value (see for example Fich and Shivdasani, 2006) although there is empirical evidence that supports the opposing view (Ferris et al., 2003). The learning-based approach in this paper shows that for the average S&P1,500 firm, busy directors are neither detrimental nor beneficial. Focusing on IPO firms, Field, Lowry and Mkrtchyan (2013) show that busy directors are beneficial for smaller firms in need of advisory services from their directors, and detrimental for larger firms which require more monitoring. Consistent with their finding, I find that busy directors joining young firms are associated with a stronger decline in volatility, which suggests that the experience and connections of busy directors are valuable for firms in need of advisory services from their board members.

In addition, there is weak evidence that directors with previous CEO experience and directors with board experience in the same industry have more impact on value creation. The fact that relevant board experience does not significantly translate into higher expected contribution provides suggestive evidence that director skills are highly firm-specific and not easily transferable from one firm to another.

In Panel C of Table 6, I examine the effect of the area of expertise of directors on the learning-induced decline in volatility. There is weak statistical evidence that directors with expertise in finance, technology and law are more important. Academics, politicians and directors with backgrounds in

marketing are not associated with a significantly different value impact. In contrast, directors with a background in human resources are associated with significantly lower participation in value creation.

[Insert Table 6, Panel C]

4.2.2. Board characteristics and firm value

This section relies on the premise that different types of boards have varying marginal contributions to firm value. Board characteristics are likely to influence the degree to which investors expect directors to play a role in value creation. As before, the results presented in this section continue to hold when CEOs are removed from the sample.

Some firms may provide their directors with an environment conducive to leveraging their ability as board members, while others may impede directors to engage fully and play their role. For example, investors may be skeptical when a new director joins an entrenched board as they might not expect him to be able monitor management effectively. CEOs who have been in place for multiple years gained more bargaining power over their board (see Hermalin and Weisbach, 1998), so that the balance of power rests in favor of the CEO. Fracassi and Tate (2012) consider CEOs who cumulate the titles Chairman of the board and President to be powerful CEOs. The dummy variable *Entrenched* is equal to one for firms with a CEO who has been in place for more than five years and combines the titles of CEO, Chairman of the board and President.

The results indicate that investors in firms with captured boards expect their directors to have a limited contribution to firm value and view powerful CEOs as obstructers to value creation by their directors.

[Insert Table 6, Panel D]

Coles, Daniel and Naveen (2015) use the fraction of directors with long tenures as a proxy for groupthink, and find that groupthink has a negative effect on firm value for firms in dynamic industries. Consistent with their findings, I show that this proxy for groupthink is associated with lower director participation to firm value.

Investors should expect directors in firms that provide generous compensation to its board members relative to its CEO to engage in more value creating activities. To test this hypothesis, I construct the variable *Board Pay Slice* by dividing the sum of independent director compensation by CEO total compensation. *High BPS* is a dummy variable equal to one for boards with *Board Pay Slice* higher than the sample mean. The negative significant coefficient on *ln(1+tenure)*High BPS* suggests that directors joining better compensated boards are expected to have significantly more impact on firm value.

Yermack (1996) and Eisenberg et al. (1998) show that smaller boards are associated with higher firm value. *Large Board* is a dummy variable equal to one for boards with more than ten members, which is the sample mean. The results based on the learning framework suggest that directors sitting on large boards are associated with lower marginal value, as evidenced by the smaller learning-induced decline in volatility over director tenure.

Gender diverse is a dummy variable equal to one if the board is gender-diverse when the incoming director joins, i.e. at least one woman is present on the board. The positive and significant coefficient on *ln(1+tenure)*Gender diverse* suggests that incoming directors joining boards with at least one woman are expected to have a smaller contribution to firm value. A possible interpretation for this result is that as women are better monitors (see Adams and Ferreira, 2009), the monitoring value from a new board member is discounted.

These findings depict how board characteristics affect investors' expectations regarding the contribution of their directors to value creation. In particular, the results in this section highlight that market participants believe that corporate directors have more impact on value creation when their boards are small, not entrenched, not prone to groupthink and compensate their directors generously relative to the CEO.

4.2.3.Firm level attributes

Panel E of Table 6 reports the effect of firm level attributes on the learning-induced changes in volatility. *Large Firm* is a dummy variable equal to one for firms with total assets larger than the sample 75th percentile. The positive coefficient on *ln(1+tenure)*Large firm* in Specification 1 shows that

directors are less value relevant for large firms. Hence investors appear to rely more on directors to engage in value creation in smaller firms.

[Insert Table 6, Panel E]

Specification 2 shows that the learning-induced decline in volatility is smaller for directors joining firms with more takeover provisions. This suggests that for the average firm, internal governance as proxied by the value impact of the average director does not act as a substitute to external governance mechanisms. Panels A and B of Table 6 show that independent directors and female directors are particularly valuable for firms with numerous takeover defenses in place. Taken together, these findings indicate that while monitoring services by the board of directors may serve as a substitute to external governance when the firm is effectively insulated from the market for corporate control, for the average firm, internal and external governance mechanisms are not substitute.

Directors arguably play a more central role for firms experiencing poor performance. Investors may hope that incoming directors will take actions conducive to the improvement of performance. *Poor performance* is a dummy variable equal to one for firms with a return on assets lower than the 25th percentile of their respective industry's ROA in the year preceding the director appointment. Industries are based on the Fama-French ten-industry classification. The negative significant coefficient on *ln(1+tenure)*Poor performance* confirms that directors are more valuable for firms with weak performance relative to their peers. In an unreported test, I find that controlling for the level of volatility in the month preceding the appointment does not alter this conclusion.

The learning-induced decline in volatility varies with industry complexity. The technology (consumer durables) industry is arguably a relatively more (less) complex and human capital intensive industry which faces greater (fewer) sources of risk. Firms that belong to the technology (consumer durables) industry exhibit larger (smaller) valuation updates upon the arrival of new directors, thereby suggesting that directors are especially (less) valuable for firms that operate in more (less) complex environments.

Using the learning-based framework and interaction variables, this section revisited part of the literature on boards and confirmed prior findings. I test new hypotheses pertaining to variables that have previously not been directly tested. In particular, I show that chairmen and members of key committees (especially the audit and compensation committees) have a greater impact on firm value. I provide evidence that the value of independent directors depends on the degree to which firms are insulated from the market for corporate control. I also document the effect of Board Pay Slice on director contribution. The results are summarized in Table 5. To substantiate the validity of the previous results, I introduce an alternative way to exploit the learning-based methodology in the next section.

4.3. Learning slopes and director contribution

4.3.1. Estimating learning slopes

Since the model implies that the extent of the decline in volatility can be used to infer the marginal value of directors, it would be useful to have a summary measure of such decline for each director. Studying the determinants of this measure would provide an alternative method to test the relation between director attributes and their value relevance. This paper follows the intuition in Pan et al. (2015) in their CEO study but uses a different execution. I regress idiosyncratic volatility on tenure controlling for factors expected to affect the level of volatility:

$$vol_{i,t} = \beta_{1,k,i} + \beta_{2,i,j} tenure_{i,j,t} + \beta_{3,i} X_{i,t} + \lambda_t + \varepsilon_{i,t} \quad (10)$$

With $vol_{i,t}$ the idiosyncratic volatility of firm *i* at time *t*,

$\beta_{1,k,i}$ the board fixed effect for board *k* of firm *i*,

$X_{i,t}$ a vector of firm level covariates: ln(assets), M/B, ROA, dividend payer, leverage,

$tenure_{i,j,t}$ the tenure of director *j* on the board of firm *i* at time *t*,

λ_t the calendar-month fixed effect.

Residual volatility is then defined as idiosyncratic volatility minus the fit from the above regression, plus the estimated coefficient on the tenure variable times tenure :

$$vol_{i,t}^{residual} = vol_{i,t} - \widehat{\beta_{1,k,i}} - \widehat{\beta_{3,i}} X_{i,t} - \hat{\lambda}_t \quad (11)$$

Residual volatility is then regressed on tenure in individual regressions for each director-firm pair for the first three years of director tenure. This procedure produces estimates of the average decline in volatility over the tenure of the director, over and above the variation in volatility predicted by firm covariates and macroeconomic factors:

$$vol_{i,t}^{residual} = \alpha_i + \beta_{i,j} tenure_{ij} + \varepsilon_{i,t} \quad (12)$$

The coefficient estimates $\beta_{i,j}$ are multiplied by (-1) for ease of interpretation and normalized by their cumulative distribution function to yield a ranking between 0 and 1. They are referred to as the learning slope for each director, for each board he joins.

Figure 4 reports learning slopes summary statistics across industries. Complex industries display larger estimated learning slopes. The technology industry has the largest estimated learning slope, whereas consumer durables has the smallest. The difference is statistically significant at the 1% level. Statistics in Table 7 suggest that there is statistically significant cross-sectional variation in learning slopes based on director attributes which affect the volatility-tenure relationship in the previous section. Entrenched and large boards have significantly lower learning slopes. The average learning slope is lower for directors who join gender-diverse boards and boards of larger firms. Chairmen have on average larger learning slopes, but directors with large networks and younger directors do not.

[Insert Table 7]

These summary statistics further suggest that there is substantial cross-sectional variation in learning on the part of investors for some combinations of director and firm attributes. Since the theoretical model implies that a larger decline in volatility is associated with a larger expected impact on firm value, learning slopes can be used as an innovative metric to assess the expected contribution of board members.[5]

4.3.2. Estimating the determinants of the learning slopes

[5] Pan et al. (2015) use their original measure of learning slopes to evaluate in what types of industries CEOs are relatively important.

This section provides estimates of the relation between learning slopes and director and firm level attributes. The results in Table 8 are largely consistent with those based on interaction variables in the previous section. In particular, chairmen, members of the compensation and audit committees and directors with large business networks are associated with larger learning slopes, which indicates a greater decline in volatility over their tenure. The learning model implies that their contribution to firm value is therefore more important.

[Insert Table 8]

Independent directors and female directors have lower learning slopes on average, although independent directors serving "dictatorships" (see Gompers et al., 2003) and female directors serving large firms have steeper learning slopes. This evidence confirms the findings based on the interaction variables in the previous section: independent directors and female directors are especially valuable for firms with high monitoring needs. Director busyness does not affect the learning slope on average, although busy directors with CEO experience have significantly higher learning slopes.

Incoming directors on better compensated boards have on average steeper learning slopes and thus have more impact on firm value. The opposite is true for directors joining entrenched, large or gender diverse boards. Firm performance prior to the arrival of a director affects his expected contribution. Directors appointed to serve on boards of firms with poor performance are expected to participate more to value creation. Finally, learning slopes vary by industry. The results suggest that directors on boards of firms operating in the technology (consumer durables) industry have on average larger (lower) learning slopes. This indicates that directors are more valuable in more complex, more human capital intensive industries.

In sum, the analysis of director, board and firm attributes based on the learning slopes is a complementary approach to the one based on interaction variables in the previous section. Both methods yield consistent results. They are both derived from the learning model and serve the purpose of quantifying the extent to which different types of directors and boards have an impact on the value of the

firm. This exercise yields a rich set of empirical results and provides new evidence on attributes previously not studied in the literature.

5. Summary and Discussion

This paper develops a new approach to evaluating boards of directors based on the idea that part of a firm's stock return volatility is related to the uncertainty about its governance. Boards of directors are critical pillars in corporate governance, and as investors learn about their new board, the governance component of volatility declines. By relying on the theory to relate the decline in volatility with the value relevance of directors, this paper draws inferences about the importance of governance in corporations.

The analysis provides empirical support for the view that directors have real value effects. The results suggest that the uncertainty about directors accounts for 9% to 14% of overall volatility when a new director joins the board. The learning-based decline in volatility documented in this paper is proved not to be driven by endogeneous director appointments and is independent from learning about the CEO.

Going beyond the overall decline in volatility to study whether directors create value, I use the learning-based approach to estimate the value of different kinds of directors and boards cross-sectionally. I confirm prior findings and explore new attributes previously not studied in the literature.

First, I examine director-level attributes and find that chairmen (in particular those with large business networks) and members of the audit and compensation committees are expected to contribute more to firm value. Independent directors are associated with lower marginal contribution on average, although independent directors with industry expertise and those joining firms with weak external governance engage in more value creating activities. Therefore, internal governance may serve as a substitute when external governance mechanisms fail. Female directors do not have as much impact on value as their male counterparts on average, although the evidence suggests that they are particularly valuable when the firm's monitoring needs are acute. Busy directors are neither detrimental nor beneficial

on average, but are associated with a high impact on firm value for young firms, in need of more advisory services from their board members.

Second, I study the effect of board level variables. The evidence suggests that large boards, entrenched boards and boards prone to groupthink impede their directors' ability to participate to the generation of cash flows, while directors joining better compensated boards are expected to have more impact on value creation. The results also indicate that investors discount the expected contribution of an incoming director joining a gender diverse board and that foreign directors joining a board composed exclusively of American directors are associated with significantly lower value impact.

Finally, I turn to firm level variables and find that directors matter more when their firms recently experienced poor performance. Further, the average director contributes more to value creation in small firms and firms that operate in more complex industries. Lastly, investors anticipate that the impact of the average director will be limited when the firm has more takeover defenses. This suggests that investors do not expect internal governance to serve as a substitute for poor external governance for the average firm. However, when external governance mechanisms are particularly weak (i.e. the firm is a "dictatorship" as termed by Gompers et al., 2003) the results indicate that the monitoring services provided by independent directors and female directors are valued. Therefore, internal governance mechanisms may serve as a substitute when external governance mechanisms fail.

The findings in this paper shed new light on the channels through which directors create value. This research has timely implications for the design of corporate boards as countries around the world are mandating quotas targeting the composition of boards of directors. The introduction of quotas should be made after careful consideration of their welfare implications. This paper offers a new unified methodology based on a learning framework to assess the value impact of directors. While they do not speak to the welfare implications of director quotas, the results indicate that mandating board diversity for example could potentially be detrimental for the average firm.

As pointed out in Adams, Hermalin and Weisbach (2010), firms face a myriad of constraints that ultimately shape their governance structures. One limitation of the results is that they do not explicitly

consider the heterogeneity in firms' governance optimization problem. Taking this heterogeneity into account is a necessary step to expand our understanding of the role and importance of boards. The learning-based framework proposed in this paper provides a potentially fruitful approach to explore this issue.

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Appendix A: Variable Definitions

All board and director variables are constructed from BoardEx, financial variables are from Compustat and market variables are from CRSP.

Director Attributes	
Tenure	Time since a director joined a board (in years)
Tenure^2	Square of *Tenure*
Nomination member	Indicator variable equal to 1 if the director is a member of the Nomination committee
Compensation member	Indicator variable equal to 1 if the director is a member of the Compensation committee
Audit member	Indicator variable equal to 1 if the director is a member of the Audit committee
All3com	Indicator variable equal to 1 if the director is a member of the Audit, Compensation and Nomination committees
Age	Age of the director (in years)
Female	Indicator variable equal to 1 if the director is female
Independent	Indicator variable equal to 1 if the director is independent
Chairman	Indicator variable equal to 1 if the director is the chairman of the board
Age > median	Indicator variable equal to 1 if the director's age is superior to 60
Large network	Indicator variable equal to 1 if the size of the director's network is larger than the sample 75th percentile
Busy	Indicator variable equal to 1 if the director serves simultaneously on three or more boards
Not American	Indicator variable equal to 1 if the director's nationality is not American
CEO public firm experience	Indicator variable equal to 1 if the director is or has previously been CEO of a public corporation
Board exp same industry	Indicator variable equal to 1 if the director is serving or has previously served on the board of a firm in the same industry. Industries are based on the Fama-French ten-industry classification
Job exp same industry	Indicator variable equal to 1 if the director is working or has previously worked for a firm in the same industry. Industries are based on the Fama-French ten-industry classification
Nb prev board seats	Number of boards the director has served in the past
Low uncertainty	Indicator variable equal to 1 if the director has previous experience as CEO and has served on at least two other boards
High uncertainty	Indicator variable equal to 1 if the director does not have board experience, has not been CEO of another firm and is less than 50 years old
Exchange mandated appointment	Indicator variable equal to 1 if the new director appointment occurred between 2002 and 2005 and resulted in the board complying with the new 50% independent listing requirement while it previously did not
Retiree replacement	Indicator variable equal to 1 for directors appointed within a month following the departure of a director who reached the maximum age requirement

Appendix A (continued)

Board Attributes	
Avg board tenure	Average tenure of the directors of a board in a given month (in years)
Avg board tenure square	Square of *Average board tenure*
Young board	Indicator variable equal to 1 for boards in the first tercile when boards are ranked by the average tenure of their members
Seasoned board	Indicator variable equal to 1 for boards in the third tercile when boards are ranked by the average tenure of their members
Gender diverse board	Indicator variable equal to 1 if at least one woman serves on the board
Board size	Number of directors on the board
Large board	Indicator variable equal to 1 if board size is larger than the sample mean
Entrenched	Indicator variable equal to 1 if the CEO has been in office for 5 or more years and cumulates the titles of CEO, Chairman and President
% tenure sup 9 yrs	Percentage of directors on the board with tenure greater than 9 years
Board Pay Slice	Ratio of total independent directors compensation over CEO compensation (salary + bonus)
High Board Pay Slice	Indicator variable equal to 1 if Board Pay Slice is larger than the sample mean

Firm Level Variables	
Ln(assets)	Natural logarithm of total firm assets (item AT in Compustat)
Dividend payer	Indicator variable to one if the firm pays dividends (item DVC in Compustat)
Leverage	Long-term debt over total assets (item DLTT/AT in Compustat)
MB	Market to book ratio: Stock price at year end*common shares outstanding over total common equity ((PRCC_C*CSHO)/CEQ in Compustat)
ROA	Return on assets: net income over total assets (NI/AT in Compustat)
Poor performance	Indicator variable equal to 1 for firms with a return on assets lower than the 25th percentile of their respective industry ROA in the year preceding the director appointment. Industries are based on the Fama-French ten-industry classification.
Firm age	Age of the firm measured as the number of years since the first appearance of the firm in CRSP, as in Fama and French (2004)
G-index	Governance index as in Gompers et al. (2003). Data from A. Metrick's website
Dictatorship	Dummy variable equal to 1 for firms with G≥14, as in Gompers, Ishii and Metrick (2003)
Large firm	Indicator variable equal to 1 if the firm's assets is greater than the sample 75^{th} percentile

Market Variables	
Idiosyncratic volatility	Variance of the residuals of a daily Fama-French three factor model as in Ang et al. (2006), aggregated monthly, winzorized at the 1% cutoff
Realized volatility	Standard deviation of daily stock returns, aggregated monthly, winzorized at the 1% cutoff
Market beta	Estimated coefficient on the excess market return in a daily Fama-French three factor model, aggregated monthly
SMB beta	Estimated coefficient on the SMB factor in a daily Fama-French three factor model, aggregated monthly
HML beta	Estimated coefficient on the HML factor in a daily Fama-French three factor model, aggregated monthly

Figure 1: Volatility and Director Tenure

In all three panels, the sample include directors who remain on the board for at least five years. In Panel A, there are no other director appointments at least two years before and three years after the new directors join. In Panel B, there are no other appointments at least one year before and one year after the new directors join. In Panel C, there are no restrictions on the appointment of other directors.

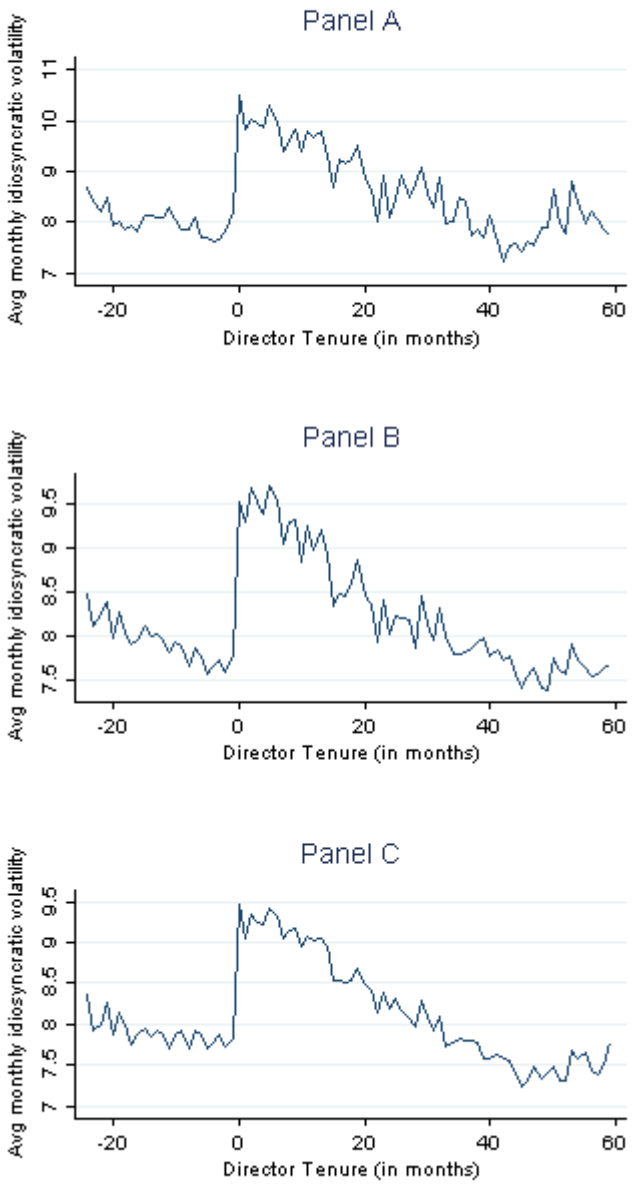

Figure 2: Exogenous Director Appointments

This figure graphs average idiosyncratic volatility as a function of director tenure for samples of exogenous director appointments. Panel A includes directors appointed to satisfy the NYSE and Nasdaq new listing requirements pertaining to board independence. Panel B uses the same sample as Panel A excluding years 2008 and 2009. Panel C includes directors appointed to replace a retiring board member.

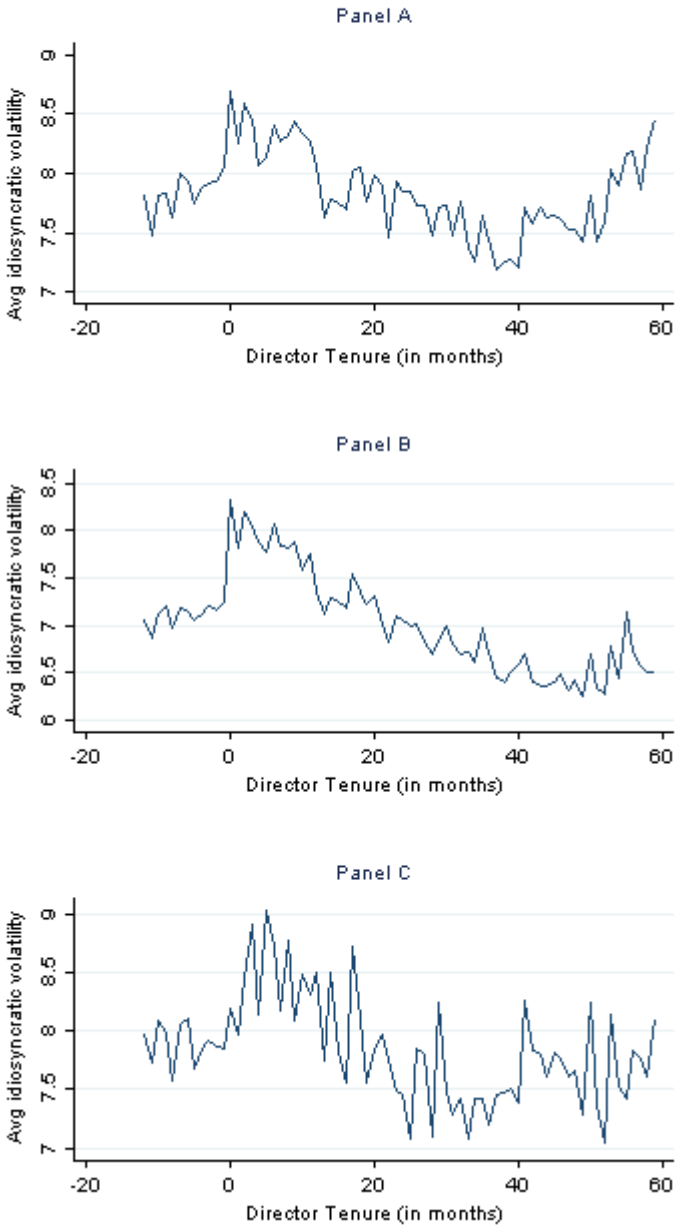

Figure 3: Volatility and Director Tenure: Young vs. Seasoned Boards

Boards are ordered by the average tenure of their members and bucketed into terciles. The monthly average idiosyncratic volatility is computed for each level of board tenure. Panel A graphs the relationship between volatility and board tenure for boards in the first tercile while Panel B graphs the relation for boards in the third tercile.

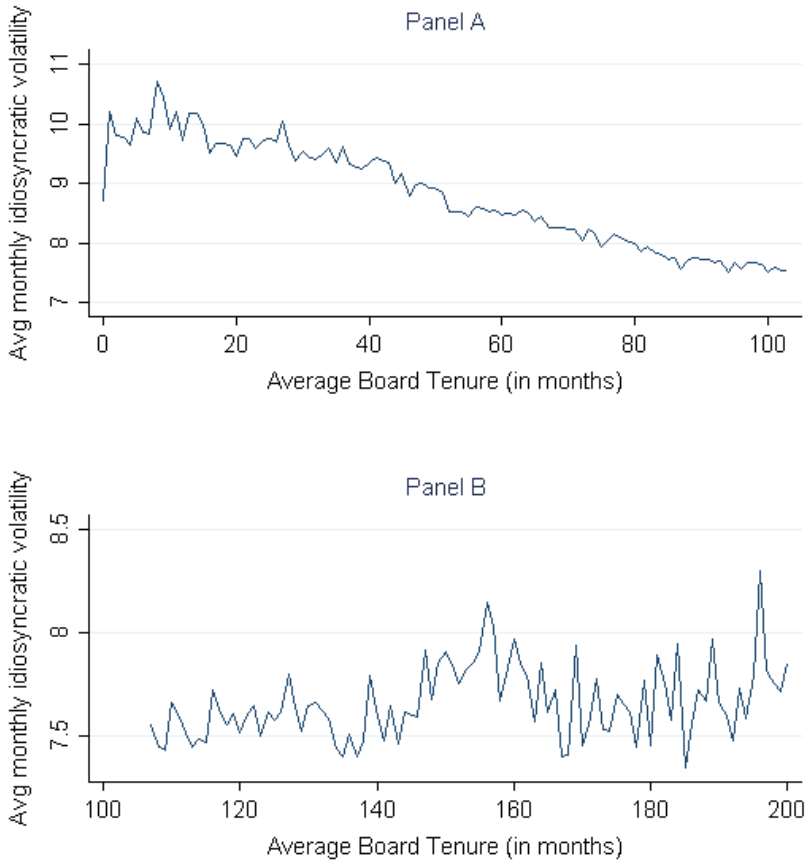

Figure 4: Mean Learning Slope by Industry

This figure plots the average learning slope for each industry in the Fama-French ten-industry classification.

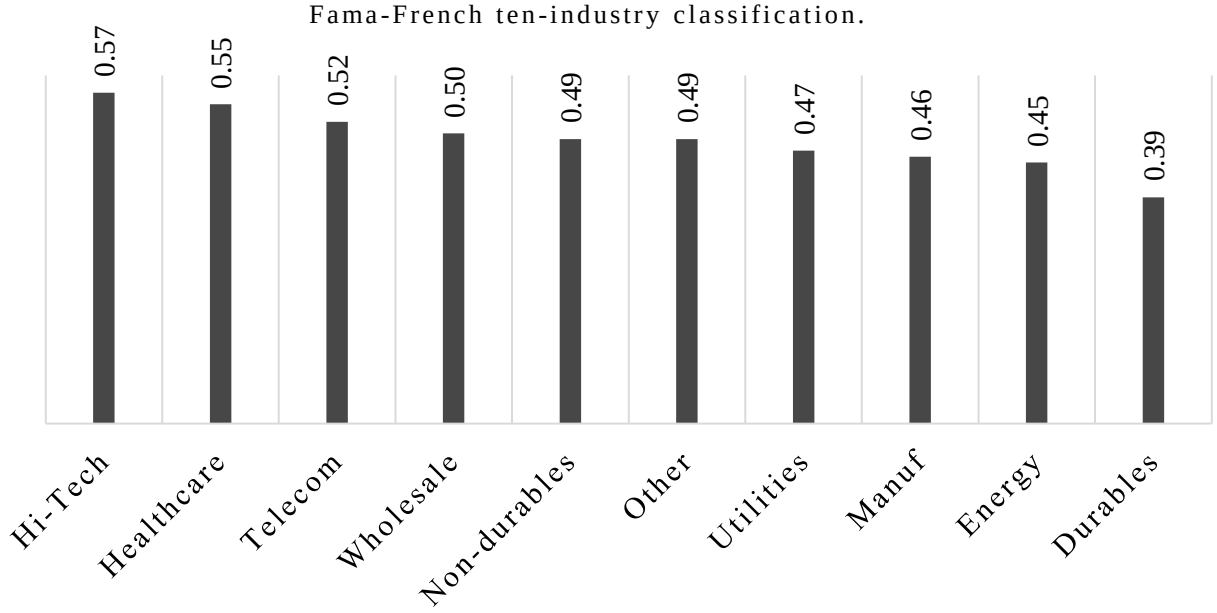

Table 1: Descriptive Statistics

This table provides summary statistics for board characteristics, volatility and beta variables as well as firm financial attributes. Board characteristics and financial attributes are at the firm-year level whereas market variables are at the firm-month level. The definition of all variables is in Appendix A.

Panel A: Director and Board Characteristics

	Obs	Mean	Std. Dev.	25%	Median	75%
Age	23,018	60.32	4.37	57.76	60.63	63.15
Female	23,018	0.11	0.10	0.00	0.11	0.17
Tenure	23,018	8.29	4.02	5.53	7.89	10.52
Independent	23,227	0.78	0.14	0.72	0.80	0.88
Not American	28,472	0.02	0.06	0.00	0.00	0.00
CEO public firm experience	24,638	0.03	0.06	0.00	0.00	0.00
Board experience same industry	24,638	0.05	0.10	0.00	0.00	0.09
Job experience same industry	24,638	0.12	0.12	0.00	0.11	0.19
Number previous board seats	24,638	1.30	0.42	1.00	1.18	1.50
Large network	25,186	0.23	0.29	1.00	1.18	1.50
Network size	23,227	596	367	341	517	761
Compensation member	23,227	0.43	0.15	0.33	0.41	0.50
Nomination member	23,227	0.34	0.23	0.22	0.37	0.48
Audit member	23,227	0.43	0.12	0.35	0.42	0.50
All three committees	23,227	0.08	0.16	0.00	0.00	0.10
Busy	25,184	0.31	0.29	0.10	0.24	0.43
Entrenched	25,184	0.53	0.48	0.00	0.75	1.00
% tenure sup 9 yrs	23,227	0.34	0.24	0.14	0.35	0.51
Board Pay Slice	10,789	0.25	0.48	0.04	0.11	0.25
Board size	23,227	9.42	2.64	7.67	9.00	11.00

Panel B: Market Variables

	Obs	Mean	Std. Dev.	25%	Median	75%
Realized volatility	239,445	11.72	8.04	6.68	9.62	14.18
Idiosyncratic volatility	239,445	8.57	6.29	4.69	6.91	10.44
Market beta	239,445	1.05	0.99	0.57	1.01	1.49
SMB beta	239,445	0.63	1.53	-0.19	0.50	1.33
HML beta	239,445	0.22	2.03	-0.71	0.18	1.13

Panel C: Firm Level Variables

	Obs	Mean	Std. Dev.	25%	Median	75%
Firm age	23,016	21.78	18.04	9.08	16.47	30.58
G-index	9,228	9.41	2.59	8.00	9.00	11.00
Democracy	9,228	0.06	0.24	0.00	0.00	0.00
Dictatorship	9,228	0.06	0.23	0.00	0.00	0.00
Ln (assets)	20,066	7.67	1.75	6.45	7.56	8.76
Dividend payer	19,990	0.55	0.50	0	1	1
Leverage	20,004	0.18	0.18	0.02	0.15	0.29
M/B	14,035	2.80	21.73	1.39	2.07	3.29
ROA	20,065	0.04	0.14	0.01	0.04	0.08

Table 2: Volatility and Director Tenure

Panel A: Quadratic Regression Model

This table reports regression results for the volatility-director tenure relation estimated with a quadratic regression model. The dependent variable is one of the two volatility measures: realized volatility and idiosyncratic volatility. The main variables of interest are Tenure and Tenure^2. All specifications include new directors who remain on the board for at least five years. In Specifications 1 and 2, there are no other director appointments at least two years before and three years after the new director joins. In Specifications 3 and 4, there are no other appointments at least one year before and one year after the new director joins. In Specifications 5 and 6, there is no restriction on the appointment of other directors. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

	(1) Idiosyncratic Volatility	(2) Realized Volatility	(3) Idiosyncratic Volatility	(4) Realized Volatility	(5) Idiosyncratic Volatility	(6) Realized Volatility
Tenure	-0.731**	-0.600	-0.170**	-0.105	-0.119***	-0.103**
	(-2.137)	(-1.483)	(-2.345)	(-1.181)	(-3.360)	(-2.389)
Tenure^2	0.101**	0.071	0.031**	0.018	0.022***	0.019**
	(2.320)	(1.264)	(2.212)	(1.059)	(3.130)	(2.187)
Market Beta		0.989***		0.962***		0.874***
		(9.548)		(21.083)		(12.511)
SMB Beta		0.311***		0.351***		0.380***
		(4.575)		(11.710)		(16.336)
HML Beta		-0.022		0.018		0.018
		(-0.466)		(0.779)		(0.792)
Ln(assets)	-0.626	-1.016**	-0.562**	-0.778***	-0.567***	-0.662***
	(-1.593)	(-1.997)	(-2.488)	(-2.608)	(-3.243)	(-3.125)
Dividend Payer	-0.322	-0.408	-0.698**	-0.602*	-0.960***	-0.949***
	(-0.897)	(-0.889)	(-2.322)	(-1.870)	(-3.844)	(-3.377)
Leverage	0.419	0.268	0.857	0.851	1.136**	1.131**
	(0.469)	(0.260)	(1.592)	(1.337)	(2.440)	(2.033)
MB	0.001	0.000	0.001***	0.001***	0.001	0.001
	(0.858)	(0.484)	(4.778)	(6.085)	(1.342)	(1.123)
ROA	-1.406	-1.316	-1.625***	-1.529**	-1.758***	-1.912***
	(-1.514)	(-1.585)	(-3.048)	(-2.448)	(-4.079)	(-3.973)
Constant	16.014***	20.000***	16.815***	19.574***	18.204***	20.284***
	(5.043)	(4.857)	(9.584)	(8.368)	(13.026)	(11.886)
Observations	36,255	36,255	174,314	174,314	416,542	416,542
R-squared	0.334	0.560	0.295	0.546	0.282	0.534
Calendar month fixed effect	yes	yes	yes	yes	yes	yes
Board fixed effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Volatility and Director Tenure

Panel B: Piecewise Linear Regression Model

This table reports regression results for the volatility-director tenure relation estimated with a piecewise linear regression model. The dependent variable is idiosyncratic volatility. All specifications include new directors who remain on the board for at least five years. In Specification 1, there are no other director appointments at least two years before and three years after the new director joins. In Specification 2, there are no other appointments at least one year before and one year after the new director joins. In Specification 3, there is no restriction on the appointment of other directors. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)
Tenure (year 1)	-0.982**	-0.251**	-0.134**
	(-2.258)	(-2.039)	(-2.210)
Tenure (year 2-5)	-0.126	0.011	0.004
	(-0.524)	(0.567)	(0.474)
Ln(assets)	-0.651*	-0.566**	-0.569***
	(-1.659)	(-2.510)	(-3.252)
Dividend Payer	-0.294	-0.696**	-0.958***
	(-0.815)	(-2.311)	(-3.832)
Leverage	0.442	0.864	1.139**
	(0.497)	(1.608)	(2.446)
MB	0.001	0.001***	0.001
	(0.811)	(4.764)	(1.345)
ROA	-1.345	-1.623***	-1.757***
	(-1.479)	(-3.043)	(-4.084)
Constant	16.508***	16.898***	18.258***
	(5.194)	(9.653)	(13.070)
Observations	36,255	174,314	416,542
R-squared	0.334	0.295	0.282
Calendar month fixed effect	yes	yes	yes
Board fixed effect	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Volatility and Director Tenure

Panel C: Logarithmic and Reciprocal Functions

This table reports regression results for the volatility-director tenure relation estimated with a logarithmic and an inverse function of director tenure. The dependent variable is idiosyncratic volatility. All specifications include new directors who remain on the board for at least five years. In Specifications 1 and 2, there are no other director appointments at least two years before and three years after the new director joins. In Specifications 3 and 4, there are no other appointments at least one year before and one year after the new director joins. In Specifications 5 and 6, there is no restriction on the appointment of other directors. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)	(6)
Ln(1+tenure)	-1.009*		-0.090*		-0.050***	
	(-1.711)		(-1.827)		(-2.622)	
-1/(1+tenure)		-2.119**		-0.299**		-0.158***
		(-2.271)		(-2.160)		(-2.983)
Ln(assets)	-0.635	-0.638	-0.567**	-0.565**	-0.568***	-0.568***
	(-1.616)	(-1.626)	(-2.506)	(-2.502)	(-3.248)	(-3.247)
Dividend Payer	-0.298	-0.297	-0.688**	-0.691**	-0.956***	-0.957***
	(-0.831)	(-0.815)	(-2.297)	(-2.301)	(-3.826)	(-3.827)
Leverage	0.507	0.432	0.877	0.87	1.144**	1.142**
	(0.562)	(0.481)	(1.627)	(1.615)	(2.455)	(2.451)
MB	0.001	0.001	0.001***	0.001***	0.001	0.001
	(0.730)	(0.848)	(4.790)	(4.784)	(1.355)	(1.351)
ROA	-1.361	-1.361	-1.621***	-1.622***	-1.755***	-1.755***
	(-1.487)	(-1.475)	(-3.042)	(-3.044)	(-4.063)	(-4.070)
Constant	15.820***	14.205***	16.847***	16.529***	18.216***	18.057***
	(5.122)	(4.454)	(9.589)	(9.384)	(13.047)	(12.905)
Observations	36,255	36,255	174,314	174,314	416,542	416,542
R-squared	0.333	0.334	0.295	0.295	0.282	0.282
Calendar month fixed effect	yes	yes	yes	yes	yes	yes
Board fixed effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Exogenous Director Appointments

This table reports regression results for the volatility-director tenure relation estimated using samples of exogenous director appointments. The sample in Specification 1 includes directors appointed to satisfy the NYSE and Nasdaq new listing requirements pertaining to board independence. Specification 2 includes the full sample of director appointments and interacts *Tenure* with *Required appointment* which is a dummy variable equal to one for director appointments included in Specification 1. The sample in Specification 3 includes directors appointed to replace a retiring board member. Specification 4 includes the full sample of director appointments and interacts *Tenure* with *Retiree replacement* which is a dummy variable equal to one for director appointments included in Specification 3. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)
Tenure	-0.092*	-0.123***	-0.261*	-0.103***
	(-1.810)	(-3.402)	(-1.856)	(-3.405)
$Tenure^2$	0.020*	0.022***	0.055*	0.019***
	(1.877)	(3.142)	(1.908)	(3.181)
Required appointment		-0.055		
		(-1.123)		
Tenure*Required appointment		0.024		
		(1.088)		
Independent		0.009		
		(0.870)		
Retiree replacement				-0.035
				(-0.523)
Tenure*Retiree replacement				0.024
				(0.810)
Ln(assets)	-0.044	-0.568***	-0.165	-0.579***
	(-0.123)	(-3.244)	(-0.351)	(-3.427)
Dividend Payer	-0.258	-0.961***	-0.542	-0.969***
	(-0.659)	(-3.845)	(-1.293)	(-4.162)
Leverage	-0.610	1.137**	-0.005	0.961**
	(-0.696)	(2.441)	(-0.002)	(2.080)
MB	-0.002	0.001	0.005	0.000
	(-0.318)	(1.340)	(1.493)	(0.850)
ROA	-1.043**	-1.758***	-3.477***	-1.538***
	(-2.065)	(-4.079)	(-2.782)	(-3.913)
Constant	12.294***	18.199***	12.369***	18.782***
	(3.483)	(13.014)	(3.401)	(14.127)
Observations	79,843	416,542	50,233	491,447
R-squared	0.260	0.282	0.247	0.262
Calendar month fixed effect	yes	yes	yes	yes
Board fixed effect	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Additional Tests

Panel A: All Firm-Months and *Ex Ante* Uncertainty

This table reports regression results for the volatility-director tenure relation estimated with all firm-month observations. The dependent variable is one of the two volatility measures: realized volatility and idiosyncratic volatility. *First 3 yrs* is a dummy variable equal to one for the first three years of tenure and zero otherwise. *Low uncertainty* is a dummy variable equal to one for directors who have previous experience as CEO and who have served on at least two boards, and zero otherwise. *High uncertainty* is a dummy variable equal to one for directors who do not have board experience, have not been CEO of another firm and are less than 50 years old. Specifications 1 through 4 include board fixed effects and month fixed effects whereas Specifications 5 and 6 include firm fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

	(1) Idiosyncratic Volatility	(2) Idiosyncratic Volatility	(3) Realized Volatility	(4) Realized Volatility	(5) Idiosyncratic Volatility	(6) Idiosyncratic Volatility
Tenure	0.001		0.001		0.003**	
	(1.082)		(0.737)		(2.206)	
$Tenure^2$	0.000		0.000			
	(-0.708)		(-0.414)			
First 3 yrs	0.125***	0.166***	0.107***	0.143***	0.323***	0.442***
	(3.645)	(3.756)	(2.629)	(2.756)	(5.124)	(4.746)
Tenure*first 3 yrs	-0.056***		-0.044**		-0.126***	
	(-3.333)		(-2.248)		(-4.920)	
Ln(1+tenure)		0.011		0.010		0.041*
		(1.617)		(1.186)		(1.851)
Ln(1+tenure)*first 3 yrs		-0.140***		-0.114**		-0.326***
		(-3.524)		(-2.475)		(-4.806)
Tenure*first 3 yrs*low uncertainty					-0.088	
					(-0.614)	
Tenure*first 3 yrs*high uncertainty					-0.531*	
					(-1.741)	
Ln(1+tenure)*first 3 yrs*low uncertainty						-0.394
						(-1.032)
Ln(1+tenure)*first 3 yrs*high uncertainty						-1.285
						(-1.455)
Low uncertainty					-0.251*	-0.582*
					(-1.956)	(-1.727)
High uncertainty					0.114	-0.365
					(0.231)	(-0.331)
Tenure*low uncertainty					0.017	
					(1.302)	
Tenure*high uncertainty					0.029	
					(0.658)	
First 3 yrs*low uncertainty					0.520	0.889*
					(1.521)	(1.727)
First 3 yrs*high uncertainty					0.861	1.372
					(0.970)	(0.981)
Ln(1+tenure)*low uncertainty						0.225
						(1.419)
Ln(1+tenure)*high uncertainty						0.336
						(0.702)

Table 4, Panel A (continued)

	(1) Idiosyncratic Volatility	(2) Idiosyncratic Volatility	(3) Realized Volatility	(4) Realized Volatility	(5) Idiosyncratic Volatility	(6) Idiosyncratic Volatility
Market Beta			0.878***	0.878***		
			(24.558)	(24.559)		
SMB Beta			0.352***	0.352***		
			(18.307)	(18.307)		
HML Beta			0.025	0.025		
			(1.386)	(1.386)		
Ln(assets)	-0.470***	-0.470***	-0.543***	-0.543***	-1.026***	-1.027***
	(-2.822)	(-2.823)	(-2.584)	(-2.584)	(-7.947)	(-7.953)
Dividend Payer	-0.959***	-0.959***	-1.017***	-1.017***	-1.912***	-1.912***
	(-4.242)	(-4.242)	(-3.764)	(-3.765)	(-9.040)	(-9.041)
Leverage	1.413***	1.412***	1.586***	1.586***	1.620***	1.619***
	(3.741)	(3.741)	(3.300)	(3.299)	(3.708)	(3.707)
MB	0.000	0.000	0.000	0.000	0.001	0.001
	-0.522	-0.52	-0.334	-0.333	-1.323	-1.322
ROA	-1.725***	-1.725***	-1.787***	-1.787***	-3.914***	-3.914***
	(-4.953)	(-4.954)	(-4.386)	(-4.386)	(-7.844)	(-7.846)
Constant	16.984***	16.970***	18.972***	18.959***	21.338***	21.280***
	(12.900)	(12.873)	(11.518)	(11.496)	(21.026)	(20.921)
Observations	1,366,770	1,366,770	1,366,770	1,366,770	1,270,337	1,270,337
R-squared	0.268	0.268	0.521	0.521	0.355	0.355
Calendar month fixed effect	yes	yes	yes	yes	yes	yes
Board fixed effect	yes	yes	yes	yes	no	no
Firm fixed effect	no	no	no	no	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Additional Tests

Panel B: Young and Seasoned Boards

This table reports regression results for the volatility-director tenure relation for young boards in Specifications 1 and 2 and for seasoned boards in Specifications 3 and 4. All regressions include board fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)
Avg board tenure	-0.599***		0.014	
	(-2.591)		(0.128)	
(Avg board tenure)^2	0.047**		0.001	
	(2.117)		(0.500)	
Ln(1+avg board tenure)		-1.124**		0.838
		(-2.247)		(0.805)
Board size	-0.013	-0.013	-0.022	-0.028
	(-0.229)	(-0.225)	(-0.511)	(-0.616)
Firm age	-0.592***	-0.565***	-0.680***	-0.722***
	(-4.188)	(-4.248)	(-7.239)	(-6.668)
Ln(assets)	-0.768***	-0.767***	0.135	0.302
	(-2.637)	(-2.632)	(0.320)	(0.626)
Dividend Payer	-0.791**	-0.809**	-1.198***	-1.503**
	(-2.187)	(-2.228)	(-2.704)	(-2.428)
Leverage	-0.313	-0.29	2.585***	2.177*
	(-0.449)	(-0.416)	(3.031)	(1.735)
MB	0.000	0.000	0.002	0.002
	(-0.040)	(-0.052)	(0.733)	(0.634)
ROA	-2.947***	-2.953***	-1.909**	-2.511***
	(-3.042)	(-3.048)	(-2.548)	(-2.766)
Constant	29.029***	28.817***	26.301***	24.923***
	(11.403)	(12.337)	(8.398)	(7.330)
Observations	528,497	528,497	473,760	473,760
R-squared	0.186	0.185	0.291	0.253
Calendar month fixed effect	yes	yes	yes	yes
Board fixed effect	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Additional Tests

Panel C: Not a CEO effect

This table reports regression results for the volatility-director tenure relation controlling for the effect of CEO tenure. Specifications 1 and 2 exclude director appointments that occur within a year of a CEO turnover, while Specifications 3 and 4 directly control for CEO tenure. All regressions include board fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)
Tenure	-0.081**			
	(-2.324)			
$Tenure^2$	0.014*			
	(1.956)			
Ln(1+tenure)		-0.050**	-0.050***	-0.021
		(-2.411)	(-2.633)	(-0.908)
Ln(1+CEO tenure)			-0.010	-1.106**
			(-0.281)	(-2.580)
Ln(assets)	-0.458**	-0.458**	-0.568***	-0.396
	(-2.542)	(-2.545)	(-3.251)	(-1.095)
Dividend Payer	-0.957***	-0.957***	-0.955***	-1.255***
	(-3.224)	(-3.218)	(-3.827)	(-2.689)
Leverage	0.712	0.717	1.143**	1.347
	(1.562)	(1.571)	(2.450)	(1.521)
MB	0.001	0.001	0.001	0.001*
	(0.640)	(0.634)	(1.360)	(1.709)
ROA	-2.086***	-2.087***	-1.755***	-1.581***
	(-4.437)	(-4.445)	(-4.064)	(-3.598)
Constant	17.190***	17.198***	18.221***	16.077***
	(11.778)	(11.794)	(13.048)	(5.418)
Observations	308,088	308,088	416,524	144,348
R-squared	0.279	0.278	0.282	0.257
Calendar month fixed effect	yes	yes	yes	yes
Board fixed effect	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Additional Tests

Panel D: Co-appointments

This table report regression results for various samples of director appointments. Specification 1 restricts the sample to director appointments not accompanied by another director appointment within a year. Specification 2 restricts the sample to appointments accompanied by at least another director appointment within a year. Specification 3 restricts the sample to appointments accompanied by exactly one other director appointment during the year. Specification 4 restricts the sample to appointments accompanied by at least 2 other director appointments within the year. Specification 5 restricts the sample to appointments accompanied by a CEO turnover within the year. Control variables are included in the regressions but omitted here for brevity purposes. All regressions include board fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)
Tenure- single appointment	0.010				
	(0.043)				
Tenure^2- single appointment	0.000				
	(0.009)				
Tenure- multiple appointments		-0.088***			
		(0.030)			
Tenure^2- multiple appointments		0.017***			
		(0.006)			
Tenure- one co-appointment			-0.076*		
			(0.045)		
Tenure^2- one co-appointment			0.016*		
			(0.009)		
Tenure- 2+ co-appointments				-0.098**	
				(0.038)	
Tenure^2- 2+ co-appointments				0.019**	
				(0.007)	
Tenure- appointment with CEO					-0.262**
					(0.110)
Tenure^2- appointment with CEO					0.060***
					(0.022)
Constant	19.066***	19.018***	17.421***	19.259***	21.474***
	(1.557)	(1.310)	(1.763)	(1.425)	(2.361)
Observations	92,805	569,069	124,788	444,281	157,173
R-squared	0.258	0.244	0.245	0.245	0.272
Calendar month fixed effect	yes	yes	yes	yes	yes
Board fixed effect	yes	yes	yes	yes	yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Additional Tests

Panel E: Matched Sample

This table reports regression results from estimating the volatility-director tenure relationship for a matched sample. Each firm for each of the three original samples is matched to the firm closest in size, based on ln(assets), that belongs to the same industry. Industries are based on the Fama-French 10 industry classification. Control firms must not experience a director appointment at least one year before and one year after the appointment of a director in the sample firm. In these regressions, all variables are control firm variables, except for the tenure variables, which track the tenure of the new director in the sample firm. All specifications include new directors who remain on the board for at least five years on the board of the sample firm. In Specification 1, there are no other director appointments at least two years before and three years after the new director joins. In Specification 2, there are no other appointments at least one year before and one year after the new director joins. In Specification 3, there is no restriction on the appointment of other directors. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)	(6)
Tenure	0.100	-0.005	-0.036			
	(0.355)	(-0.087)	(-1.090)			
$Tenure^2$	-0.014	-0.001	0.007			
	(-0.260)	(-0.116)	(1.046)			
Ln(1+tenure)				-0.011		
				(-0.528)		
-1/(1+tenure)					-0.035	
					(-0.667)	
Tenure (year 1)						-0.027
						(-0.516)
Tenure (year 2-5)						0.001
						(0.107)
Ln(assets)	-1.430**	-0.253	-0.043	-0.044	-0.044	-0.044
	(-2.558)	(-0.969)	(-0.177)	(-0.179)	(-0.179)	(-0.179)
Dividend payer	-1.721**	-0.693**	-0.464	-0.464	-0.464	-0.464
	(-1.986)	(-2.063)	(-1.536)	(-1.538)	(-1.538)	(-1.538)
Leverage	1.956*	0.798	0.301	0.303	0.303	0.303
	(1.796)	(0.810)	(0.352)	(0.354)	(0.354)	(0.354)
MB	0.001	0.002**	0.000	0.000	0.000	0.000
	(1.297)	(2.282)	(0.425)	(0.424)	(0.424)	(0.422)
ROA	-1.011	-1.069**	-1.563***	-1.564***	-1.564***	-1.563***
	(-1.144)	(-2.370)	(-3.395)	(-3.398)	(-3.397)	(-3.396)
Constant	24.567***	15.594***	13.575***	13.572***	13.541***	13.581***
	(5.749)	(7.736)	(6.995)	(6.992)	(6.964)	(7.000)
Observations	28,570	154,262	366,944	366,944	366,944	366,944
R-squared	0.252	0.272	0.284	0.284	0.284	0.284
Calendar month fixed effect	yes	yes	yes	yes	yes	yes
Board fixed effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Summary of Previous Empirical Evidence and Evidence from the Learning-based Methodology

	Study	Finding	Evidence from the Learning-based Methodology
Position on the Board			
Chairman	N/A	N/A	Chairman contributes significantly more to firm value
Audit member	N/A	N/A	Members contribute significantly more to firm value
Compensation member	N/A	N/A	Members contribute significantly more to firm value
Nominating member	N/A	N/A	Members contribute marginally more to firm value
All 3 key committees	N/A	N/A	Members of all three key committees contribute significantly more to firm value
Independent directors	Bhagat and Black (2000); Hermalin and Weisbach (1991)	No relation between % outside directors and Tobin's Q/accounting measures	Independent directors contribute significantly less to firm value on average. However, independent directors with industry expertise and independent directors joining firms insulated from the market for corporate control are expected to contribute significantly more to firm value
	Weisbach (1988)	Boards dominated by outside directors more likely to replace CEO in bad times	
	Masulis, Ruzzier, Xiao and Zhao (2012)	Positive correlation between the presence of independent directors with industry expertise and firm performance	
	Gillan, Hartzell and Starks (2011)	Powerful boards are substitute for the market of corporate control	
Director Characteristics			
Gender	Adams and Ferreira (2009)	Female directors are better monitors, but at the cost of lower firm performance	Female directors contribute significantly less to firm value on average. However, when the need for monitoring services is acute, female directors are expected to be particularly valuable
	Matsa and Miller (2012); Ahern and Dittmar (2012)	Female directors are associated with decreased firm value and profitability	
Nationality	Masulis, Wang and Xie (2012)	Foreign directors are associated with reduced monitoring	No statistical difference in the expected contribution to firm value for American or foreign directors for the average sample firm. However, foreign directors joining American-only boards are associated with a significantly lower value impact
	Daniel, McConnell and Naveen (2013)	Foreign directors are associated with increased firm value for multinational firms	
Busyness	Fich and Shivdasani (2006)	Busy directors are associated with lower firm value	Busy directors are not associated with higher or lower contribution to firm value on average. However, for young firms in need of advisory services, busy directors contribute significantly more to firm value
	Core, Holthausen and Larcker (1999)	Busy outside directors are associated with increased CEO compensation	
	Ferris, Jagannathan and Pritchard (2003)	Positive announcement returns to appointments of busy directors	
	Field, Lowry and Mkrtchyan (2013)	Busy directors are beneficial for small young firms but detrimental for large firms	
Connections	Larcker, So and Wang (2013)	Firms with well-connected directors have higher abnormal returns	The number of business connections is positively related to the expected impact of directors on firm value, although the estimated coefficient is not statistically significant for the average director. Chairmen with more business connections do however have significantly higher marginal value
	Coles, Wang and Zhu (2015)	Firms with well-connected directors have more CEO turnover	
	Kuhnen (2009)	The positive and negative effects of board-management connections balance out in the mutual fund industry	

Table 5 (continued)

	Study	Finding	Evidence from the Learning-based Methodology
Board Level Characteristics			
Entrenched boards and powerful CEOs	Hermalin and Weisbach (1998)	Model predicts increased CEO bargaining power vis-a-vis the board over CEO tenure	Boards with powerful CEOs contribute less to firm value
	Shivdasani and Yermack (1999)	More powerful CEOs are able to select a less independent board	
	Fracassi and Tate (2012)	Powerful CEOs appoint directors with ties to the CEO resulting in weaker monitoring	
Groupthink	Coles, Daniel and Naveen (2015)	Groupthink has a negative effect on firm value for firms in dynamic industries	Directors joining boards prone to groupthink (with a high percentage of directors with long tenure) contribute less to firm value
Board size	Yermack (1996); Eisenberg, Sundgren and Wells (1998)	Inverse association between board size and Tobin's Q	Smaller boards contribute more to firm value
Board Pay Slice	N/A	N/A	Better compensated boards contribute more to firm value
Gender-diverse	Schwartz-Ziv (2015)	Boards with at least three women are more active	Directors joining gender-diverse boards contribute less to firm value
	Adams & Ferreira (2009)	Female directors are better monitors, but at the cost of lower firm performance	
Firm Level Characteristics			
Firm size	N/A	N/A	Directors contribute more to firm value in small firms
Prior performance	Mace (1971)	Interview evidence that boards' activiness is limited to crisis situations	Directors contribute more to firm value when the firm has recently performed poorly
	Larcker, So and Wang (2013)	Board network resources are most valuable for firm with poor performance	
Industry	Coles, Daniel and Naveen (2015)	Groupthink is more detrimental for firms in more dynamic industries	Directors contribute more to firm value in complex and human capital intensive industries
Governance	Gillan, Hartzell and Starks (2011)	Powerful boards are substitute for the market of corporate control	For the average firm, directors contribute less to firm value when firms have weaker external governance (more takeover defenses). When firms are "dictatorships" (G-index≥14) however, independent directors are expected to contribute significantly more to firm value

Table 6: The Effect of Director and Board Characteristics on the Volatility-Tenure Relation

Panel A: Position on the board

This table reports regression results using interaction variables to identify director attributes that affect the volatility-director tenure relation. All regressions include firm fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)	(6)
Ln(1+tenure)	-0.154***	-0.296***	-0.519***	-0.194**	-0.261***	-0.288***
	(-3.165)	(-3.073)	(-3.211)	(-1.984)	(-2.735)	(-2.992)
Chairman	0.416**					
	(2.215)					
Ln(1+tenure)*Chairman	-0.310**					
	(-2.281)					
Independent		-0.197	-0.498**	-0.203	-0.347**	-0.209*
		(-1.618)	(-2.467)	(-1.558)	(-2.423)	(-1.704)
Ln(1+tenure)*Independent		0.148	0.383**	0.206**	0.307***	0.161*
		(1.567)	(2.444)	(2.014)	(2.777)	(1.692)
Job exp same industry			-0.560**			
			(-2.278)			
Ln(1+tenure)*Job exp same industry			0.409**			
			(2.197)			
Independent*Job exp same industry			0.646**			
			(2.135)			
Ln(1+tenure)*Job exp same industry*Indep			-0.668***			
			(-2.927)			
Dictatorship				-1.409***		
				(-2.945)		
Ln(1+tenure)*Dictatorship				0.526*		
				(1.664)		
Independent*Dictatorship				0.670*		
				(1.809)		
Ln(1+tenure)*Dictatorship*Independent				-0.540*		
				(-1.705)		
Nomination member					0.079	
					(0.827)	
Ln(1+tenure)*Nomination member					-0.094	
					(-1.312)	
Compensation member					0.147*	
					(1.785)	
Ln(1+tenure)*Compensation member					-0.162**	
					(-2.547)	
Audit member					0.167**	
					(2.160)	
Ln(1+tenure)*Audit member					-0.159***	
					(-2.647)	
All3com						0.321
						(1.430)
Ln(1+tenure)*All3com						-0.327**
						(-1.973)

Table 6, Panel A (continued)

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)	(6)
Age	-0.001	0.000	0.000	-0.002	0.000	0.000
	(-0.281)	(-0.164)	(-0.212)	(-0.761)	(-0.052)	(-0.142)
Number previous jobs	-0.032	-0.035	-0.011	0.024	-0.036	-0.035
	(-1.349)	(-1.440)	(-0.443)	(1.104)	(-1.483)	(-1.447)
Nb prev board seats	-0.009	-0.007	-0.007	-0.016	-0.006	-0.007
	(-0.627)	(-0.521)	(-0.476)	(-1.146)	(-0.396)	(-0.512)
CEO public firm experience	0.098	0.094	0.098	-0.061	0.091	0.091
	(1.388)	(1.320)	(1.374)	(-0.785)	(1.280)	(1.279)
Ln(assets)	-1.114***	-1.113***	-1.109***	-0.134	-1.113***	-1.114***
	(-7.079)	(-7.074)	(-7.061)	(-0.581)	(-7.078)	(-7.081)
Dividend Payer	-1.673***	-1.673***	-1.673***	-0.650***	-1.673***	-1.673***
	(-7.721)	(-7.717)	(-7.732)	(-2.793)	(-7.723)	(-7.724)
Leverage	1.573***	1.572***	1.557***	0.019	1.563***	1.570***
	(3.001)	(2.999)	(2.964)	(0.032)	(2.983)	(2.996)
MB	0.002**	0.002**	0.002**	0.002	0.002**	0.002**
	(2.198)	(2.194)	(2.171)	(1.219)	(2.236)	(2.217)
ROA	-2.955***	-2.955***	-2.955***	-4.809***	-2.964***	-2.960***
	(-4.713)	(-4.706)	(-4.714)	(-10.472)	(-4.720)	(-4.708)
Constant	22.067***	22.231***	22.477***	13.523***	22.195***	22.233***
	(17.075)	(17.206)	(17.224)	(6.960)	(17.185)	(17.207)
Observations	389,558	389,558	389,558	191,367	389,558	389,558
R-squared	0.358	0.358	0.358	0.378	0.358	0.358
Calendar month fixed effect	yes	yes	yes	yes	yes	yes
Firm fixed effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: The Effect of Director and Board Characteristics on the Volatility-Tenure Relation

Panel B: Personal Director Attributes

This table reports regression results using interaction variables to identify director attributes that affect the volatility-director tenure relation. All regressions include firm fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Ln(1+tenure)	-0.203***	-0.033	-0.769***	-0.163***	-0.174***	-0.159***	-0.154***	-0.161***	0.053	-0.156***	-0.162***
	(-3.993)	(-0.663)	(-5.121)	(-3.298)	(-3.528)	(-2.976)	(-2.915)	(-3.025)	(0.961)	(-3.160)	(-3.296)
Large network						0.001	-0.037				
						(0.012)	(-0.368)				
Ln(1+tenure)*Large network						-0.035	0.004				
						(-0.463)	(0.049)				
Chairman							0.236				
							(1.078)				
Ln(1+tenure)*Chairman							-0.148				
							(-0.933)				
Large network*Chairman							0.847*				
							(1.904)				
Ln(1+tenure)*Large network*Chairman							-0.781**				
							(-2.436)				
Female	-0.335***	-0.208	-0.649**								
	(-2.728)	(-1.513)	(-2.410)								
Ln(1+tenure)*Female	0.252***	0.142	0.385								
	(2.666)	(1.186)	(1.641)								
Dictatorship		-1.096**									
		(-2.017)									
Ln(1+tenure)*Dictatorship		0.110									
		(0.842)									
Female*Dictatorship		0.513*									
		(1.659)									
Ln(1+tenure)*Female*Dictatorship		-0.514									
		(-1.606)									
Large Firm			-0.592**								
			(-2.117)								
Ln(1+tenure)*Large Firm			0.926***								
			(5.685)								
Female*Large Firm			0.589*								
			(1.910)								
Ln(1+tenure)*Female*Large Firm			-0.370								
			(-1.385)								
Not American				0.065							
				(0.349)							
Ln(1+tenure)*Not American				-0.103							
				(-0.685)							
Not American on American only board					-0.583***						
					(-2.729)						
Ln(1+tenure)*Not American on American only board					0.401**						
					(2.353)						

Table 6, Panel B (continued)

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Busy								0.084	0.000		
								(0.848)	(0.002)		
Ln(1+tenure)*Busy								-0.022	0.040		
								(-0.306)	(0.531)		
Young Firm									1.587***		
									(6.674)		
Ln(1+tenure)*Young Firm									-0.809***		
									(-5.940)		
Busy*Young Firm									0.361		
									(1.594)		
Ln(1+tenure)*Busy*Young Firm									-0.289*		
									(-1.675)		
Board exp same industry										0.149	
										(0.792)	
Ln(1+tenure)*Board exp same industry										-0.215	
										(-1.490)	
CEO experience											0.310
											(1.641)
Ln(1+tenure)*CEO experience											-0.208
											(-1.407)
CEO public firm experience	0.095	-0.062	-0.129	0.099	0.100	0.099	0.099	0.104	0.117*	0.101	
	(1.343)	(-0.721)	(-1.495)	(1.396)	(1.409)	(1.391)	(1.408)	(1.469)	(1.654)	(1.433)	
Age	-0.001	-0.003	-0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(-0.461)	(-1.087)	(-1.389)	(-0.270)	(-0.278)	(-0.234)	(-0.282)	(-0.466)	(-0.564)	(-0.338)	(-0.315)
Number previous jobs	-0.033	-0.022	0.005	-0.033	-0.033	-0.032	-0.033	-0.030	-0.026	-0.029	-0.030
	(-1.390)	(-0.832)	(0.191)	(-1.355)	(-1.363)	(-1.356)	(-1.377)	(-1.237)	(-1.108)	(-1.212)	(-1.264)
Nb prev board seats	-0.009	-0.001	-0.026	-0.009	-0.009	-0.008	-0.007	-0.015	-0.019	0.000	-0.008
	(-0.653)	(-0.032)	(-1.486)	(-0.630)	(-0.641)	(-0.558)	(-0.538)	(-1.070)	(-1.329)	(-0.018)	(-0.557)
Ln(assets)	-1.110***	-0.196		-1.113***	-1.112***	-1.113***	-1.114***	-1.116***	-0.995***	-1.113***	-1.114***
	(-7.059)	(-0.797)		(-7.070)	(-7.068)	(-7.068)	(-7.078)	(-7.080)	(-6.283)	(-7.069)	(-7.067)
Dividend Payer	-1.670***	-1.025***	-1.937***	-1.671***	-1.670***	-1.673***	-1.674***	-1.672***	-1.595***	-1.672***	-1.671***
	(-7.710)	(-3.234)	(-5.299)	(-7.716)	(-7.714)	(-7.720)	(-7.728)	(-7.720)	(-7.344)	(-7.719)	(-7.712)
Leverage	1.571***	-0.102	1.236*	1.572***	1.574***	1.573***	1.576***	1.574***	1.514***	1.567***	1.571***
	(2.996)	(-0.146)	(1.722)	(3.002)	(3.008)	(3.003)	(3.006)	(3.012)	(2.892)	(3.001)	(3.001)
MB	0.002**	-0.002	-0.001	0.002**	0.002**	0.002**	0.002**	0.002**	0.002**	0.002**	0.002**
	(2.192)	(-0.988)	(-0.640)	(2.189)	(2.190)	(2.186)	(2.204)	(2.189)	(2.553)	(2.200)	(2.181)
ROA	-2.955***	-3.401***	-3.624***	-2.957***	-2.956***	-2.957***	-2.950***	-2.956***	-2.893***	-2.956***	-2.957***
	(-4.704)	(-5.344)	(-5.721)	(-4.702)	(-4.703)	(-4.703)	(-4.708)	(-4.705)	(-4.823)	(-4.703)	(-4.702)
Constant	22.123***	14.199***	13.032***	22.076***	22.081***	22.070***	22.071***	22.102***	20.493***	22.068***	22.082***
	(17.111)	(6.867)	(22.329)	(17.075)	(17.088)	(17.083)	(17.082)	(17.075)	(15.515)	(17.069)	(17.061)
Observations	389,558	92,818	121,811	389,558	389,558	389,558	389,558	389,558	388,298	389,558	389,558
R-squared	0.358	0.376	0.385	0.358	0.358	0.358	0.358	0.358	0.361	0.358	0.358
Calendar month fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: The Effect of Director and Board Characteristics on the Volatility-Tenure Relation

Panel C: Director Field of Expertise

This table reports regression results using interaction variables to identify director background fields that affect the volatility-director tenure relation. The set of controls for *ex ante* uncertainty and the set of firm level control variables included in previous regressions are included in the regressions but omitted here for brevity. All regressions include firm fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(1+tenure)	-0.154***	-0.152***	-0.167***	-0.167***	-0.169***	-0.163***	-0.165***	-0.165***
	(-3.021)	(-2.986)	(-3.403)	(-3.411)	(-3.452)	(-3.310)	(-3.273)	(-3.366)
Finance background	0.091							
	(0.824)							
Ln(1+tenure)*Finance background	-0.110							
	(-1.259)							
Finance background 5+ yrs		0.098						
		(0.855)						
Ln(1+tenure)*Finance bkgd 5+ yrs		-0.124						
		(-1.402)						
Academic background			-0.075					
			(-0.316)					
Ln(1+tenure)*Academic background			-0.016					
			(-0.077)					
Politician background				-0.224				
				(-0.617)				
Ln(1+tenure)*Politician background				0.096				
				(0.349)				
HR background					-0.737			
					(-1.645)			
Ln(1+tenure)*HR background					0.731**			
					(2.227)			
Tech background						0.211		
						(0.705)		
Ln(1+tenure)*Tech background						-0.297		
						(-1.306)		
Marketing background							0.057	
							(0.389)	
Ln(1+tenure)*Marketing background							-0.041	
							(-0.365)	
Legal background								0.387
								(1.137)
Ln(1+tenure)*Legal background								-0.320
								(-1.213)
Constant	22.078***	22.075***	22.079***	22.082***	22.078***	22.078***	22.081***	22.082***
	(17.092)	(17.071)	(17.079)	(17.083)	(17.083)	(17.091)	(17.084)	(17.082)
Observations	389,558	389,558	389,558	389,558	389,558	389,558	389,558	389,558
R-squared	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358
Calendar month fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effect	yes	yes	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: The Effect of Director and Board Characteristics on the Volatility-Tenure Relation

Panel D: Board Level Attributes

This table reports regression results using interaction variables to identify board level attributes that affect the volatility-director tenure relation. All regressions include firm fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)	(5)	(6)
Ln(1+tenure)	-0.287***	-0.424***	-0.423***	-0.539***	0.027	-0.566***
	(-3.893)	(-4.931)	(-5.937)	(-6.050)	(0.457)	(-4.933)
Entrenched	-0.493***					-0.479***
	(-3.599)					(-3.536)
Ln(1+tenure)*Entrenched	0.252***					0.241***
	(2.792)					(2.734)
% tenure sup 9 yrs		-1.116***				
		(-2.906)				
Ln(1+tenure)*% tenure sup 9 yrs		1.055***				
		(4.649)				
High BPS					0.358**	0.207
					(2.565)	(1.479)
Ln(1+tenure)*High BPS					-0.387***	-0.269***
					(-4.337)	(-3.025)
Large Board			-0.540***			-0.377**
			(-3.477)			(-2.359)
Ln(1+tenure)*Large Board			0.561***			0.416***
			(5.961)			(4.193)
Gender diverse board				-0.551***		-0.328*
				(-2.945)		(-1.726)
Ln(1+tenure)*Gender diverse board				0.505***		0.306***
				(4.874)		(2.809)
Age	0.000	-0.001	-0.001	-0.001	-0.001	0.000
	(-0.068)	(-0.315)	(-0.283)	(-0.377)	(-0.291)	(-0.149)
Number previous jobs	-0.035	-0.033	-0.032	-0.033	-0.031	-0.036
	(-1.469)	(-1.369)	(-1.335)	(-1.383)	(-1.303)	(-1.506)
Nb prev board seats	-0.006	-0.008	-0.008	-0.008	-0.008	-0.006
	(-0.425)	(-0.591)	(-0.599)	(-0.600)	(-0.602)	(-0.458)
CEO public firm experience	0.087	0.101	0.097	0.099	0.094	0.084
	(1.239)	(1.416)	(1.366)	(1.392)	(1.318)	(1.189)
Ln(assets)	-1.097***	-1.106***	-1.081***	-1.082***	-1.096***	-1.042***
	(-6.973)	(-7.040)	(-6.903)	(-6.869)	(-6.971)	(-6.648)
Dividend Payer	-1.665***	-1.672***	-1.666***	-1.665***	-1.675***	-1.656***
	(-7.678)	(-7.720)	(-7.662)	(-7.660)	(-7.742)	(-7.616)
Leverage	1.557***	1.557***	1.540***	1.546***	1.566***	1.521***
	(2.954)	(2.971)	(2.910)	(2.951)	(2.990)	(2.856)
MB	0.002**	0.002**	0.002**	0.002**	0.002**	0.002**
	(2.211)	(2.305)	(2.349)	(2.222)	(2.099)	(2.285)
ROA	-2.945***	-2.941***	-2.950***	-2.948***	-2.963***	-2.937***
	(-4.722)	(-4.766)	(-4.765)	(-4.663)	(-4.752)	(-4.778)
Constant	22.113***	22.269***	22.233***	22.334***	21.728***	22.146***
	(17.083)	(17.267)	(17.368)	(17.517)	(16.688)	(17.252)
Observations	389,558	389,558	389,558	389,558	389,558	389,558
R-squared	0.359	0.359	0.359	0.359	0.359	0.360
Calendar month fixed effect	yes	yes	yes	yes	yes	yes
Firm fixed effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: The Effect of Director and Board Characteristics on the Volatility-Tenure Relation

Panel E: Firm Level Attributes

This table reports regression results using interaction variables to identify firm level attributes that affect the volatility-director tenure relation. All regressions include firm fixed effects and month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix A.

Dependent Variable: Idiosyncratic Volatility	(1)	(2)	(3)	(4)
Ln(1+tenure)	-0.247***	-0.393**	-0.006	-0.001
	(-4.172)	(-2.220)	(-0.145)	(-0.026)
Large firm	0.086			
	(0.402)			
Ln(1+tenure)*Large firm	0.231**			
	(2.224)			
G-index		-0.152		
		(-1.592)		
Ln(1+tenure)*G		0.039**		
		(2.254)		
Poor performance			0.774***	
			(4.422)	
Ln(1+tenure)*Poor performance			-0.193*	
			(-1.681)	
Ln(1+tenure)*HighTech				-1.344***
				(-9.584)
Ln(1+tenure)*Consumer durables				0.491*
				(1.915)
Age	-0.001	-0.002	0.001	-0.001
	(-0.496)	(-0.710)	(0.447)	(-0.288)
Number previous jobs	-0.026	0.021	-0.018	-0.031
	(-1.064)	(0.935)	(-0.883)	(-1.295)
Nb prev board seats	-0.012	-0.015	-0.025**	-0.008
	(-0.858)	(-1.051)	(-2.011)	(-0.542)
CEO public firm experience	0.095	-0.054	0.073	0.103
	(1.252)	(-0.702)	(1.162)	(1.445)
Ln(assets)		-0.121	-0.929***	-1.091***
		(-0.520)	(-5.999)	(-7.085)
Dividend Payer	-1.799***	-0.646***	-1.771***	-1.678***
	(-7.894)	(-2.763)	(-7.746)	(-7.791)
Leverage	1.554**	0.019	1.576***	1.533***
	(2.542)	(0.033)	(2.991)	(3.040)
MB	0.002***	0.002	0.001	0.001**
	(2.613)	(1.154)	(1.447)	(1.984)
ROA	-3.051***	-4.788***	-3.354***	-2.873***
	(-4.652)	(-10.424)	(-6.714)	(-4.597)
Constant	13.610***	14.636***	20.001***	21.917***
	(31.246)	(7.302)	(15.342)	(17.301)
Observations	389,558	191,367	345,428	389,558
R-squared	0.353	0.378	0.358	0.361
Calendar month fixed effect	yes	yes	yes	yes
Firm fixed effect	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Learning Slopes

This table reports normalized learning slopes for different subsamples. Learning slopes are computed by first regressing idiosyncratic volatility on director tenure and controlling for covariates that affect the level of volatility, using board and year fixed effects. Residual volatility is defined as idiosyncratic volatility minus the fit of this regression, plus the estimated coefficient on the tenure variable times tenure. Next, residual volatility is regressed on tenure in individual regressions for each director-firm pair. The coefficient estimates on the tenure variable are multiplied by (-1) for ease of interpretation and normalized by their cumulative distribution function to yield a ranking between 0 and 1. They are referred to as the learning slope for each director, for each board he joins.

	N	Mean	Std dev.	Means difference p-value
Not chairman	11,329	0.50	0.0027	0.006
Chairman	463	0.54	0.0138	
Large network	9,402	0.50	0.29	0.845
Small network	2,390	0.50	0.28	
Young director	7,717	0.50	0.29	0.952
Old director	4,075	0.50	0.29	
Entrenched board	4,865	0.48	0.28	0.000
Not entrenched	6,927	0.51	0.29	
Large board	5,727	0.48	0.28	0.000
Small board	6,065	0.52	0.30	
Large firm	6,824	0.49	0.28	0.000
Small firm	4,968	0.51	0.30	
Gender diverse board	8,616	0.49	0.28	0.000
Not gender diverse	3,176	0.54	0.30	
Low board pay slice	5,516	0.48	0.28	0.000
High board pay slice	6,276	0.52	0.30	
Busy	2,901	0.50	0.28	0.862
Not busy	8,891	0.50	0.29	

Table 8: Director, Board and Firm Attributes: Evidence from Learning Slopes

This table explores the determinants of directors' learning slope. Learning slopes are computed by first regressing idiosyncratic volatility on director tenure and controlling for covariates that affect the level of volatility, using board and year fixed effects. Residual volatility is defined as idiosyncratic volatility minus the fit of the above regression, plus the estimated coefficient on the tenure variable times tenure. Next, residual volatility is regressed on tenure in individual regressions for each director-firm pair. The coefficient estimates on the tenure variable are multiplied by (-1) for ease of interpretation and normalized by their cumulative distribution function to yield a ranking between 0 and 1. They are referred to as the learning slope for each director, for each board he joins. All regressions include a year fixed effect and standard errors are clustered at the industry level. The definition of all variables is in Appendix A.

Dependent Variable: Learning slope	(1)	(2)	(3)	(4)	(5)
Large network			0.009		
			(1.211)		
Chairman	0.049**		0.023		
	(2.202)		(1.382)		
Large network*Chairman			0.043		
			(1.147)		
Female			-0.033**		
			(-2.504)		
Large firm			-0.022**		
			(-1.994)		
Female*Large firm			0.030*		
			(1.912)		
Busy			-0.003		
			(-0.404)		
CEO experience			-0.018		
			(-0.783)		
Busy*CEO experience			0.074*		
			(1.799)		
Not American			0.010		
			(0.648)		
Independent	-0.019	-0.030***			
	(-1.454)	(-2.989)			
Dictatorship	-0.034				
	(-0.825)				
Independent*Dictatorship	0.059				
	(1.466)				
Compensation member		0.015**			
		(2.270)			
Audit member		0.009			
		(1.419)			
Nomination member		-0.004			
		(-0.485)			

Table 8 (continued)

Dependent Variable: Learning slope	(1)	(2)	(3)	(4)	(5)
Board Pay Slice				0.031**	
				(2.149)	
Entrenched				-0.018**	
				(-1.985)	
Large board				-0.032**	
				(-2.573)	
Gender diverse				-0.024*	
				(-1.891)	
Poor performance					0.040***
					(3.591)
Consumer durables					-0.085***
					(-2.808)
Technology					0.045***
					(2.967)
Ln(Age)	0.026	-0.007	-0.025	-0.019	-0.020
	(0.774)	(-0.305)	(-1.016)	(-0.709)	(-0.797)
Number previous jobs	0.003	-0.005	-0.003	-0.001	-0.002
	(0.651)	(-1.159)	(-0.681)	(-0.298)	(-0.533)
Nb prev board seats	0.004	0.002	-0.001	-0.001	-0.003
	(1.138)	(0.597)	(-0.450)	(-0.382)	(-0.963)
CEO public firm experience	-0.006	-0.002	0.002	-0.007	-0.003
	(-0.297)	(-0.142)	(0.126)	(-0.471)	(-0.181)
Dividend Payer	-0.070***	-0.078***	-0.085***	-0.076***	-0.053***
	(-4.814)	(-6.816)	(-7.656)	(-6.546)	(-4.770)
Ln(assets)	-0.005	-0.008**		0.002	-0.005
	(-1.176)	(-2.500)		(0.448)	(-1.425)
Constant	0.465**	0.723***	0.790***	1.027***	0.572***
	(2.442)	(4.817)	(5.088)	(8.629)	(4.943)
Observations	4,978	10,199	10,199	7,360	7,770
R-squared	0.041	0.059	0.058	0.069	0.066
Year fixed effect	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1