A Learning-Based Approach to Evaluating Boards of Directors

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March 2017

Abstract

Using predictions from a learning model, this paper exploits the cross-sectional variation in the learning-induced decline in stock return volatility over director tenure to infer the marginal value of different kinds of directors. This new framework confirms prior empirical findings and documents new results. For example, directors joining better compensated boards have higher marginal value while the marginal value of a director joining an entrenched board is muted. Furthermore, the estimates imply that governance related uncertainty associated with the arrival of a new director accounts for 7% of return volatility, shedding light on the extent to which governance matters.

JEL Classification: G30, G34, G39, M12, M51

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

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* Foster School of Business, University of Washington, leastern@uw.edu. I am grateful to Mike Weisbach for his invaluable insights, as well as Renée Adams, David De Angelis, Byoung-Hyoun Hwang, Kose John, Andrew Karolyi, Hamed Mahmudi, Yihui Pan, Miriam Schwartz-Ziv, Tracy Wang, David Weinbaum, Scott Yonker, as well as seminar participants at Cornell, Syracuse, HEC Montréal, the 2015 FMA meetings, North Carolina State, University of Denver, Portland State, Oregon State, Temple, Michigan State, Villanova, University of Utah, University of Washington, Baruch College, George Mason, Southern Methodist University and UCLA for helpful comments and discussions.

Introduction

Boards of directors are critical pillars in corporate governance. They are legally responsible for governing the firm and protecting the interests of shareholders. Yet, inasmuch as corporate directors are not perfect agents, providers of capital may find it beneficial to assess them.. 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 front and center in the governance debate for over a decade and have been addressed to some extent. The literature however often yields conflicting evidence and it is difficult to draw conclusions due to methodological issues.[2] Understanding the importance of boards and what the constituents of a well performing board are is still an open question.

This paper attempts to shed some light on this issue by proposing a novel approach based on a theoretical model of learning, which yields a general method to assess how the market reacts to the appointments of directors. The model relies on the idea that the arrival of new directors creates uncertainty and through their actions, newly appointed directors provide information to investors who update their assessment of their ability to contribute to the generation of cash flows. 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.

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[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).

[2] See Hermalin and Weisbach (2003) and Adams, Hermalin and Weisbach (2010).

The formal model of this process is borrowed from Pan, Wang and Weisbach (2015) who study learning about management and derive their stylized model based on the work of Pastor and Veronesi (2003). The model as applied to boards yields intuitive testable predictions about the relationship between stock return volatility and director tenure which motivate the empirical analysis. First, if directors do not purely engage in window-dressing but do in fact affect firm value, investors should react to their appointment and stock return volatility should subsequently decline over their tenure. Furthermore, stock return volatility should decline faster at the beginning of their tenure when uncertainty is highest. Second, the model predicts that volatility should decline by different amounts for different kinds of directors. In other words, the magnitude of the decline in volatility over a director's tenure is related to her marginal return to ability. Support for these predictions is found in the data.

The focus on the second moment of stock returns stems from the observation that whereas the first moment provides the market's assessment of the anticipated effect of a director upon her arrival, this is a very uncertain valuation at time zero. To wit, having a low expected value does not necessarily imply that a particular director is irrelevant. Hence, the mean does not provide a complete picture of the extent to which directors matter. Studying the second moment of returns provides a new and complementary lens through which to examine the importance of boards.

The increase in return volatility upon the arrival of directors is driven by the conjunction of two effects: that director ability is relevant and that it is uncertain. Importantly, how much uncertainty there is about a director decreases at a predetermined rate due to Bayes' rule. This rate is faster for higher *ex-ante* levels of uncertainty. The model therefore provides a theoretical framework to assess which directors matter more: after controlling for the *ex-ante* uncertainty about the ability of a new director, the cross-sectional variation in the magnitude of the learning-induced decline in return volatility provides an estimate of the marginal return to ability of different kinds of directors. For example, the results suggest that if the current board is entrenched, investors expect an incoming director's ability to sway the fortunes of the firm to be muted.

In addition, the model is useful to quantify the fraction of return volatility imputable to the uncertainty about the firm's board and to compare it to the uncertainty about management.

The empirical analysis uses a sample of 18,579 directors on the boards of 2,228 firms, taken from the intersection of S&P 1,500 firms in BoardEx, CRSP and Compustat during the 2000-2014 period. The estimates indicate that when a director joins a board, stock return volatility jumps by 13% on average and subsequently declines over the next few years. This implies that learning about directors lowers volatility, presumably by reducing governance-related uncertainty. Interpreted in light of the learning model, the decline in return volatility over the course of director tenure provides empirical support for the assumption that investors expect board members to be relevant in their valuation of the firm.

An important concern with this interpretation is the potential endogeneity of director appointments. To wit, firms could reshuffle their boards in times of crisis, when volatility tends to be especially high. In particular, we might expect periods of turmoil to be accompanied by a transition in leadership. Therefore, all estimates exclude directors appointed within a year around a CEO turnover. For this subsample of director appointments, which is the one used in the regressions, the median (mean) ratio of the average return volatility over the three month period prior to the arrival of a new director to the average return volatility over the two year period preceding the director appointment is 0.94 (1.00). This suggests that for this sample, return volatility does *not* appear to be especially high in the period leading to the appointment.

To alleviate the endogeneity concern further, the documented patterns still hold when restricting the sample to exogenous director appointments. First, results hold for 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, results hold for directors appointed to replace a board member who either passed away or retired. A board member is defined as retiring if she is over 70 and/or was sitting on multiple boards and left all her boards within two years. Restricting the sample to directors appointed to replace a director who passed away or who retired yields a sample of board turnovers that are likely exogenous to firm conditions.

The concern of potentially endogenous turnover is most valid when the firm is going through turmoil. Therefore, a further restriction that is imposed is that these appointments occur when the firm has had good stock return performance and low return volatility over the past year.

A similarity score is used to compare the individual profiles of the departing directors who left due to deaths or retirements to the profile of the directors replacing them. Requiring that the departing and incoming directors share a similar profile helps further ensure that the firm did not appoint a particular director due to a major shift in strategy[3].

A series of additional tests are designed to rule out the possibility that the documented volatility patterns are a byproduct of potentially endogenous director appointments. These tests also help to disentangle the investor learning hypothesis put forth in this paper from potential alternative explanations.

First, stock return volatility patterns for young boards are compared to those of mature boards. There is presumably more governance related uncertainty for younger boards than there is for more seasoned boards. If the decline in stock return volatility reflects the resolution of governance related uncertainty, we should observe a stronger decline for these younger boards. Consistent with this idea, stock return volatility declines sharply over the average board tenure for relatively young boards while it does not for mature boards (controlling for firm age and board size). In contrast, if the documented volatility patterns were due to the endogenous nature of director appointments there would be no reason to expect different patterns based on the average tenure of board members.

A potential alternative explanation for the decline in return volatility rests on the assumption that directors come on the board having little idea how to do their job thus creating a lot of noise around their decisions. As directors get better at their job over time, they develop skills which allow them to produce better decisions in the interest of the firm, which may drive the decline in return volatility. The findings contrasting young and mature boards is difficult to reconcile with this director learning alternative hypothesis though. If anything, it should be easier

[3] Note that the firms' exposure to systematic risk does not appear to change over the learning period: plots of the firms' market, SMB and HML betas over director tenure do not show any specific pattern.

for new directors to learn to do their job if the board is more mature and can more effectively coach a newly appointed director. The director learning alternative explanation is addressed directly in additional tests below.

Second, if the documented volatility pattern reflects investors learning about incoming directors, we should observe an attenuated decline in volatility for directors who are well-known to market participants. The data shows that this is the case: the decline in return volatility is sharply muted for well-known directors.

The alternative director learning explanation is grounded in the idea that as directors get better over time, they develop skills to produce better decisions in the interest of the company which reduces return volatility. This paper exploits the fact that some directors are better equipped than others to produce better decisions when joining new boards: directors with board experience in the same industry who have held multiple previous directorships will arguably be quicker to adjust to the production function of a particular firm, thereby predicting a smaller decline in return volatility over their tenure. The investor learning hypothesis predicts the opposite: directors with industry expertise who have a rich history of directorships should be a wealth of resources for the board and therefore be more relevant for firm value. The data supports the investor learning hypothesis: controlling for how much the market knows about them, "professional" directors are associated with larger declines in stock return volatility over their tenure.

Third, the analysis is run using all firm-months instead of using the first years of director tenure to test the volatility-tenure relationship. This exercise is designed to ensure that the results are not inflated by zooming in on a narrow window. The results indicate that volatility declines significantly over the first three years following the arrival of new directors, but does not outside this window.

Finally, a matched sample confirms that the drop in volatility exceeds what is observed for firms that do not experience the arrival of a director. These findings are consistent with the notion that the spike and subsequent decline in stock return volatility following director appointments reflect the uncertainty about how much a new director will sway the fortunes of their firm.

The model has implications about the fraction of overall volatility attributable to the uncertainty about the board. Borrowing the methodology developed in Pan et al. (2015), the estimates imply that the uncertainty about a new director's ability accounts for about 7% of overall stock return volatility on average. These estimates indicate that the arrival of corporate directors generates substantial uncertainty.

Next, the learning slope is computed for each director-firm pair, by estimating the average decline in volatility over the course of their tenure, over and above the variation in volatility predicted by firm level covariates and macroeconomic factors. Performance (as measured by the firm's return on assets and abnormal stock returns three years post appointment) clearly improves following the appointment of high learning slope directors, (i.e. directors with learning slopes in the top decile), while it tends to stagnate for directors with learning slopes in the bottom decile. The diverging performance paths for top and bottom learning slope deciles provides suggestive evidence that the decline in return volatility reflects not only the extent to which a director can make a difference but also the extent to which they participate in value creation.

This learning-based framework can be used to revisit the literature on boards and test new hypotheses on the importance of different governance attributes. The last section of the paper studies how some director, board or firm characteristics affect the volatility-tenure relationship, thereby testing which governance characteristics are important and under which circumstances.

The results suggest that chairmen and chairs of the compensation and audit committees are expected to be more important contributors than the average director. This is not the case for any of the other committee chairs. 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 average. However, consistent with evidence in Masulis et al. (2012) and Faleye et al. (2012), independent directors with industry expertise do. In addition, investors expect independent directors joining firms with high monitoring needs to make a difference.

Female directors do not contribute to firm value as much as their male counterparts on average. There is however evidence that as in the case of independent directors, female directors make a difference when the firm's monitoring needs are acute, which is consistent with evidence

in Adams et al. (2009) and Adams et al. (2012). Busy directors, directors with more board experience and those with work experience in the industry have higher marginal value.

Boards dominated by a powerful CEO (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 return volatility indicate that the ability to make a difference for entrenched boards is muted, 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, groupthink mutes directors' marginal value. This result supports growing voices in the market for the need of board refreshment.[4] In addition, directors joining small boards are more important and boards with a high Board Pay Slice, i.e. boards that compensate their directors generously relative to their CEO, play a larger role.

Finally, the results indicate that directors matter more in small firms, in firms that have had poor performance and in firms that operate in more complex industries. This last finding corroborates the evidence in Coles, Daniel and Naveen (2015) who show that groupthink is particularly detrimental in dynamic industries.

This paper contributes to the literature by providing evidence that providers of capital expect corporate directors to play a role in the fortunes of their firm. Not all directors are equal though and this paper proposes a new framework to estimate the importance of various governance attributes. In addition, the estimates allow for a direct comparison of the extent to which governance related uncertainty affects stock return volatility relative to management uncertainty. More broadly, this paper also relates to the literature on learning in financial market.

1. Background and related literature

[4] 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.

Part of the literature on boards of directors is summarized in Table 5. Early empirical work focused 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 studied how the composition of the board or its size impacts 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). Empirical studies have also looked at the dynamics of board composition (Shivdasani and Yermack, 1999; Baker and Gompers, 2000). Theoretical work 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.

Given the potentially endogenous nature of board turnovers, researchers have looked at plausibly exogenous director appointments or departures (see among others Nguyen and Nielsen, 2010, Falato, Kadyrzhanova and Lel, 2014 and Ahern and Dittmar, 2012). 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.

Richardson et al. (2003) 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. They show that boards are important in shaping firm performance whereas Fernau (2013) finds that the variation in firm performance is partially attributable to director fixed effects. The study conducted by Schwartz-Ziv and Weisbach (2013) provides an opportunity to understand the workings of boards and shows that they do play an active management role when necessary.

In a recent paper, Denis, Denis and Walker (2015) 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 is performed not by the board but by investors, who learn about new directors. Using a Bayesian learning model, this paper provides estimates of the value of directors and studies the value relevance of director attributes and board characteristics. 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

Appendix B develops the theoretical framework of rational learning that motivates the empirical hypotheses in this paper. It is based on Pan et al. (2015) who study learning about management. 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 uncertainty surrounding the appointment of new directors and stock price volatility.

The model generates the following predictions:

1) Volatility decreases in a convex manner over director tenure.
2) Return volatility increases with uncertainty about ability.
3) Return volatility increases with the marginal return to ability of directors.

By testing these predictions, the goal of this article is to uncover what drives learning about director ability, thereby shedding light on the importance of corporate boards.

2.2. Empirical design

2.2.1. Regression model

The predictions from the learning model 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:

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

where $\beta_{1,k,i}$ is a board fixed effect for board k of firm i,

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

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

λ_t is 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 self-select to 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 2,228 firms from the intersection of S&P 1,500 firms in BoardEx, CRSP and Compustat from 2000 to 2014. It comprises 18,579 directors and 13,074 new director appointments.

The relationship between director tenure and stock return volatility is estimated 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, 12% of whom are women. On average, 19% of board members have experience as CEO of a public company and 10% have previously had a directorship in the same industry. The average director is 61 years old and has been a director for 6.5 years. There is a new director on average every two years. The average director stays for over eleven years. On average, 79% of board members are independent. 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, 35% of boards are considered entrenched. Coles et al. (2015) use the percentage of directors with tenure greater than nine years as a proxy for groupthink. In this sample, 43% of board members are prone to groupthink. On average, 15% of board members sit on three or more boards. *Board Pay Slice* is defined as the sum of independent directors' compensation over CEO total compensation, and averages 25%.[5]

[5] 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

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. 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 as 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. Panel A shows the volatility pattern for all newly appointed directors. In Panel B, only directors appointed solo are included (i.e. no other director are appointed over the six months period around their appointment). In Panel C, there are no other director appointments at least two years before and two years after the new director joins. For the three samples, volatility sharply increases at time zero, i.e. the arrival of new directors.

If directors are relevant for firm value, their arrival adds a random variable to the firm's value and as investors discover what that random variable is, return volatility declines. The 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]

Three 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 logarithmic specification and a reciprocal specification. The convexity of the volatility-tenure relationship can be verified with all three specifications. Two restrictions are imposed in all specifications: appointments must not overlap with a CEO turnover within a year and directors must remain on the board for at least five years to ensure that the decline in volatility is not driven by the high volatility in firms with high director turnover. Panel A of Table 2 presents regression results for the three functional forms and for the two volatility measures. All new director appointments satisfying the above two restrictions are included. All regressions estimate the volatility-tenure relation over the first five years of tenure. In Panel B, the tenure variables are interacted with an indicator variable equal to one when directors are appointed solo, i.e. no other directors are appointed during the six months period around their appointment. In Panel C, the tenure variables are interacted with an indicator variable equal to one when there is no other directors appointed during the two year period preceding the appointment as well as during the two year period following the appointment.

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 Panel A, the estimated coefficients on *Tenure* are negative and statistically significant for both measures of volatility, regardless of the functional form used. The coefficients on $Tenure^2$ are positive and statistically significant, which indicates that volatility declines at a faster rate at the beginning of director tenure. There is therefore a negative and convex relationship between stock return volatility and director tenure in the data, which is in line with the predictions of the learning model.

[Insert Table 2, Panel A]

In Panel B, the estimated coefficients on *Tenure* are negative and almost always statistically significant. They are also larger in absolute value when compared to those in Panel A

and the estimated coefficients on the interaction terms are positive. This suggests that directors appointed solo are associated with a smaller decline in volatility over their tenure on average. This is not surprising and supports the view that more directors joining adds more uncertainty. However, the estimated coefficients on the interaction terms are not statistically significant, suggesting that even single appointments are meaningful.

[Insert Table 2, Panel B]

Similar results are shown in Panel C of Table 2, where the tenure variables are interacted with an indicator variable equal to one when there is no other directors appointed during the two year period preceding the appointment as well as during the two year period following the appointment.

[Insert Table 2, Panel C]

The results in the three panels of Table 2 indicate that investors behave according to the predictions of the learning model when updating their assessment of a new director's ability.

3.2. Samples of plausibly 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.

In the tests below, only director appointments occurring when the firm is performing well in a low volatility environment are included. Specifically, the firm's stock return performance the year preceding the appointment must exceed that of the S&P 500 and its average monthly stock return volatility over the three months preceding the appointment must be inferior to its average

monthly return volatility over the previous two years. Director appointments must not overlap with a CEO turnover within a year and directors must remain on the board for at least five years.

The first subsample 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 exchange listing requirements has been used in the literature to study the effect of board structure on firm value (Wintocki, 2007; Duchin et al. 2010), CEO compensation (Chhaochharia et al. 2009), and firm transparency (Armstrong et al. 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.

The second exogenous sample consists of newly appointed directors who replace directors who passed away or who retired. To construct the retiree replacement sample, a new director is included if she joins the board within six months following the departure of a director who is older than 70. Fracassi and Tate (2012) show that director retirements are typically not related to firm conditions. This sample is augmented with directors who served simultaneously on multiple boards and left all of their boards within two years[6]. These directors arguably left the boardroom for reasons exogenous to the situation of one particular firm. Directors who retired due to health reasons before reaching the maximum age requirement would be included in this subsample. Director deaths are identified in BoardEx.

Panel A of Table 3 shows regression results for the various subsamples of exogenous director appointments. For brevity, only results with the quadratic functional form and idiosyncratic volatility are shown, but the results also hold for the logarithmic and reciprocal

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

specifications and realized volatility. Specification 1 in Table 3 provides regression results for the two subsamples pooled together. Specification 2 uses only the exchange mandated appointments while Specification 3 uses only the replacement directors. The results are unaltered: volatility decreases over the tenure of newly appointed directors and does so at a decreasing rate.

[Insert Table 3, Panel A]

To confirm that the documented relation between director tenure and volatility is not affected by the endogeneity of director appointments, Specifications 3 to 6 use the full sample of director appointments and *Tenure* is interacted with an indicator variable for each exogenous appointment type. The estimated coefficients on the interaction terms are insignificant. This suggests that there is no significant difference in the volatility-tenure relationship between the full sample and the exogenous samples. The results in the previous section are therefore unlikely to be driven by the potential endogeneity of director appointments.

Panel B of Table 3 reports regression results for the subsamples of exogenous director appointments when the departing and replacing directors have a high similarity score. Such a score is constructed by looking at six attributes: gender, generation, job expertise, level of board experience, previous directorship in the same industry and job experience in the same industry. Two directors are considered to have a similar profile if they share at least four attributes out of the six, which is the median score for all incoming-departing director pairs for death or retirement replacements when the firm operates in an environment of good stock return performance and low return volatility. Appendix C provides details on the construction of the similarity score. Panel B of Table 3 uses only exogenous appointments occurring when the firm is performing well, its stock return volatility is low, the appointment does not overlap with a CEO turnover and the departing and incoming directors have a very similar profile. The conclusion from this exercise remains the same: volatility declines over the tenure of newly appointed directors.

[Insert Table 3, Panel B]

3.3. Additional tests

The evidence above is consistent with learning-induced declines in volatility and supports the hypothesis that directors make a difference in the fortunes of their firm. Importantly, this pattern does not appear to be the product of the potential endogeneity of director appointments. Follow-on tests provide additional evidence that investors learn about incoming directors.

3.3.1. Young *vs.* seasoned boards

If the decline in stock return volatility reflects the resolution of governance related uncertainty, we should observe a stronger decline for young boards than for seasoned boards. Consistent with this idea, stock return volatility declines sharply over the average board tenure for relatively young boards but does not decline for mature boards, even after controlling for firm age and board size. If the documented volatility patterns were due to the endogenous nature of director appointments or to directors learning about their job, rather than investors learning about directors, there would be no reason to expect different patterns based on the average tenure of board members. If anything, we should expect it to be easier for directors to learn to do their job if the board is more mature and can more effectively coach a newly appointed director.

Panel A of Table 4 shows the estimated coefficients for the volatility and average board tenure relationship for all boards in Specification 1, for young boards in Specification 2 and for seasoned boards in Specification 3. 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.

[Insert Table 4, Panel A]

Figure 2 graphs firm volatility as a function of average director tenure for young and seasoned boards in Panels A and B, respectively. It 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 2]

3.3.2. All firm-months, ex-ante uncertainty and professional directors

Specification 1 in Panel B of Table 4 shows regression results using all firm-months as opposed to restricting the sample to the first years of director tenure. *First 3 yrs* is an indicator variable equal to one for the first three years of tenure and is interacted with *Tenure*. The purpose of this exercise is to broaden the analysis to ensure that the relation between return volatility and tenure is not inflated when the estimation is restricted to the first years of tenure.

The coefficients on the interaction term is negative and significant. Therefore, volatility declines significantly more over the first three years of tenure than over other periods. Note that the estimated coefficient on *Tenure* is insignificant, which indicates that volatility does not significantly decrease over tenure outside the first three year window.

[Insert Table 4, Panel B]

Learning by market participants should be more important when prior uncertainty about the new director is high. This is an intuitive prediction derived from the model. To test whether the decline in volatility is reduced when the new director is well-known, *High uncertainty* is an indicator variable equal to one for directors who do not have previous board experience and do not have experience as CEO. *Low uncertainty* is an indicator variable equal to one for directors who have experience as the CEO of a public firm and have served on at least four corporate boards prior to joining this one.

Because the *ex-ante* uncertainty of a director is constant, regressions using the level of *ex-ante* uncertainty include firm fixed effects rather than board fixed effects. Specifications 3 and 4 in Panel B of Table 4 show that stock return volatility declines significantly more over director tenure for directors characterized by high *ex-ante* uncertainty. Although the estimated coefficient on the interaction term does not satisfy traditional levels of significance, it is positive which shows that well-known directors are associated with smaller declines in return volatility over their tenure. Because low initial uncertainty corresponds to more visible directors, this exercise rules out the interpretation that larger declines in volatility reflect more visible directors.

Specification 5 in Panel B of Table 4 reports regression results for "professional" directors. The director learning alternative explanation is grounded in the idea that directors come on the board having little idea how to do their job, thus creating a lot of noise around their decisions.

Directors get better over time and develop skills to produce better decisions in the interest of the company. The analysis exploits the fact that some directors are better equipped than others to produce better decisions when joining new boards: directors with experience in the industry who have held previous directorships will arguably be quicker to adapt to the production function of a particular firm and should be associated with a smaller decline in return volatility over their tenure. The investor learning hypothesis predicts the opposite: controlling for how much the market knows about these directors, directors with industry expertise with a history of directorships should be a wealth of resources for the board and should be more relevant for firm value. Controlling for the level of *ex-ante* uncertainty about the ability of directors (using director age, number of previous boards, number of previous jobs and whether the director has been a CEO of a public company), Specification 5 in Panel B of Table 4 supports the investors learning hypothesis: professional directors are associated with bigger declines in stock return volatility over their tenure.

3.3.3. Matched sample

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 (assets) and operates in the same industry. 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 Panel A of 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 C 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 C]

3.4. The importance of directors

3.4.1. How much do directors matter?

Pan et al. (2015) estimate that around a CEO turnover, the uncertainty about 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 importance of directors relative to that of the CEO?

This section directly relies on the methodology derived in Pan et al. (2015), which is summarized in Appendix D. It uses 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).

The average estimated decline in volatility over the first three years of tenure is 1.5%, the average volatility of corporate dividends (σ) is 23% and the average realized annual volatility when a director joins (Vol_0) is 38%. Therefore, on average the uncertainty about new directors accounts for about 7% ($\frac{\delta_0}{Vol_0} = \sqrt{\frac{1}{3}\left[\frac{1}{1-1.5\%\times\frac{38\%}{38\%-23\%}}-1\right]} \times \frac{23\%}{38\%}$) of return volatility when there is a new director, which implies that on average, the governance related uncertainty associated with the arrival of a new director is about a third of the uncertainty associated with new leadership (Pan et al., 2015). 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.

3.4.2. Importance of directors and value creation

The results derived above are consistent with the predictions of the learning model and imply that directors are relevant for firm value. While the model is agnostic about the sign and cannot speak to whether a larger decline in volatility implies that the director will be a "better" director, this is potentially an interesting question in itself. How does the average performance of firms after the appointment of directors for whom we observed a large decline in volatility over their tenure compare to the performance of those that appointed directors associated with small

decline in volatility? The learning slope is a metric for each incoming director measuring the average decline in volatility over the first years of her tenure.

Pan et al. (2015) construct learning slopes for CEOs and although the intuition is similar here, the execution is different. Specifically, whereas Pan et al. regress return volatility on CEO tenure in individual regressions for the first 36 months in office and use the estimated coefficient on tenure as a measure of the learning slope, idiosyncratic volatility is regressed on tenure controlling for factors expected to affect the level of volatility:

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

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 :

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

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:

$$vol_{i,t}^{residual} = \alpha_i + \beta_{i,j} tenure_{ij} + \varepsilon_{i,t} \quad (4)$$

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 she joins.

Figures 3 shows the performance paths as measured by return on assets for high learning slope vs. low learning slope directors. Performance clearly improves following the appointment of directors in the top learning slope decile, while it tends to deteriorate for directors in the bottom learning slope decile.

[Insert Figure 3]

Similarly, Figure 4 reports the performance paths for high and low learning slope directors as measured by the abnormal stock return performance relative to the firm's industry over the three year period following their appointment. Again, directors with high learning slope are associated with improved performance. Taken together, these results provide suggestive evidence that high learning slope directors are not only more important, as the learning model suggests, but are actually better agents for shareholders.

[Insert Figure 4]

The results in this section indicate that governance-related uncertainty accounts for a substantial percentage of overall stock return volatility. Furthermore, there is suggestive evidence supporting the idea that larger declines in volatility can not only be interpreted as directors making a bigger difference, but also that this difference has positive effects. Taken together, these findings suggest that directors matter and are not simple rubber stampers. These results have important implications for governance research 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 marginal return to ability of directors

4.1. Prior empirical evidence on board and director characteristics

Hermalin and Weisbach (2003), Yermack (2006) and Adams et al. (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 quota was associated with deteriorating performance.

Researchers have studied the effect of the number of current directorships and provided mixed evidence as to whether busy directors 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 deeply understand the business. Their contribution 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.

This succinct review of the literature on board attributes highlights that the way the literature traditionally studies boards of directors is to select a board or director attribute, examine 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, the analysis relies on the learning-based framework to revisit part of this literature and offers new results on the importance of some governance attributes. Specifically, this paper exploits the cross-sectional variation of the learning-induced changes in return volatility following the arrival of new directors. The learning model implies that a higher marginal return to ability is associated with larger

declines in 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 importance 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

The learning framework proposed in this paper offers an alternative method to measure the expected contribution of different kinds of directors and boards. The model shows that the 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 return volatility provides estimates of directors' marginal return to ability. In other words, the magnitude of the decline in volatility over the tenure of a director reflects her marginal value. 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 the CEO of a public company. Directors appointed within a year around a CEO turnover are excluded. The median (mean) ratio of the average return volatility over the three month period prior to the arrival of a new director to the average return volatility over the two year period preceding the director appointment is 0.94 (1.00). This sample of director appointments is thus unlikely to coincide with fundamental shifts in strategy.

4.2.1. Director characteristics

4.2.1.1. Position on the board

In Specification 1 in Panel A, the coefficient estimate on the interaction term 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. Note that CEOs are not included in

the sample and that directors appointed within a year of a CEO turnover are removed. This result is therefore not attributable to chairmen cumulating the CEO and chairman functions.

[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 looked 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 matter more, as evidenced by the insignificant coefficient on the interaction term. However, Specification 3 provides evidence that independent directors with industry expertise do have a stronger effect on value, consistent with evidence in Masulis et al. (2012) and Faleye et al. (2012). In addition, Specification 4 shows that when the firm has high monitoring needs, independent directors are expected to be more important. Firms with high monitoring needs are large firms with an entrenched board.

Specification 5 provides insights into which board committees are more important by looking at the volatility-tenure relationship for committee chairs. Chairs of the audit and compensation committees appear to be particularly relevant.

4.2.1.2. Personal attributes

Panel B of Table 6 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. However, similarly to the case of independent directors, female directors appear to be especially important when the firm has high monitoring needs, as evidenced by the negative and significant interaction term in Specification 2. This result provides evidence that female directors are particularly valuable when the need for monitoring services is acute.

[Insert Table 6, Panel B]

The literature on busy directors provides mixed evidence (Fich et al., 2006 and Ferris et al., 2003). Using the learning-based approach, the results indicate that busy directors are on average more important contributors.

Specifications 4 and 5 show that directors with previous board experience in the same industry and directors with work experience in the same industry have higher marginal value.

4.2.2. Board characteristics

This section relies on the premise that different types of boards have varying marginal contributions to firm value. In other words, 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, play their role and make a difference. 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 results indicate that investors in firms with captured boards, which are prone to more agency costs, expect their directors to face obstacles in their ability to sway the fortunes of the firm.

[Insert Table 6, Panel C]

Coles et al. (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, this proxy for groupthink is associated with decreased marginal value.

Investors should expect directors in firms that provide generous compensation to its board members relative to its CEO to contribute more. To test this hypothesis, the variable *Board Pay Slice* is constructed by dividing the sum of independent director compensation by CEO total compensation. *High BPS* is an indicator variable equal to one for boards in the top BPS quartile. The negative significant coefficient on the interaction term suggests that directors joining better compensated boards are expected to have significantly more impact. Yermack (1996) and

Eisenberg et al. (1998) show that smaller boards are associated with higher firm value. *Large Board* is an indicator 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.

These findings depict how board characteristics affect investors' expectations regarding the contribution of their directors. In particular, the results in this section highlight that market participants believe that corporate directors are more important 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 characteristics

Panel D of Table 6 reports the effect of firm level attributes. *Large Firm* is an indicator variable equal to one for firms with total assets in the top quartile. The positive coefficient on the interaction term in Specification 1 shows that directors are less relevant in large firms.

[Insert Table 6, Panel D]

Directors arguably play a more central role for firms experiencing poor performance. *Poor performance* is an indicator variable equal to one for firms with a stock return performance inferior to that of the S&P500 over the one year period preceding the appointment. The estimates indicate that directors are more important for firms with weak performance.

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 in 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, this section revisited part of the literature on boards and confirmed prior findings. It shed new light on the importance of some governance attributes. The results are summarized in Table 5.

5. Conclusion

This paper is based on the idea that part of a firm's stock return volatility is related to the uncertainty about its governance. As governance-related uncertainty dissipates, the governance component of volatility declines. By relying on the theory to relate the decline in volatility to the marginal return to ability of directors, this article explores the importance of governance attributes.

The estimates provide empirical support for the view that directors matter. Results suggest that governance related uncertainty accounts for about 7% of stock return volatility when a new director joins the board, which is a third of the estimate for new leadership estimated by Pan et al. (2015). The learning-based decline in volatility documented in this paper is shown 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 make a difference, the learning-based approach can be used to estimate the importance of different kinds of directors and boards.

Chairmen, chairs of the audit and compensation committees, busy directors, independent directors with industry expertise and those joining firms with high monitoring needs have higher marginal returns to ability. While female directors do not have as much impact as their male counterparts on average, the evidence suggests that they are particularly important when the firm's monitoring needs are acute.

Large boards, entrenched boards and boards prone to groupthink impede their directors' ability to influence the firm’s actions, while directors joining better compensated boards are expected to be more important. Directors are more important when their firms recently experienced poor performance, in small firms and firms that operate in more complex industries.

The findings in this paper help delineate the channels through which directors can make a difference. In addition, the findings highlight that the importance of various governance attributes is highly context-specific. Taking the heterogeneity in firms' governance optimization problem into account is a necessary step to expand our understanding of the role governance. The learning-based framework may provide a potentially fruitful approach to examine this issue.

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Appendix A: Variable Definitions

All board and director variables are 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). Constructed from BoardEx start and end role dates.
First3	Indicator variable equal to one each month of the first three years of the director's tenure
Director age	Age of the director (in years)
Female	Indicator variable equal to one if the director is female. From BoardEx and manually collected
Independent	Indicator variable equal to one if the director is independent
Chairman	Indicator variable equal to one if the director is the chairman of the board
Busy	Indicator variable equal to one if the director serves simultaneously on three or more boards
Experience CEO public firm	Indicator variable equal to one if the director is or has previously been CEO of a public corporation
Board exp same industry	Indicator variable equal to one 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 one 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
Number previous boards	Number of previous directorships held
Low uncertainty	Indicator variable equal to one for directors who have experience as the CEO of a public firm and have served on at least four corporate boards
High uncertainty	Indicator variable equal to one for directors who do not have previous board experience and do not have experience as CEO
Pro director	Indicator variable equal to one for directors who have held at least four previous directorships and have held directorships in the same industry
Single appointment	Director appointed solo, i.e. no other directors were appointed during the six month period around her appointment
Single appointment2yrs	Director appointments for which there are no other appointments during the two year period around her appointment
Exchange mandated	Appointments designed to meet the new exchange independence requirement. Director arrival results 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. These appointments must occur when the firm's stock return has outperformed the S&P500 over the year preceding the appointment and the firm's average monthly stock return volatility over the six month period preceding the appointment is lower than the average over the two years preceding the appointment
Retirement/death replacement	Appointments within six months following the departure of a director who was over 70 years old, or of a director who served simultaneously on multiple boards and left all of her directorships within three years, or who passed away. These appointments must occur when the firm's stock return has outperformed the S&P500 over the year preceding the appointment and the firm's average monthly stock return volatility over the six month period preceding the appointment is lower than the average over the two years preceding the appointment
Pooled exogenous	Includes exchange mandated appointments and retirement/death replacements
SimScore	Similarity score for each incoming-departing director pair. See Appendix C for details

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 boards	Boards are ranked based on the average tenure of their members, each month. Young boards are those in the first tercile
Seasoned boards	Boards are ranked based on the average tenure of their members, each month. Young boards are those in the third tercile
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
Groupthink	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 in the top quartile

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)
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)
High monitoring needs	Indicator variable equal to one for large firms with entrenched boards
Poor performance	Indicator variable equal to one for firms with a stock return performance inferior to that of the S&P500 over the one year period preceding the appointment
Large firm	Indicator variable equal to one if the firm's assets is in the top quartile

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

Appendix B: Learning Model

The learning model is based on the theoretical work of Pastor and Veronesi (2003). The setup is similar to the stylized model in Pan, Wang and Weisbach (2015). 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:

$$\frac{dD_{it}}{D_{it}} = \left(\sum_{j=1}^{n} \alpha_j^i\right)dt + \sigma dW_t \qquad \text{(A1)}$$

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

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

σ is 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. For example, a director with relevant industry expertise may contribute more to firm value for a firm which operates in that particular industry.

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:

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

(A2)

The sum of assessed abilities also follows a normal distribution:

$$\sum_{j=1}^{n} \alpha_{j,t}^{i} \sim N\left(\sum_{j=1}^{n} \theta_{j,t}^{i}, \sum_{j=1}^{n} \delta_{j,t}^{i2}\right) \quad \text{(A3)}$$

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

$$d\left(\sum_{j=1}^{n} \theta_{j,t}^{i}\right) \approx m_t \left[\frac{dD_{i,t}}{D_{i,t}} - \left(\sum_{j=1}^{n} \theta_{j,t}^{i}\right)dt\right] \quad \text{(A4)}$$

$$with \quad m_t = \frac{\sum_{j=1}^{n} \delta_{j,t}^{i2}}{\sigma^2} = \frac{\sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right)t} \quad \text{(A5)}$$

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:

$$\sum_{j=1}^{n} \delta_{j,t}^{i2} = \frac{\sigma^2 \sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right)t} \quad \text{(A6)}$$

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 ability, the uncertainty dissipates and eventually $\delta_{j,t}^{i2} \to 0$. 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. In the context of this paper:

$$\text{Return Volatility} \approx \text{Dividend Growth Volatility} \times \left[1 + \left(\frac{\partial \log\left(\frac{P}{D}\right)_t}{\partial\left(\sum_{j=1}^{n} \theta_{j,t}\right)}\right)\left(\frac{\sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right)t}\right)\right] \quad \text{(A7)}$$

Equation (A7) directly motivates the empirical analysis in this paper. In the above equation, $\frac{\partial \log\left(\frac{P}{D}\right)_t}{\partial\left(\sum_{j=1}^{n} \theta_{j,t}^{i}\right)}$ 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 (A5)). Equation (A7) therefore implies that three components affect stock return volatility: fundamental volatility, *ex-ante* uncertainty about directors' ability and marginal return to ability (MRA). Equation (A7) can be rewritten as:

$$Vol \approx \sigma\,(1 + MRA_t \times m_t) \quad \text{(A8)}$$

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 (A5) 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 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.

Appendix C: SimScore

SimScore counts the number of shared characteristics from a pool of six characteristics for incoming-departing director pairs when the departing director left due to death or retirement and the firm operates in an environment of good stock return performance and low return volatility at the time of appointment. All variables are constructed from BoardEx data and supplemented with manual data collection when necessary. An incoming-departing director pair gets one point for each characteristic in common, for a total of six possible points.

Gender	from BoardEx, supplemented with manual collection.
Generations	depression babies (born before 1926) mature generation (born 1927-1945) baby boomers (born 1946-1964) generation X (born 1965-1980) generation Y (born after 1981)
Job expertise	based on the directors' job history in BoardEx. Word searches are used to define eleven categories: management academia politics military human resources technology science marketing law finance consulting
Board experience	indicator variable equal to one for directors who have held a minimum of two public directorships.
Industry directorship	indicator variable equal to one for directors who have held directorships in the same industry as the firm they are joining/leaving.
Industry work experience	indicator variable equal to one for directors who have worked in the industry of the firm they are joining/leaving.

SimScore summary statistics

Mean	3.49
25%	3
Median	4
75%	4
Std dev	1.22
Min	0
Max	6

Appendix D: Estimating Director Related Uncertainty

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). 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 the return volatility approximation (see Appendix B for details):

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

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, $\frac{\delta_0}{Vol_0} = \sqrt{\frac{1}{3}\left[\frac{1}{1 - \frac{\Delta Vol'}{Vol'_0}} - 1\right]} \times \frac{\sigma}{Vol_0}$.

Figure 1: Volatility and Director Tenure

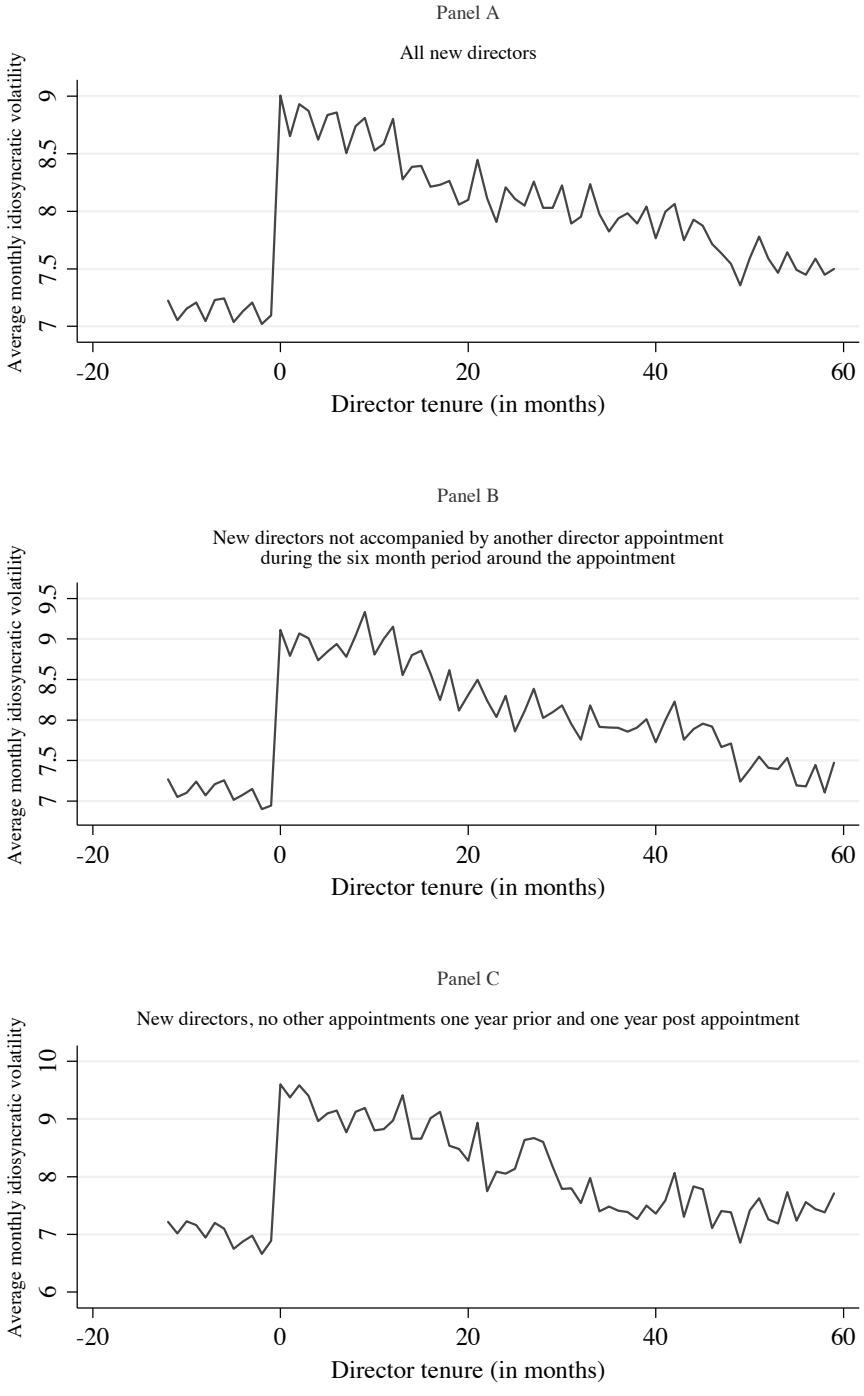

Figure 2: Volatility and Average Board Tenure

Boards are categorized into terciles based on the average tenure of their members.

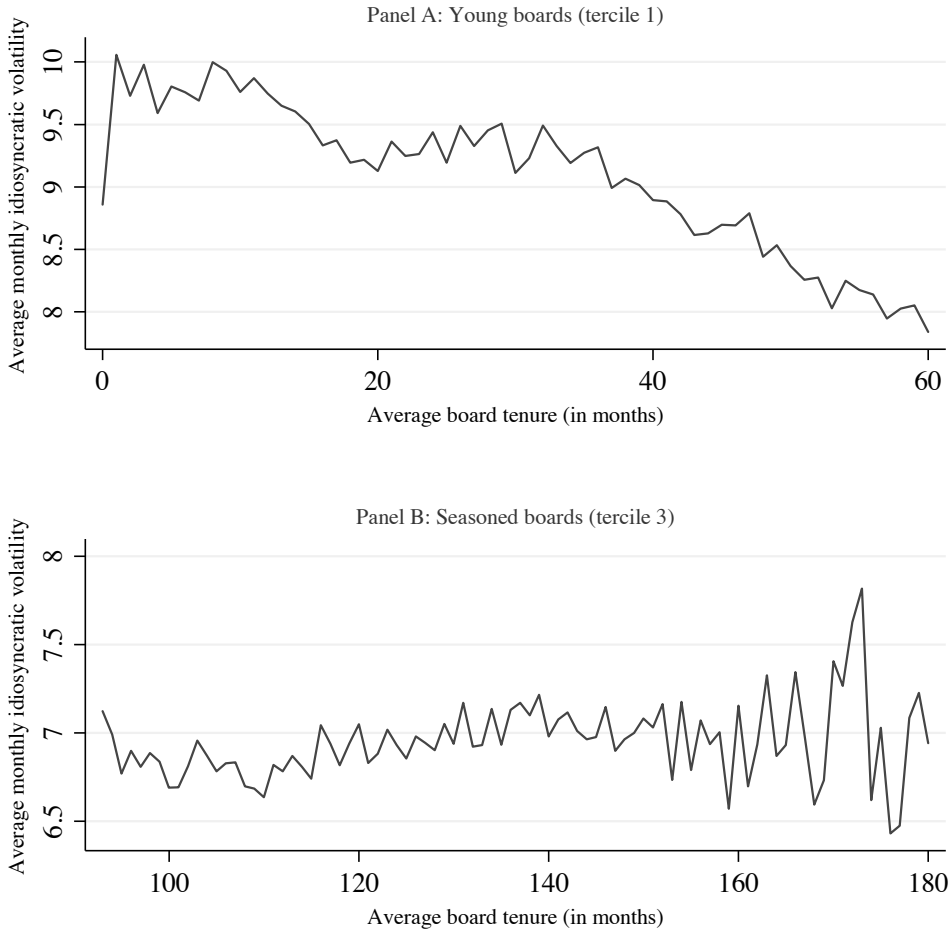

Figure 3: Learning Slopes and Firm Performance

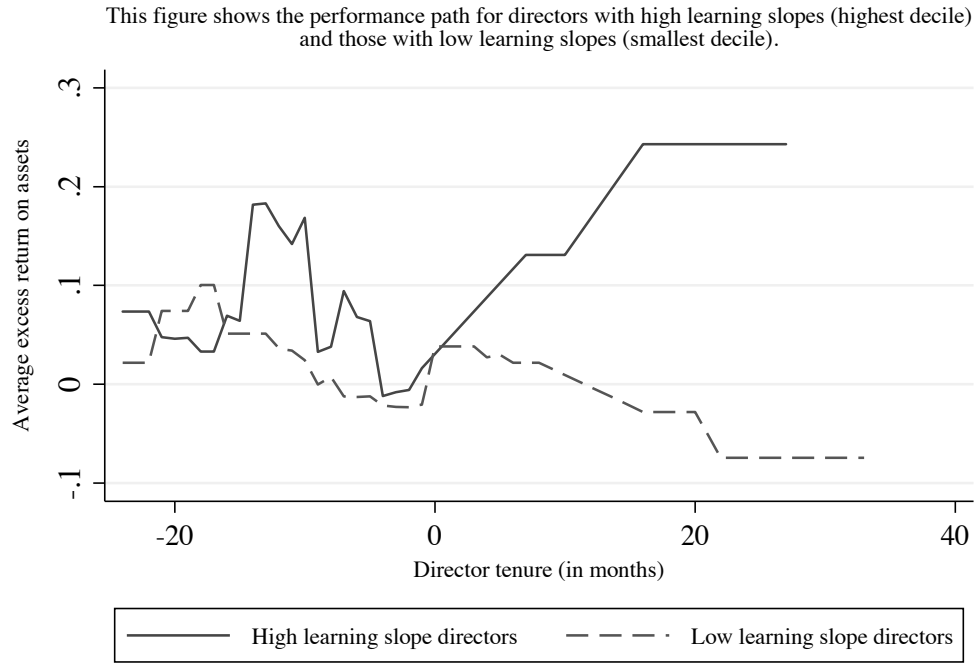

Figure 4: Learning Slopes and Stock Performance

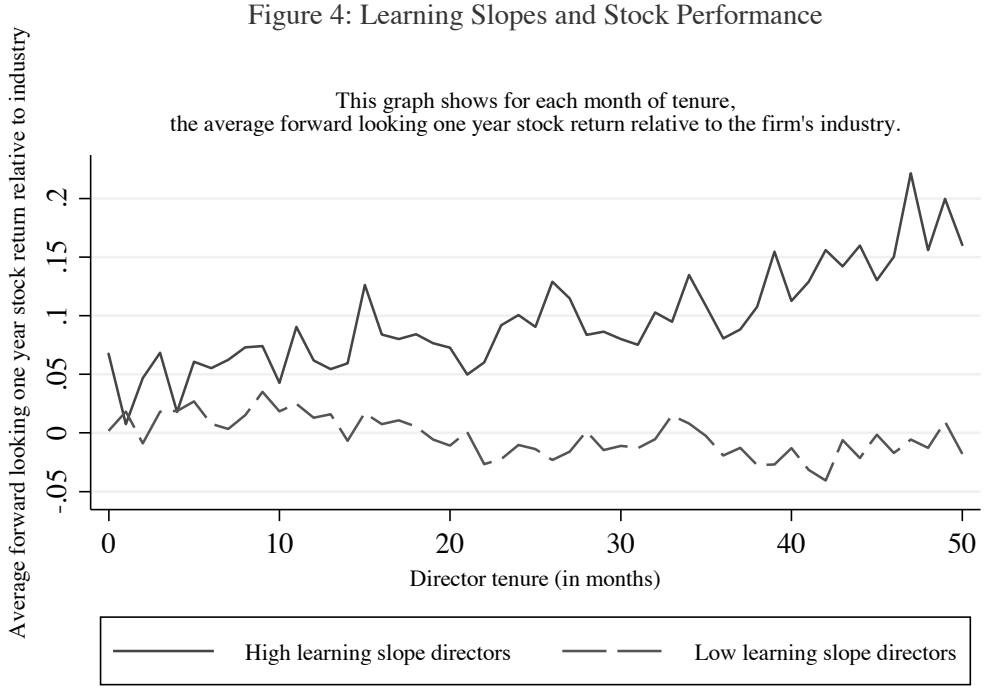

Table 1: Descriptive Statistics

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%
Tenure	24,870	6.45	3.50	3.96	6.07	8.46
Time between appointments	20,866	1.83	1.28	1.05	1.50	2.17
Time stay on board	24,870	11.26	4.44	8.26	10.87	13.91
Female	24,805	0.12	0.14	0.00	0.10	0.19
Age	21,928	61	6	58	62	65
Independent	24,870	0.79	0.19	0.71	0.84	0.93
Board size	24,870	9.38	2.62	7.50	9.00	11.00
Nomination member	23,678	0.42	0.32	0.00	0.43	0.61
Compensation member	23,678	0.52	0.26	0.38	0.50	0.67
Audit member	23,678	0.56	0.23	0.42	0.59	0.68
Member all three committees	23,678	0.12	0.24	0.00	0.00	0.14
Network size	24,847	850	528	476	753	1101
Busy	24,870	0.15	0.19	0.00	0.09	0.22
Entrenched board	19,474	0.35	0.47	0.00	0.00	1.00
Board Pay Slice	6,499	0.25	0.30	0.07	0.15	0.34
Other public directorships, total	24,870	3.19	1.52	2.02	3.00	4.04
Other public directorships, current	24,870	1.99	0.81	1.43	1.87	2.37
Tenure superior 9 years (groupthink)	24,870	0.43	0.30	0.20	0.43	0.62
CEO experience	24,870	0.19	0.20	0.00	0.15	0.31
CFO experience	24,870	0.07	0.12	0.00	0.00	0.14
Professional directors	24,870	0.05	0.11	0.00	0.00	0.18
Previous directorship in same industry	24,870	0.10	0.17	0.00	0.00	0.15

Panel B: Market Variables

	Obs	Mean	Std. Dev.	25%	Median	75%
Realized volatility	290,015	11.43	8.06	6.41	9.30	13.84
Idiosyncratic volatility	290,015	8.44	6.42	4.51	6.74	10.31
Market beta	290,015	1.05	1.04	0.57	1.01	1.48
SMB beta	290,015	0.64	1.57	-0.18	0.51	1.34
HML beta	290,015	0.22	2.08	-0.70	0.19	1.13

Panel C: Firm Level Variables

	Obs	Mean	Std. Dev.	25%	Median	75%
Firm age	23,016	23.06	18.71	10.00	18.00	33.00
G-index	10,391	9.39	2.56	8.00	9.00	11.00
Ln (assets)	24,864	7.66	1.76	6.42	7.54	8.76
Dividend payer	24,334	0.54	0.50	0	1	1
Leverage	24,773	0.19	0.19	0.02	0.15	0.29
M/B	24,843	3.41	52.37	1.42	2.15	3.49
ROA	24,862	0.04	0.14	0.01	0.04	0.08

Table 2: Volatility and Director Tenure
Panel A

This table reports regression results for the volatility-director tenure relation estimated with three functional forms for two measures of stock return volatility, realized volatility and idiosyncratic volatility. The first five years of director tenure are used in all specifications. The sample does not include CEOs and excludes all directors appointments overlapping with a CEO turnover over a one year period. All model specifications inclue 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	-0.099***	-0.119**				
	(-2.622)	*(-2.503)*				
$Tenure^2$	0.018**	0.022**				
	(2.407)	*(2.289)*				
Ln(1+tenure)			-0.045**	-0.050**		
			(-2.546)	*(-2.337)*		
-1/(1+tenure)					-0.135**	-0.152**
					(-2.501)	*(-2.341)*
Ln(assets)	-0.940***	-1.064***	-0.942***	-1.067***	-0.942***	-1.066***
	(-5.814)	*(-5.232)*	*(-5.821)*	*(-5.242)*	*(-5.820)*	*(-5.241)*
Dividend Payer	-1.154***	-1.314***	-1.152***	-1.313***	-1.153***	-1.313***
	(-4.040)	*(-3.937)*	*(-4.032)*	*(-3.928)*	*(-4.034)*	*(-3.930)*
Leverage	1.558***	1.801***	1.555***	1.797***	1.555***	1.797***
	(3.751)	*(3.640)*	*(3.734)*	*(3.624)*	*(3.738)*	*(3.627)*
MB	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(2.654)	*(2.593)*	*(2.673)*	*(2.616)*	*(2.667)*	*(2.610)*
ROA	-1.343***	-1.481***	-1.342***	-1.480***	-1.343***	-1.481***
	(-4.077)	*(-3.866)*	*(-4.066)*	*(-3.855)*	*(-4.071)*	*(-3.860)*
Market Beta		0.964***		0.964***		0.964***
		(12.123)		*(12.119)*		*(12.121)*
SMB Beta		0.418***		0.418***		0.418***
		(20.345)		*(20.340)*		*(20.343)*
HML Beta		0.077***		0.077***		0.077***
		(2.896)		*(2.897)*		*(2.897)*
Constant	17.108***	18.981***	17.197***	19.093***	17.015***	18.887***
	(13.630)	*(12.178)*	*(13.672)*	*(12.227)*	*(13.503)*	*(12.084)*
Observations	428,746	428,746	428,746	428,746	428,746	428,746
R-squared	0.285	0.555	0.285	0.555	0.285	0.555
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month 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: Director appointments not accompanied by another appointment around arrival

This table reports regression results for the volatility-director tenure relation estimated with three functional forms for two measures of stock return volatility. It documents the effect of director appointments not accompanied by another director appointment six month around the appointment.The first five years of director tenure are used in all specifications. The sample does not include CEOs and excludes all directors appointments overlapping with a CEO turnover over a one year period. All model specifications inclue 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	-0.114***	-0.128**				
	(-2.660)	*(-2.511)*				
$Tenure^2$	0.018**	0.022**				
	(2.435)	*(2.313)*				
Single appointment	-0.047	-0.032	-0.101	-0.104	0.099	0.106
	(-0.820)	*(-0.434)*	*(-1.250)*	*(-1.066)*	*(1.609)*	*(1.439)*
Single appointment*Tenure	0.022	0.013				
	(0.939)	*(0.438)*				
Ln(1+tenure)			-0.107*	-0.109		
			(-1.815)	*(-1.559)*		
Single appointment*Ln(1+tenure)			0.092	0.088		
			(1.307)	*(1.021)*		
-1/(1+tenure)					-0.314**	-0.361**
					(-2.089)	*(-2.116)*
Single appointment*-1/(1+tenure)					0.267	0.311
					(1.570)	*(1.569)*
Ln(assets)	-0.940***	-1.064***	-0.943***	-1.067***	-0.942***	-1.067***
	(-5.814)	*(-5.231)*	*(-5.823)*	*(-5.243)*	*(-5.826)*	*(-5.244)*
Dividend Payer	-1.153***	-1.314***	-1.152***	-1.312***	-1.154***	-1.314***
	(-4.035)	*(-3.933)*	*(-4.030)*	*(-3.926)*	*(-4.037)*	*(-3.933)*
Leverage	1.558***	1.801***	1.556***	1.797***	1.556***	1.798***
	(3.749)	*(3.639)*	*(3.733)*	*(3.624)*	*(3.739)*	*(3.628)*
MB	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(2.662)	*(2.597)*	*(2.691)*	*(2.630)*	*(2.694)*	*(2.636)*
ROA	-1.342***	-1.481***	-1.342***	-1.480***	-1.343***	-1.482***
	(-4.078)	*(-3.867)*	*(-4.071)*	*(-3.859)*	*(-4.081)*	*(-3.870)*
Market Beta		0.964***		0.964***		0.964***
		(12.123)		*(12.120)*		*(12.124)*
SMB Beta		0.418***		0.418***		0.418***
		(20.345)		*(20.343)*		*(20.349)*
HML Beta		0.077***		0.077***		0.077***
		(2.897)		*(2.897)*		*(2.897)*
Constant	17.134***	18.999***	17.269***	19.165***	16.974***	18.842***
	(13.681)	*(12.219)*	*(13.759)*	*(12.312)*	*(13.445)*	*(12.022)*
Observations	428,746	428,746	428,746	428,746	428,746	428,746
R-squared	0.285	0.555	0.285	0.555	0.285	0.555
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month 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 C: Director appointments, no other appointments over two year period

This table reports regression results for the volatility-director tenure relation estimated with three functional forms for two measures of stock return volatility. It documents the effect of directors appointments not accompanied by another director appointment over the one year period prior to and the one year period following the appointment.The first five years of director tenure are used in all specifications. The sample does not include CEOs and excludes all directors appointments overlapping with a CEO turnover over a one year period. 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	-0.098**	-0.114**				
	(-2.465)	*(-2.365)*				
$Tenure^2$	0.018**	0.022**				
	(2.404)	*(2.286)*				
Single appointment2yrs	-0.007	0.006	-0.048	-0.054	0.042	0.052
	(-0.131)	*(0.094)*	*(-0.659)*	*(-0.598)*	*(0.751)*	*(0.743)*
Single appointment2yrs*Tenure	-0.001	-0.009				
	(-0.030)	*(-0.309)*				
Ln(1+tenure)			-0.06	-0.064		
			(-1.437)	*(-1.271)*		
Single appointment2yrs*Ln(1+tenure)			0.031	0.028		
			(0.477)	*(0.350)*		
-1/(1+tenure)					-0.211**	-0.255**
					(-1.987)	*(-2.069)*
Single appointment2yrs*-1/(1+tenure)					0.157	0.213
					(1.060)	*(1.181)*
Ln(assets)	-0.940***	-1.064***	-0.943***	-1.067***	-0.943***	-1.068***
	(-5.819)	*(-5.235)*	*(-5.826)*	*(-5.247)*	*(-5.827)*	*(-5.248)*
Dividend Payer	-1.154***	-1.314***	-1.153***	-1.313***	-1.154***	-1.314***
	(-4.040)	*(-3.938)*	*(-4.033)*	*(-3.930)*	*(-4.038)*	*(-3.935)*
Leverage	1.558***	1.801***	1.555***	1.797***	1.556***	1.799***
	(3.751)	*(3.641)*	*(3.735)*	*(3.626)*	*(3.740)*	*(3.631)*
MB	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(2.653)	*(2.591)*	*(2.679)*	*(2.621)*	*(2.684)*	*(2.630)*
ROA	-1.343***	-1.482***	-1.342***	-1.480***	-1.342***	-1.481***
	(-4.078)	*(-3.867)*	*(-4.067)*	*(-3.856)*	*(-4.074)*	*(-3.864)*
Market Beta		0.964***		0.964***		0.964***
		(12.123)		*(12.120)*		*(12.123)*
SMB Beta		0.418***		0.418***		0.418***
		(20.345)		*(20.342)*		*(20.346)*
HML Beta		0.077***		0.077***		0.077***
		(2.896)		*(2.897)*		*(2.897)*
Constant	17.109***	18.971***	17.227***	19.124***	17.032***	18.910***
	(13.683)	*(12.223)*	*(13.753)*	*(12.312)*	*(13.519)*	*(12.104)*
Observations	428,746	428,746	428,746	428,746	428,746	428,746
R-squared	0.285	0.555	0.285	0.555	0.285	0.555
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month 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
Panel A: Exogenous appointments, good performance, low volatility

This table reports regression results for the volatility-director tenure relation using samples of exogenous director appointments.The first five years of director tenure are used in all specifications. In all regressions, only director appointments occurring when the firm is performing well in a low volatility environment are included. Specifically, the firm's stock return performance the year preceding the appointment must exceed that of the S&P 500 and its average monthly stock return volatility over the six months preceding the appointment must be inferior to its average monthly return volatility over the previous two years. Specification 1 restricts the sample to directors appointed to meet the new exchange independence requirement as well as directors appointed to replace directors who either retired or passed away. Specification 2 includes only exchange mandated directors and Specification 3 only replacement directors. In Specifications 4, 5 and 6, the full sample is used in the regression and indicator variables corresponding to the type of appointment are used. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications inclue 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 volatilit	(1)	(2)	(3)	(4)	(5)	(6)
Tenure	-0.550**	-0.650**	-0.196	-0.101***	-0.100***	-0.099***
	(-2.131)	*(-2.194)*	*(-0.253)*	*(-2.676)*	*(-2.670)*	*(-2.633)*
Pooled exogenous				-0.100		
				(-1.495)		
Pooled exogenous*Tenure				0.022		
				(0.734)		
Exchange mandated					-0.090	
					(-1.263)	
Exchange mandated*Tenure					0.017	
					(0.538)	
Retirement/death replacement						-0.261
						(-1.556)
Retirement/death replacement*Tenure						0.087
						(0.941)
$Tenure^2$	0.070*	0.072	0.075	0.018**	0.018**	0.018**
	(1.722)	*(1.556)*	*(0.609)*	*(2.431)*	*(2.431)*	*(2.407)*
Ln(assets)	-1.065**	-0.880**	-4.568**	-0.940***	-0.940***	-0.940***
	(-2.387)	*(-2.072)*	*(-2.497)*	*(-5.813)*	*(-5.813)*	*(-5.812)*
Dividend Payer	-1.324**	-1.603**	-0.732	-1.154***	-1.154***	-1.155***
	(-2.343)	*(-2.562)*	*(-1.081)*	*(-4.040)*	*(-4.039)*	*(-4.043)*
Leverage	1.715	0.774	6.015*	1.557***	1.557***	1.558***
	(1.303)	*(0.536)*	*(1.981)*	*(3.747)*	*(3.748)*	*(3.752)*
MB	-0.007	-0.006	-0.082	0.001***	0.001***	0.001***
	(-1.565)	*(-1.311)*	*(-1.341)*	*(2.651)*	*(2.651)*	*(2.653)*
ROA	0.378	-1.054	6.221***	-1.342***	-1.342***	-1.343***
	(0.315)	*(-0.855)*	*-4.774*	*(-4.076)*	*(-4.076)*	*(-4.078)*
Constant	16.884***	15.945***	50.645***	17.111***	17.112***	17.104***
	(4.384)	*(4.551)*	*(3.687)*	*(13.633)*	*(13.635)*	*(13.627)*
Observations	18,035	15,965	2,415	428,746	428,746	428,746
R-squared	0.322	0.31	0.436	0.285	0.285	0.285
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month 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

Panel B: Exogenous appointments, good performance, low volatility and high SimScore

This table reports regression results for the volatility-director tenure relation using a sample of exogenous director appointments.The first five years of director tenure are used in all specifications. In all regressions, only director appointments occurring when the firm is performing well in a low volatility environment are included. Specifically, the firm's stock return performance the year preceding the appointment must exceed that of the S&P 500 and its average monthly stock return volatility over the six months preceding the appointment must be inferior to its average monthly return volatility over the previous two years. In addition, the departing director and replacement director must share a very similar profile, i.e. a SimScore ≥ 4. Specification 1 restricts the sample to directors appointed to meet the new exchange independence requirement as well as directors appointed to replace directors who either retired or passed away. Specification 2 includes only exchange mandated directors and Specification 3 only replacement directors. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. 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	-0.571**		
	(-2.078)		
$Tenure^2$	0.078		
	(1.626)		
Ln(1+tenure)		-0.803**	
		(-2.112)	
-1/(1+tenure)			-1.137*
			(-1.865)
Ln(assets)	-0.962*	-0.978*	-0.977*
	(-1.722)	*(-1.733)*	*(-1.732)*
Dividend Payer	-1.280	-1.295	-1.298
	(-1.468)	*(-1.488)*	*(-1.489)*
Leverage	0.495	0.505	0.491
	(0.284)	*(0.289)*	*(0.280)*
MB	-0.017***	-0.017***	-0.017***
	(-2.981)	*(-3.023)*	*(-3.021)*
ROA	0.84	0.806	0.782
	(0.745)	*(0.709)*	*(0.686)*
Constant	15.474***	15.518***	14.554***
	(3.453)	*(3.432)*	*(3.154)*
Observations	10,964	10,964	10,964
R-squared	0.305	0.305	0.305
Board fixed effect	yes	yes	yes
Calendar month fixed effect	yes	yes	yes

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

Table 4: Additional Tests

Panel A: Young vs. seasoned boards

This table reports regression results for the volatility-director tenure relation using the average board tenure for all board in Specification 1, for young boards (average board tenure, tercile 1) in Specification 2 and seasoned boards (average board tenure, tercile 3) in Specification 3. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. 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)
Average board tenure	-0.127***	-0.326*	-0.004
	(-4.563)	*(-1.814)*	*(-0.050)*
Average board tenure^2	0.005***	0.072**	-0.001
	(3.443)	*(2.497)*	*(-0.280)*
Board size	-0.109***	-0.038	-0.044
	(-5.190)	*(-1.110)*	*(-1.021)*
Firm age	0.823***	1.438***	-0.072
	(26.278)	*(9.775)*	*(-1.228)*
Ln(assets)	-1.082***	-0.847***	-0.563*
	(-10.604)	*(-3.979)*	*(-1.941)*
Dividend Payer	-1.508***	-0.898***	-1.009***
	(-11.742)	*(-3.098)*	*(-3.281)*
Leverage	1.594***	1.579***	1.429*
	(4.598)	*(2.672)*	*(1.663)*
MB	0.000**	0.001	0.001***
	(2.236)	*(1.012)*	*(6.951)*
ROA	-3.675***	-1.260***	-2.191***
	(-8.784)	*(-3.616)*	*(-2.644)*
Constant	6.221***	12.118***	14.332***
	(6.660)	*(4.732)*	*(6.949)*
Observations	1,656,575	419,320	409,427
R-squared	0.343	0.213	0.249
Board fixed effect	yes	yes	yes
Calendar month fixed effect	yes	yes	yes

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

Table 4: Additional Tests

Panel B: All firm-months, first 3 years, ex-ante uncertainty and professional directors

This table reports regression results for the volatility-director tenure relation using all firm-months in Specification 1 and using an indicator variable for the first three years of tenure. The first five years of tenure are used in Specifications 2 through 5.CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications inclue 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)
Tenure	0.001	-0.174***	-0.147***	-0.149***	-0.108**
	(0.326)	*(-3.984)*	*(-3.170)*	*(-3.208)*	*(-2.158)*
First3	0.087**				
	(2.315)				
First3*Tenure	-0.036**				
	(-2.094)				
Low uncertainty		-0.13		-0.063	
		(-0.621)		*(-0.298)*	
Low uncertainty*Tenure		0.096		0.072	
		(1.518)		*(1.134)*	
High uncertainty			0.117*	0.114*	
			(1.701)	*(1.651)*	
High uncertainty*Tenure			-0.041*	-0.039*	
			(-1.771)	*(-1.646)*	
Pro director					0.171
					(1.174)
Pro director*Tenure					-0.094**
					(-1.983)
$Tenure^2$	0.000	0.034***	0.034***	0.034***	0.029***
	(0.364)	*(4.190)*	*(4.161)*	*(4.162)*	*(3.225)*
Ln(assets)	-0.844***	-1.035***	-1.031***	-1.031***	-0.733***
	(-6.387)	*(-8.264)*	*(-8.234)*	*(-8.240)*	*(-4.983)*
Dividend Payer	-0.895***	-1.499***	-1.500***	-1.502***	-1.211***
	(-4.991)	*(-8.190)*	*(-8.202)*	*(-8.207)*	*(-7.020)*
Leverage	1.196***	1.726***	1.721***	1.722***	1.303**
	(3.823)	*(4.057)*	*(4.037)*	*(4.044)*	*(2.443)*
MB	0.001***	0.001**	0.001**	0.001**	0.001***
	(6.636)	*(2.242)*	*(2.276)*	*(2.272)*	*(3.159)*
ROA	-1.790***	-2.688***	-2.689***	-2.689***	-3.461***
	(-6.253)	*(-5.170)*	*(-5.172)*	*(-5.174)*	*(-6.602)*
Director age					0.003
					(0.897)
Number previous jobs					-0.050**
					(-2.286)
Number previous boards					-0.001
					(-0.153)
Experience CEO public company					0.077
					(1.045)
Constant	17.895***	18.787***	18.750***	18.749***	16.204***
	(11.888)	*(20.160)*	*(20.137)*	*(20.135)*	*(13.798)*
Observations	1,388,539	419,220	419,220	419,220	235,380
R-squared	0.262	0.351	0.351	0.351	0.36
Board fixed effect	yes	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes	yes

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

Table 4: Additional Tests

Panel C: Matched sample

This table reports regression results from estimating the volatility-director tenure relation for a matched sample. Specifications replicate those of Panel A of Table 2 but for a matched sample. Each firm for each of the three original samples is matched to the firm closest in size, based on total 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.The first five years of director tenure are used in all specifications. The sample does not include CEOs and excludes all directors appointments overlapping with a CEO turnover over a one year period. All model specifications inclue 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	-0.007	-0.013				
	(-0.158)	*(-0.236)*				
$Tenure^2$	0.005	0.004				
	(0.614)	*(0.422)*				
Ln(1+tenure)			0.049	0.024		
			(1.089)	*(0.444)*		
-1/(1+tenure)					0.086	0.036
					(0.864)	*(0.301)*
Ln(assets)	-0.840***	-0.783***	-0.840***	-0.783***	-0.840***	-0.783***
	(-7.251)	*(-5.676)*	*(-7.251)*	*(-5.676)*	*(-7.255)*	*(-5.678)*
Dividend Payer	-1.783***	-1.813***	-1.783***	-1.813***	-1.783***	-1.813***
	(-11.035)	*(-9.863)*	*(-11.031)*	*(-9.861)*	*(-11.028)*	*(-9.860)*
Leverage	1.060***	1.073***	1.059***	1.073***	1.059***	1.072***
	(2.970)	*(2.773)*	*(2.967)*	*(2.771)*	*(2.966)*	*(2.771)*
MB	0.001	0.001	0.001	0.001	0.001	0.001
	(0.793)	*(1.071)*	*(0.802)*	*(1.075)*	*(0.804)*	*(1.076)*
ROA	-2.988***	-3.264***	-2.990***	-3.266***	-2.992***	-3.267***
	(-7.755)	*(-7.156)*	*(-7.761)*	*(-7.160)*	*(-7.766)*	*(-7.163)*
Market Beta		1.118***		1.118***		1.118***
		(24.236)		*(24.236)*		*(24.234)*
SMB Beta		0.461***		0.461***		0.461***
		(20.773)		*(20.773)*		*(20.773)*
HML Beta		0.110***		0.110***		0.110***
		(5.681)		*(5.679)*		*(5.679)*
Constant	16.868***	18.216***	16.911***	18.247***	16.982***	18.270***
	(17.646)	*(15.747)*	*(17.706)*	*(15.819)*	*(17.377)*	*(15.468)*
Observations	386,981	386,981	386,981	386,981	386,981	386,981
R-squared	0.283	0.539	0.283	0.539	0.283	0.539
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month 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 Learning-based Approach
Position on the Board			
Chairman	Nguyen and Nielsen (2010)	Larger stock price reaction to death of chairman	Chairman has higher marginal value
Audit member	Nguyen and Nielsen (2010)	Larger stock price reaction to death of audit committee member	Chair of audit committee has higher marginal value
Compensation member	N/A	N/A	Chair of compensation committee has higher marginal value
Nominating member	Nguyen and Nielsen (2010)	Larger stock price reaction to death of nominating committee member	No significant effect
Independent directors	Bhagat and Black (2000); Hermalin and Weisbach (1991)	No relation between % outside directors and Tobin's Q/accounting measures	Independent directors with industry expertise and independent directors joining firms with high monitoring needs have higher marginal value
	Duchin, Matsesaka, Ozbas (2010)	Independent directors improve performance when their information cost is low	
	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 have lower marginal value on average. However, when the need for monitoring services is acute, female directors have higher marginal value
	Matsa and Miller (2012); Ahern and Dittmar (2012)	Female directors are associated with decreased firm value and profitability	
Busyness	Fich and Shivdasani (2006)	Busy directors are associated with lower firm value	Busy directors have higher marginal 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	
	Falato, Kadyrzhanova and Lel (2014)	Busy directors are detrimental to board monitoring quality and shareholder value	
	Field, Lowry and Mkrtchyan (2013)	Busy directors are beneficial for small young firms but detrimental for large firms	

Table 5 (continued)

	Study	Finding	Evidence from Learning-based Approach
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 have lower marginal 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) have lower marginal value
Board size	Yermack (1996); Eisenberg, Sundgren and Wells (1998)	Inverse association between board size and Tobin's Q	Smaller boards have higher marginal value
Board Pay Slice	N/A	N/A	Better compensated boards have higher marginal value
Firm Level Characteristics			
Firm size	N/A	N/A	Directors have higher marginal value in small firms
Prior performance	Mace (1971)	Interview evidence that boards' activiness is limited to crisis situations	Directors have higher marginal 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 have higher marginal value in complex and human capital intensive industries

Table 6: Cross-sectional Tests
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. Individual terms for committee chairs, control variables, including controls for the ex-ante level of uncertainty are included but not reported for brevity. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include firm 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)
Tenure	-0.058	-0.082*	-0.104*	-0.137**	-0.06
	(-1.537)	*(-1.658)*	*(-1.725)*	*(-2.071)*	*(-1.473)*
$Tenure^2$	0.009	0.009	0.019**	0.002	0.016**
	(1.314)	*(1.297)*	*(2.512)*	*(0.273)*	*(2.005)*
Independent		-0.232**	-0.304**	-0.441***	
		(-2.168)	*(-2.157)*	*(-2.839)*	
Independent*Tenure		0.022	0.046	0.096*	
		(0.617)	*(0.901)*	*(1.835)*	
Job experience same industry			0.055		
			(0.255)		
Job experience same industry*Tenure			-0.041		
			(-0.572)		
Independent*Job experience same industry			0.411*		
			(1.925)		
Independent*Job experience same industry*Tenure			-0.134*		
			(-1.868)		
Chairman	0.345**				
	(2.431)				
Chairman*Tenure	-0.081*				
	(-1.783)				
High monitoring needs				-0.668*	
				(-1.872)	
High monitoring needs*Tenure				0.276***	
				(2.888)	
Independent*High monitoring needs				0.905***	
				(2.707)	
Independent*High monitoring needs*Tenure				-0.216**	
				(-2.228)	
Nomination committee chair*Tenure					-0.044
					(-0.553)
Audit committee chair*Tenure					-0.157***
					(-4.368)
Compensation committee chair*Tenure					-0.086**
					(-2.290)
Governance committee chair*Tenure					-0.06
					(-0.813)
Risk committee chair*Tenure					0.253
					(1.293)
Social committee chair*Tenure					0.062
					(0.636)
Strategy committee chair*Tenure					0.217
					(1.251)
Technology committee chair*Tenure					0.024
					(0.158)
Constant	17.231***	17.393***	17.275***	18.708***	19.967***
	(14.517)	*(14.561)*	*(14.393)*	*(12.895)*	*(17.792)*
Observations	369,321	369,321	369,321	170,499	330,506
R-squared	0.352	0.352	0.353	0.349	0.348
Firm fixed effect	yes	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes	yes

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

Table 6: Cross-sectional Tests
Panel B: Personal attributes

This table reports regression results using interaction variables to identify director attributes that affect the volatility-director tenure relation. Control variables are included but not reported for brevity. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include firm 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)
Tenure	-0.072*	-0.06	-0.026	-0.05	-0.049
	(-1.861)	*(-1.233)*	*(-0.608)*	*(-1.303)*	*(-1.271)*
$Tenure^2$	0.009	0.002	0.009	0.009	0.009
	(1.311)	*(0.288)*	*(1.166)*	*(1.242)*	*(1.191)*
Female	-0.171**	-0.163			
	(-2.223)	*(-1.525)*			
Female*Tenure	0.066**	0.068*			
	(2.391)	*(1.792)*			
High monitoring needs		0.144			
		(1.037)			
High monitoring needs*Tenure		0.092***			
		(3.095)			
Female*High monitoring needs		0.207			
		(1.172)			
Female*High monitoring needs*Tenure		-0.104*			
		(-1.757)			
Busy			0.119*		
			(1.770)		
Busy*Tenure			-0.042*		
			(-1.830)		
Board experience same industry				0.156	
				(1.535)	
Board experience same industry*Tenure				-0.054*	
				(-1.739)	
Job experience same industry					0.156
					(1.376)
Job experience same industry*Tenure					-0.113***
					(-3.296)
Director Age	0	-0.002	0.002	0	0
	(-0.140)	*(-0.677)*	*(0.600)*	*(-0.108)*	*(-0.154)*
Number previous jobs	-0.040*	-0.050**	-0.027	-0.040*	-0.03
	(-1.882)	*(-2.207)*	*(-1.311)*	*(-1.889)*	*(-1.401)*
Number previous boards	0.002	-0.001	-0.001	0.001	0.001
	(0.228)	*(-0.053)*	*(-0.125)*	*(0.098)*	*(0.156)*
Experience CEO public firm	0.07	0.073	0.011	0.069	0.067
	(1.044)	*(1.129)*	*(0.194)*	*(1.030)*	*(1.000)*
Constant	17.246***	18.454***	20.989***	17.210***	17.186***
	(14.513)	*(12.898)*	*(20.357)*	*(14.502)*	*(14.469)*
Observations	369,321	170,499	266,480	369,321	369,321
R-squared	0.352	0.349	0.331	0.352	0.352
Firm fixed effect	yes	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes	yes

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

Table 6: Cross-sectional Tests
Panel C: Board characteristics

This table reports regression results using interaction variables to identify board attributes that affect the volatility-director tenure relation. Control variables are included but not reported for brevity. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include firm 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**	-0.026	-0.133***	-0.047
	(-2.279)	*(-0.395)*	*(-3.179)*	*(-0.999)*
$Tenure^2$	0.008	0.009	0.009	0.002
	(1.136)	*(0.718)*	*(1.320)*	*(0.240)*
Groupthink	0.057			
	(0.623)			
Groupthink*Tenure	0.063***			
	(2.904)			
High BPS		1.288*		
		(1.862)		
High BPS*Tenure		-0.530**		
		(-2.444)		
Large board			-0.492***	
			(-4.883)	
Large Board*Tenure			0.115***	
			(4.723)	
High monitoring needs				0.177
				(1.302)
High monitoring needs*Tenure				0.075***
				(2.735)
Director Age	0	-0.007*	0	-0.002
	(-0.094)	*(-1.869)*	*(-0.110)*	*(-0.683)*
Number previous jobs	-0.040*	-0.063***	-0.039*	-0.050**
	(-1.902)	*(-2.865)*	*(-1.859)*	*(-2.218)*
Number previous boards	0.002	0.005	0.002	-0.001
	(0.238)	*(0.531)*	*(0.269)*	*(-0.061)*
Experience CEO public firm	0.068	0.031	0.071	0.07
	(1.024)	*(0.510)*	*(1.058)*	*(1.091)*
Constant	17.364***	11.394***	17.284***	18.424***
	(14.675)	*(6.122)*	*(14.743)*	*(12.863)*
Observations	369,321	113,998	369,321	170,499
R-squared	0.353	0.355	0.353	0.349
Firm fixed effect	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes

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

Table 6: Cross-sectional Tests
Panel D: Firm characteristics

This table reports regression results using interaction variables to identify firm characteristics that affect the volatility-director tenure relation. Control variables are included but not reported for brevity. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include firm 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	-0.131***	-0.069	-0.028
	(-3.206)	*(-1.468)*	*(-0.726)*
$Tenure^2$	0.008	0.001	0.008
	(1.162)	*(0.182)*	*(1.104)*
Large firm	-0.807***		
	(-4.876)		
Large firm*Tenure	0.133***		
	(5.336)		
Poor performance		-0.550***	
		(-6.014)	
Poor performance*Tenure		0.122***	
		(3.906)	
Consumer durables*Tenure			0.149*
			(1.793)
High tech*Tenure			-0.180***
			(-4.871)
Director Age	0.000	0.003	0.000
	(-0.005)	*(1.101)*	*(-0.029)*
Number previous jobs	-0.036*	-0.022	-0.034
	(-1.706)	*(-1.126)*	*(-1.604)*
Number previous boards	0.000	0.000	0.000
	(-0.047)	*-0.018*	*(-0.019)*
Experience CEO public firm	0.064	0.033	0.061
	(0.948)	*(0.574)*	*(0.901)*
Constant	11.112***	22.260***	10.703***
	(23.859)	*(93.469)*	*(24.094)*
Observations	369,321	245,060	369,321
R-squared	0.350	0.328	0.349
Firm fixed effect	yes	yes	yes
Calendar month fixed effect	yes	yes	yes

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