Corporate Governance and the Volatility of Volatility*

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Abstract

This paper is the first to provide empirical evidence on the effect of internal and external corporate governance mechanisms on both the volatility of corporate performance and the volatility of the volatility, or vol-of-vol. Since high vol-of-vol stocks, that is stocks with high degrees of uncertainty about risk, significantly underperform low vol-of-vol stocks, it is crucial for managers not to ignore the connection between governance structures and the vol-of-vol. We deal with endogeneity concerns inherent in such analyses by also using option-implied volatilities that by their forward-looking nature cannot be the cause of observed governance structures.

We find strong evidence that board size and managerial entrenchment reduce the volatility and, against our expectations, also reduce the vol-of-vol. As such, it may be beneficial for firms to insulate managers from the market for corporate control in order to reduce the uncertainty about future stock returns. Results are robust to a variety of different tests and model specifications.

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1 Introduction

The relation between corporate governance characteristics of a firm and corporate performance has been extensively researched with many studies finding that good corporate governance leads to higher returns (e.g., Gompers et al., 2003; Cremers and Nair, 2005). Contrarily, the effect of individual corporate governance on the volatility of returns has received considerably less attention (Hermalin and Weisbach, 2003) with three notable exceptions Adams et al. (2005), Ferreira and Laux (2007), and Cheng (2008). The first study finds that firms with more powerful CEOs have a higher volatility of returns; the second study finds that having fewer anti-takeover provisions increases the information flow into the market and increases the idiosyncratic volatility while the latter shows that larger boards will lead to a lower volatility. In this paper we consider a wider range of corporate governance characteristics with an explicit distinction between internal and external mechanisms—following Cremers and Nair (2005)—and analyze their effects on stock price volatility. More importantly though, we argue that only looking at the volatility of returns ignores a second highly important dimension of risk and that is the volatility of volatility (vol-of-vol), which is crucial to consider for companies striving to increase their corporate performance.

Vol-of-vol is sometimes characterized as capturing the "extent to which investors don't know what they don't know" (Baltussen et al., 2014, p. 26). Put differently, it is the uncertainty about the risk of future stock returns. Research into possible applications of this construct, especially market-wide vol-of-vol, has increased considerably in recent years, specifically in asset pricing, forecasting, and financial risk management (Chen et al., 2014; Corsi et al., 2008; Drimus and Farkas, 2013). Individual stocks with a high vol-of-vol, that is with a high degree of uncertainty about future risk, underperform low vol-of-vol stocks by up to ten percent on a per annum basis, an effect that persists for long periods of time and even after controlling for a variety of known stock return drivers

(Baltussen et al., 2014). Additionally, high ambiguity about future stock returns can lead to fewer investors holding the stock (Easley and O'Hara, 2009). As a consequence, stock liquidity could suffer. Further, strong volatility of the volatility makes derivative pricing more complicated which makes risk-management more difficult which in turn could lead to a higher cost of capital. Clearly, there is a strong concern for managers, who are supposed to act in the shareholders best interest, to pay attention to the vol-of-vol when they are trying to increase their firm's performance.

In terms of good governance, prior research has identified the market for corporate control as a highly relevant external governance mechanism for both performance and volatility. Generally speaking, managers can be 'punished' for poor performance if, for example, their firm is taken over and the acquirer installs a new management in the process. Bebchuk et al. (2009) show that managers who are entrenched, as measured by their famous E index, avoid this risk, and their firms consequently exhibit comparably worse performance. Less entrenched managers, however, have an incentive to increase performance and that generally means to increase—or at the very least manage—the firm's risk profile. Thus, it is logical to analyze any effect of corporate governance on the volatility of stock returns, but that may be a too limited view. Whether or not the volatility of stock returns remains constant or changes over time is an important factor as well. Managers who are subject to the market for corporate control should, therefore, focus on both the volatility and the vol-of-vol and especially the latter deserves closer attention from a corporate governance point of view.

We contribute to the literature in three ways. First, we extend the research on the influence of corporate governance on the volatility of returns. Specifically, we take a broader view than Adams et al. (2005) and Cheng (2008) by including characteristics related to both internal and external governance mechanisms. Our results show that firms with entrenched managers indeed show lower volatility of stock returns, a result that is in line with lower returns achieved by such managers. Moreover, we document

that even when controlling for external governance via the E index, larger boards lead to lower volatility, as found by Cheng (2008). These results are robust to a variety of model specifications and endogeneity tests.

Second, we are the first to analyze the impact of corporate governance on the vol-of-vol. With the substantial negative effects that the vol-of-vol can have on the ambiguity, liquidity, or costs of capital, it is puzzling that this relationship has not yet received more scrutiny. Our results show that corporate governance can contribute to lowering this kind of uncertainty about stock returns. While financial leverage and growth opportunities increase the vol-of-vol, governance mechanisms can reduce it. The effect is strongest for board size and somewhat weaker for the E index, that is managerial entrenchment. Surprisingly, they both affect the vol-of-vol in the same way as the volatility. Considering the popularity and success of low volatility investing (e.g., Baker et al., 2011), our results are also relevant for asset managers engaging in this field, who can look towards governance mechanisms to identify companies that will have consistently low volatility.

Third, we are the first to use forward-looking option-implied volatilites to avoid endogeneity concerns often inherent in corporate governance research. Such volatilites represent investors' expectations of future realized volatilites and as such they cannot have an influence on the currently observed corporate governance structure. If a connection exists, it can only be in the sense and direction that governance structures influence and shape investors' expectations about the future volatility. Option-implied volatility has previously been used successfully to, for example, optimize portfolio selection (e.g., Kempf et al., 2015) or predict equity risk (e.g., Buss and Vilkov, 2012). We propose using these forward-looking information derived from option prices as an alternative to historical volatilites in corporate governance research, so as to mitigate endogeneity concerns.

Our sample includes all firms in the Institutional Shareholders Services (ISS) database, formerly known as RiskMetrics. Because the data collection methodology changed when ISS acquired the database, some information, such as the G index, is not available for the whole period, but we paid great attention to carefully match the two systems. This allows us to investigate a time period from 1996 through 2015 with sufficient data points to calculate meaningful vol-of-vol values.

All in all, our results provide an important first step in understanding what characteristics influence the vol-of-vol, which has already been recognized as an important risk factor in stock performance. Thus, it enables a better understanding of the connection between governance structures and risk-return profiles of firms.

The remainder of this paper is organized as follows. Section 2 reviews the literature and outlines the expected relation between corporate governance and both the volatility of stock returns and the vol-of-vol. Section 3 describes our data set, while Section 4 contains the empirical analysis as well as a discussion of our results. Section 5 concludes the paper.

2 Corporate Governance and the Relation with Volatility

2.1 Corporate Governance and Volatility

Defining corporate governance as the set of rules and mechanisms put in place within an organization that are designed to reduce agency costs (Larcker and Tayan, 2011, p. 4) may be easy, measuring it is much more difficult and many different concepts have been tried. While some papers analyze the effect of individual governance characteristics on firm value, such as board size (e.g., Yermack, 1996), Gompers et al. (2003) construct a governance index, or G index, out of 24 provisions that proxy for the level of shareholder rights and find that firms with strong rights have higher firm values and earned abnormal returns of 8.5 percent per year compared to firms with

low shareholder rights.[1] Subsequently, Bebchuk et al. (2009) have identified six of those provisions, namely staggered boards, limits to shareholder bylaw amendments, poison pills, golden parachutes, supermajority requirements for mergers, and limits to charter amendments, that together form the entrenchment or E index. Firms with highly entrenched managers exhibit substantially lower corporate performance than those without it. The authors argue that entrenchment insulates managers from the market for corporate control and consequently they may engage in shirking, a behavior that has also been shown to occur after anti-takeover legislation (Bertrand and Mullainathan, 2003). Other examples of governance indexes can be found in Aggarwal et al. (2009), who use 41 provisions, and in Brown and Caylor (2006), who create the GOV-7 index from 51 external and internal provisions.[2]

According to Cremers and Nair (2005), however, it is important to distinguish between internal mechanisms of governance (e.g., strong blockholders) and external ones, as measured by anti-takeover provisions. The latter one is conceptually similar to the E index, yet the authors find that returns of firms with high takeover vulnerability are only high, when there is also a strong blockholder in the form of a public pension fund. This indicates an interplay between the two types of corporate governance mechanisms when it comes to corporate performance and looking at only one of the two may be a too limited approach.

These and similar studies focus on the level of performance, but do not say anything about whether corporate governance has an effect on the volatility of stock returns. Of the literature that does look at the connection between governance and risk, a large block focuses on risk taking in, for example, investment strategies and typically employs the introduction of the Sarbanes-Oxley Act (SOX) in 2002. For instance, Bargeron et al. (2010) find that U.S. companies did decrease risky activities and exhibited lower stock

[1] Abnormal returns caused by good corporate governance have since disappeared as market participants have learned of this effect (Bebchuk et al., 2013).

[2] In addition, attempts have been made to construct and/or use country-wide corporate governance indexes. See, for instance, John et al. (2008).

volatility. Cohen et al. (2013) identify the reduction in performance- and incentive-based pay post SOX as the driver behind this development as it led to less risky investment strategies.[3]

Papers that look at the effect of firm-specific governance characteristics on volatility are less numerous, yet have proceeded in a similar fashion to those investigating performance. That is they either employ a governance index or look at individual provisions. Ferreira and Laux (2007), for example, use the G index and find that being subject to the market for corporate control leads to higher stock price volatility. Intuitively, this is in accordance with basic finance principles that higher risk is compensated for by higher returns. Less entrenched managers have to generate higher returns in order to secure their positions and avoid being replaced. Individual governance provisions have been investigated by Adams et al. (2005) and Cheng (2008). The former analyze CEO power, which they measure by CEO status as founder, chairman of the board, and sole insider on the board. Their results indicate that firms with powerful CEOs have higher stock price volatility. Cheng (2008), on the other hand, looks at board size and finds that having larger boards leads to less volatility as the need for compromises results in less radical decisions.

So far no paper has examined the question of whether internal and external mechanisms together affect stock price volatility. Our first research question addresses this gap as we are the first to include both external anti-takeover provisions, as measured by the E index, and internal ones, measured by several board characteristics. From a theoretical point of view one would expect that good corporate governance increases the volatility. For example, Holmstrom and Ricart I Costa (1986) show that career concerns can lead managers to choose less risky investment projects although this is not in the interest of shareholders. Similarly, Amihud and Lev (1981) argue that managers engage in conglomerate mergers simply to diversify their own employment risk while the achieved

[3] See also Balachandran and Faff (2015) for a further discussion of the effects SOX has had on risk taking.

risk reduction is not beneficial to shareholders. Finally, Hirshleifer and Thakor (1992) show in their model that increased takeover activity, which in the context of Cremers and Nair (2005) can be interpreted as external governance, induces managers to chose a higher debt-to-equity level which is optimal for shareholders. Based on the empirical finding that less entrenched managers have an incentive to increase the risk in order to increase performance, we expect that firms with a lower E index will have a higher volatility. More generally speaking, we expect good corporate governance to increase stock return volatility.

2.2 Corporate Governance and Volatility of Volatility

Simply increasing the volatility of stock returns to increase returns may be a too myopic view, given that the volatility itself can be volatile. In other words, there is another level of uncertainty about future stock prices if the risk is risky. The idea that the volatility is stochastic is, of course, nothing new and has been incorporated in, for example, option pricing in the Heston model (Heston, 1993). In addition, Bollerslev et al. (2009) provide theoretical and empirical evidence that the volatility of volatility is an important risk factor affecting expected market returns for which investors expect to be compensated accordingly.

The risk captured by the vol-of-vol is quite distinct from the one captured by the volatility as Huang and Shaliastovitch (2014) show. While the market volatility index (VIX) and the volatility of volatility index (VVIX) share some peaks (e.g., during the financial crisis), overall they are only weakly correlated and exhibit different dynamics. Whereas the volatility is generally more persistent than stock returns, the vol-of-vol can indicate extreme downside risks (Chen et al., 2014) and when it is high, it affects the dynamic of the volatility, especially during the financial crisis (Grassi and Santucci de Magistris, 2015). So far, the market vol-of-vol has been used to explain stock returns (Chen et al., 2014), option returns (Huang and Shaliastovitch, 2014), and even hedge fund returns (Agarwal et al., 2017).

Research on the vol-of-vol of individual stocks is so far sparse. Branger et al. (2017) interpret idiosyncratic vol-of-vol as a measure of mean reversion of the idiosyncratic volatility, which helps them explain the compensation for idiosyncratic risk. Baltussen et al. (2014) show in their model that the stock vol-of-vol can be interpreted as uncertainty about risk.[4] Empirically, they show that the vol-of-vol as a characteristic is an important predictor of future stock returns. High vol-of-vol stocks consistently underperform other stocks by up to ten percent per year, even after controlling for a variety of known stock return drivers. This phenomenon can possibly be explained by investors' ambiguity aversion. Experimental evidence has shown that investors can differ widely in terms of their preference towards ambiguity (e.g., Bossaerts et al., 2010; Halevy, 2007) and at very high levels of ambiguity aversion investors will no longer hold assets with high levels of ambiguity (Easley and O'Hara, 2009). If only those investors with very positive outlooks on a stock hold and price it, the stock would not have to earn an ambiguity premium. In addition, Baltussen et al. (2014) confirm that vol-of-vol is also a reliable predictor of lower future trading activity, effectively reducing the stock's liquidity.

So managers may inadvertently worsen their firm's performance and the stock's liquidity if they decide to increase volatility without also focusing on the vol-of-vol. Considering that corporate governance can have an influence on the volatility of a stock as well as the liquidity (Chung et al., 2010), it stands to reason that it might also impact the vol-of-vol. Moreover, given the strong underperformance of high vol-of-vol stocks, corporate governance should, in the interest of the shareholders, improve stock price performance which would in this case mean reduce the vol-of-vol. This is the first paper to address this issue in our second research question. In particular we will analyze if and how internal and external governance mechanisms can lead to a lower

[4] The authors acknowledge that it is debatable whether their model captures true ambiguity as in Ellsberg (1961), yet their interpretation is supported in, among others, Klibanoff et al. (2005). Moreover, the terms uncertainty and ambiguity are often used synonymously (e.g., Easley and O'Hara, 2009).

vol-of-vol. In general, we expect 'good' corporate governance to be associated with a more constant risk policy, which in turn should reduce the vol-of-vol.

3 Data Set and Descriptive Statistics

We construct our sample beginning with all firms covered in the ISS database (formerly RiskMetrics), from which we collect all governance data. Our sample begins in 1996 when most director-related data became available, and it ends in 2015. We carefully match firms in the ISS governance and director databases with the legacy databases provided by RiskMetrics to attain one continuous corporate governance data set. Following Gompers et al. (2003), we exclude all dual class firms, as their corporate governance structure will likely differ too much for any meaningful comparison, as well as financial institutions.

We merge the data set with COMPUSTAT to get accounting and financial data and we obtain data on CEO ownership from ExecuComp. Daily stock returns are from the Center for Research in Security Prices (CRSP). Our main variables of interest are stock return volatility and the vol-of-vol, which we calculate in two different ways: based on historical data and from option prices. For the former we calculate annualized volatilites per year and to get a time series of the vol-of-vol we also calculate monthly volatilites from which we calculate a yearly vol-of-vol.[5] For the yearly volatilities we require at least 130 return observations per year and for the monthly ones we require at least 15 observations per month.

In addition to the overall volatility and vol-of-vol, we also calculate the idiosyncratic volatility and vol-of-vol as the volatility of the residuals from the Fama-French-3-Factor model.[6] We do so for several reasons. First, it is conceivable that overall volatility is

[5] Using daily stock returns to calculate volatilities has also been carried out by, for example, Campbell et al. (2001).

[6] We collect data, including the risk-free rate, for the model from Kenneth French's data library (available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html).

driven to a large extent by influences outside of managerial control, in which case corporate governance might have only a small or no effect. Second, while the idiosyncratic volatility should generate no premium in the CAPM-context or a positive one in case of incomplete information (Merton, 1987), Ang et al. (2006) have shown that it can actually generate negative premiums and thus deserves special managerial attention. Third, higher idiosyncratic volatility has been shown to be indicative of a stronger emphasis on growth strategies (Campbell et al., 2001) and to be a reliable predictor of future firm performance (e.g., Fu, 2009). As such it may be more informative about managerial action and thus be more relevant when analyzing the effects of corporate governance.

Using historical data to calculate the volatility, or the vol-of-vol for that matter, in corporate governance research always leads to endogeneity concerns, since it cannot be stated with certainty that governance structures lead to a certain volatility level, or if the volatility levels lead to a certain governance structure. We address this issue by also using forward-looking implied volatilities which we obtain from option prices. Since option-implied volatilities represent the investors' expectations about future realized volatilities at that specific date, they must be based on the current corporate governance structures. The reverse is not possible, as any changes in the governance structure based on the implied volatility would lead to a change in options prices and consequently to an adjustment in the implied volatility.

We obtain option prices from the IVY DB provided by OptionMetrics. Most studies based on these data use model-free implied volatilites first proposed by Britten-Jones and Neuberger (2000). As demonstrated by Jiang and Tian (2005) the information contained in such volatilities encompasses the information content of implied volatilites extracted from the Black-Scholes model. However, that approach requires a large variety of options for different maturities and strike prices, which is usually available for index options, yet is often difficult to find for individual options. Therefore, we

follow Baltussen et al. (2014) and use model-based implied volatilites directly provided by OptionMetrics, which are obtained from the binomial model due to Cox et al. (1979). In accordance with prior literature, especially Cao and Han (2013) and Baltussen et al. (2014), we apply standard filters to select only plain-vanilla call and put options that are trading at the money[7] and do not violate no-arbitrage rules. For each firm-year we then choose the one call and the one put option that are closest to being at the money, because these are usually the most actively traded options, with a time to maturity of one year and calculate the average implied yearly volatility. We proceed in the same manner for options with one month left to maturity and use those average implied monthly volatilities to calculate yearly volatilites of volatilites. For the calculation of the yearly vol-of-vols we require at least 6 observations of monthly option-implied volatilities in a specific year.

For the governance variables, we follow the extant literature (e.g., Cremers and Nair, 2005) and use anti-takeover defenses as a proxy for the extent to which managers are subject to the external market for corporate control. In particular, we employ the E index according to Bebchuk et al. (2009), which we construct from the ISS database. A high E index signifies a high level of entrenchment, which in turn means that managers are protected from the external market for corporate control. According to Ferreira and Laux (2007), who use the G index, being insulated against outside takeover threats will decrease volatility, as less information enters the market about firms that are not potential targets.

To measure internal governance, we focus on board characteristics.[8] The board of directors is the primary means for shareholders to monitor top management, who are too dispersed to carry out the task themselves (John and Senbet, 1998), which makes it

[7] We define "at-the-money" as a moneyness between 0.95 and 1.05.

[8] There is some overlap between our internal and external governance measures, as the board characteristic 'staggered boards' is one of the provisions covered by the E index. Since its significance is clearly related to takeover threats, it should not influence the board's ability for managerial control. Therefore, we remain confident that this should not impact our results.

a natural starting point for our analysis. Strong boards have been shown to positively affect risk taking in banks (Pathan, 2009) or to reduce earnings management concerns (Klein, 2002). To assess how well the monitoring function can be fulfilled, we follow Cheng (2008) and Adams et al. (2005) and look at board size and CEO power, measured as CEO/chairperson duality.

The negative effect that board size has on firm performance is well documented, both for large firms and small firms (Yermack, 1996; Eisenberg et al., 1998). In larger boards, free-rider problems are more likely to occur (Lipton and Lorsch, 1992) and CEOs can more easily get their say without running into a unified opposition (Jensen, 1993). In terms of the volatility of performance, however, board size leads to reduced stock return volatility, because it becomes less likely, that extreme decisions will be made, compromises are more common (Cheng, 2008). We expect board size to be negatively linked to the vol-of-vol.

We also look at CEO power, which has been shown to increase the volatility of returns (Adams et al., 2005). In order to relate the concept of CEO power to board structure, we use a dummy variable *Duality* that is one when the CEO is also the chairperson of the board. Combining the decision making role and the monitoring role in one person, arguably gives that person a lot of power (Finkelstein et al., 2009). The effect on performance is, however, unclear, with some studies finding negative and others positive effects.[9] A case can be made that duality reduces information and communication needs and leads to faster decision making (Yang and Zhao, 2014). In that sense it should be expected that duality leads to better control of the vol-of-vol.

As other controls for the volatility of performance and of risk, we include firm age, collected from CRSP, the number of business segments from COMPUSTAT, and CEO ownership from ExecuComp. We expect the first two to lower risk and uncertainty

[9] See Krause et al. (2014) for a review of the research on CEO chairperson duality and a discussion of the ambiguous results.

and the the third one to increase them. We also control for several firm characteristics, such as firm size, performance, financial leverage, and growth opportunities, which we measure as capital expenditures over sales. All of the inputs are obtained from COMPUSTAT. An overview of our variables, including definitions and databases can be found in Table A.1 in the appendix.

Table 1 provides summary statistics for the volatility, vol-of-vol as well as governance and firm characteristics.

[*Insert Table 1 about here.*]

It can be seen that the average stock price volatility is 42.73 percent and the average vol-of-vol is 14.87 percent. As expected both idiosyncratic values are somewhat lower. We have substantially fewer observations for the option-implied volatilities for two reasons: first, most trading occurs in options with time to maturity of one month or less so there are not many options with one year to maturity in the first place.[10] Second, applying several standard filters in order to only select well-traded and well-priced options further reduces the number of options from which we are able to calculate our two option-implied volatility measures.[11] Because of the reduced sample size a direct comparison with the historical estimates should be taken with caution. Again, the forward-looking volatility and vol-of-vol are somewhat lower than their historical counterparts.

Mean (median) board size is 9.2 (9), which makes this variable comparable to the one observed by Cheng (2008). Firms in our sample have on average 58 percent of firm year observations with a CEO who is also the chairperson of that firm. Moreover, it

[10] In terms of options with a time to maturity of one year that are at the money IVY DB only contains data for 2,113 of the 3,635 firms that are included in our final dataset. Option-implied volatilities with one month to maturity, which we use to calulate option-implied vol-of-vol, are available at a higher frequency.

[11] Eventually, 1,184 (2,457) of the 3,635 companies of our final dataset remain for which the average option-implied volatility (vol-of-vol) can be calculated.

can be seen that several variables exhibit extreme values. Firms size as measured by total assets ranges from 1.9 to 797,776 with a mean (median) of 7,855 (1,761). Similar observations can be made for leverage and growth opportunities. To alleviate concerns that these extreme values might drive our results, we winsorize our control variables at the one and 99 percent level.

4 Empirical Analysis

Our empirical approach follows existing literature and begins with panel data analyses, followed by several robustness checks.

4.1 Corporate governance, volatility, and vol-of-vol

Given that volatility of corporate performance may arise between firms as well within firms, we begin our analyses with a fixed effects panel model. We calculate a time-series on an annual basis for both the volatility and the vol-of-vol of stock returns for each company. In order to obtain annual vol-of-vols we begin by computing monthly standard deviations from daily stock returns, which we then use to calculate the vol-of-vol per firm and year. Annual volatilities are calculated as the annualized standard deviation of daily stock returns. Idiosyncratic volatility and vol-of-vol are similarly calculated, but from the residuals from the Fama-French three-factor model.[12] We incorporate the data structure in our econometric model:

$$\begin{aligned} Y_{i,t} = \quad & \beta_0 + \beta_1\, E\_Index_{i,t} + \beta_2\, Ln(Board\_Size)_{i,t} + \beta_3\, Duality_{i,t} \\ & + \beta_4\, Firm\_Age_{i,t} + \beta_5\, Business\_Segments_{i,t} \\ & + \beta_6\, Ln(Total\_Assets)_{i,t} + \beta_7\, ROA_{i,t} + \beta_8\, ROA\_prior\_year_{i,t} \\ & + \beta_9\, Leverage_{i,t} + \beta_{10}\, CAPEX/Sales_{i,t} \\ & + \beta_{11}\, CEO\_Ownership_{i,t}, \end{aligned} \tag{1}$$

[12] Our empirical results remain unaffected when we use the market model instead.

where $Y_{i,t}$ is either the volatility or the vol-of-vol of stock returns. Additionally, the model includes industry and year fixed effects. We do not use firm fixed effects as several of our independent variables do not change much over time, most notably the E Index, and therefore including firm fixed may prevent detection of any relationships in the data.[13]

[*Insert Table 2 about here.*]

Columns (1) and (2) of Table 2 present the estimation results of Equation 1. It can be seen in column (1) that we confirm our expectations that higher levels of entrenchment and larger boards, both indicative of "poor" corporate governance, are associated with a lower volatility of a firm's stock returns, as the coefficients of the E index (-0.0086, p-value < 0.0001) and board size (-0.0868, p-value < 0.0001) show significant negative values. Duality is insignificant, while our control variables have the expected sign and are almost all highly significant.

Column (2) illustrates similar results for the vol-of-vol. Entrenchment (-0.0024, p-value of 0.0011) and board size (-0.0305, p-value < 0.0001) consistently lower the volatility of a firm's level of risk. Consequently, the three governance provisions affect the vol-of-vol in the same way as they affect the volatility.

Duality again does not show any significant coefficients, neither for the volatility nor for the vol-of-vol. The fact that we do not find any significant relationship between our proxy for CEO power and our two volatility measures may not be all that surprising. It is in line with the contradictory literature about its effects on performance, which does not find consistent results on whether duality is positively or negatively linked to performance.

[13] Note that Adams et al. (2005) and Cheng (2008) also use industry fixed effects and that procedure is strongly supported by Zhou (2001). Since Himmelberg et al. (1999), on the other hand, argue in favor of using firm fixed effects, we report the results in our robustness checks.

Colums (3) and (4) repeat the analyses with the idiosyncratic volatility and the results are virtually identical. Again, a higher level of entrenchment and larger boards reduce both the volatility of returns and the vol-of-vol. In addition, it is confirmed that older, larger and more diversified firms are less volatile and have lower vol-of-vol while more highly levered firms and growth firms exhibit both greater risk and uncertainty about stock returns.

All in all, we find that the volatility and the vol-of-vol react to the same factors in the same way. While higher leverage and growth opportunities increase both types of risk, external and internal governance alike can reduce it. Insulating managers from the market for corporate control or increasing board size can reduce the volatility of stock returns and the volatility of the volatility. Results hold for both the overall volatility and vol-of-vol as well as the idiosyncratic ones.

4.2 Robustness Checks

We subject our results to a series of robustness checks, beginning with a different model specification to address endogeneity concerns. Additionally, we rule out that our results are driven solely by large firms or the assumptions that unobservable heterogeneity exists on the industry level and not the firm level.

4.2.1 Endogeneity test

It is of course conceivable that the results are impacted by endogeneity, specifically by reverse causality, as a high volatility or vol-of-vol may cause a firm to alter its corporate governance structure and not the other way around. To alleviate these concerns, we perform several tests, both by using lagged values and option-implied forward-looking volatilities. First, we re-run the regressions according to Equation 1, but this time, we use lagged valued of the corporate governance variables:

$$
\begin{aligned}
Y_{i,t} = \quad & \beta_0 + \beta_1\, E\_Index_{i,t-s} + \beta_2\, Ln(Board\_Size)_{i,t-s} + \beta_3\, Duality_{i,t-s} \\
& + \beta_4\, Firm\_Age_{i,t} + \beta_5\, Business\_Segments_{i,t} \\
& + \beta_6\, Ln(Total\_Assets)_{i,t} + \beta_7\, ROA_{i,t} + \beta_8\, ROA\_prior\_year_{i,t} \\
& + \beta_9\, Leverage_{i,t} + \beta_{10}\, CAPEX/Sales_{i,t} \\
& + \beta_{11}\, CEO\_Ownership_{i,t},
\end{aligned} \tag{2}
$$

where $t > s$ and $Y_{i,t}$ is either the volatility or the vol-of-vol of stock returns. Again, we control for industry and year fixed effects. Using lagged values of our governance measures allows us to exclude the possibility that the corporate governance may have been influenced by the volatility or the vol-of-vol. Table 3 reports regression results for three lags, yet results are virtually the same when using one or two lags.

[*Insert Table 3 about here.*]

Replacing our internal and external governance variables with their lagged versions and re-estimating the model consistently provides us with the same results as in the analysis above. In the case of three lags, we observe only slightly lower significance levels for the E index when it comes to the vol-of-vol. Otherwise, our results hold. A high level of entrenchment (-0.0052, p-value of 0.0026) and large boards (-0.0661, p-value < 0.0001) lower the volatility of stock returns. Moreover, column (2) also illustrates significant negative coefficients for the E index (-0.0014, p-value < 0.0926) and board size (-0.0217, p-value < 0.0001), which also confirms their negative influence on the vol-of-vol. These results suggest that the investigated corporate governance mechanisms influence volatility and the vol-of-vol, not the other way around. Results for the idiosyncratic volatility and vol-of-vol are again virtually identical.

Nonetheless, lagged values, even when lagged for multiple periods, may still not be independent. Therefore, we also collect forward-looking implied volatilities, calculated

from option prices. Since these volatilities represent investors' expectation about future realized volatilities, it is impossible that there can be a reverse causality. Even if managers decide to alter governance structures based on the observed implied volatilities, these changes would immediately lead to a change in market prices of the options, which in turn results in a new implied volatility. Values available in the OptionMetrics Ivy DB are based on the binomial model due to Cox et al. (1979) and are overall volatilities. Regression results are reported in Table 4.

[*Insert Table 4 about here.*]

The results for the volatility are given in column (1) and confirm earlier results for the E index and for board size. Increases in both, which represents bad governance, leads to a reduction in volatility and in the vol-of-vol. All in all, our results so far demonstrate that board size is a major factor in influencing both the volatility and the vol-of-vol. Against our expectations, however, both are affected in the same direction.

4.2.2 Size Effect

Our sample contains both large firms listed in the S&P 500 as well as mid-cap and small-cap firms, which all taken together constitute the S&P 1500. Several of our governance measures, however, are linked to firm size, such as board size (e.g., Lehn et al., 2009). As a consequence, it is possible that our results are mostly driven by firm size more than anything else. In order to mitigate this concern, we split our sample at the median firm size and re-run the regressions according to Equation 1 for our separate sub-samples. Our results are presented in Table 5.[14]

[*Insert Table 5 about here.*]

[14] Results for the idiosyncratic volatility are again almost identical and therefore not reported.

It can be seen that our main results remain mostly unaffected by the sample split, with the exception of the finding for the E index and its effect on the vol-of-vol. In contrast to our previous analyses, it is no longer significant for large firms when it comes to the vol-of-vol. It does, however, still have a significant negative effect on the volatility of large and small firms as well as on the vol-of-vol of small firms. In addition, board size is also highly significant and negative in all four models, indicating that the effect does not depend on firm size.

Interestingly, the effect of CEO ownership differs after the split. CEOs who own large stakes in smaller companies seem to focus more on reducing the risk and the uncertainty about risk, whereas in larger firms they tend to increase it. The latter result is in line with findings by Adams et al. (2005). The effects of the other control variables persist after the sample split, which is why we remain confident that firm size is not the driving factor behind our main results.

4.2.3 Other Sensitivity Tests

Besides the above mentioned robustness checks, we also run several other versions of our model to test for firm fixed effects and effects of other variable specifications.

So far our analyses have used industry fixed effects in order to control for unobserved factors unique to an industry. It is, however, also conceivable that this approach is too broad, because the unobservable heterogeneity exists on the firm level. As mentioned before, there is some dispute in the literature on this issue.[15] Therefore, we run our analyses of the volatility and the vol-of-vol again, this time using firm fixed effects. Results are presented in Table 6.

[*Insert Table 6 about here.*]

[15] See Himmelberg et al. (1999) and Zhou (2001).

The results show fewer variables as significant, especially the ones that do not change much over time (e.g., the E index or the number of business segments). This seems to support the assertion by Zhou (2001) that industry effects are more appropriate in this kind of research. Nonetheless, some of our results are again supported. Volatility of stock returns is increased by higher financial leverage and higher growth opportunities, whose coefficients are both significant at the one percent level. Moreover, we again find the E index ($p-$value of 0.0242) and board size ($p-$value < 0.0001) to be highly significant and negative.

The vol-of-vol is likewise increased by leverage and growth opportunities, while the E index does not have any significant effect. Board size is the main governance attribute that lowers the vol-of-vol, besides firm size and accounting performance. Overall, our main results appear to be robust to the assumption of where the fixed effects lie.

Next, we replace several of our variables. First, we replace the natural log of board size with the levels of the number of directors sitting on a board. This has no effect on our results in any of the models.

Next, we measure growth opportunities not as capital expenditures over sales, but as the market-to-book (MTB) ratio. This causes virtually no changes in the results of Table 2 concerning the governance variables, yet the growth opportunities themselves lose in significance. Specifically, growth opportunities no longer show a significant relationship with the vol-of-vol.

Finally, we change size from the natural log of total assets to the natural log of market capitalization, which we calculate as the number of outstanding shares multiplied by the closing price on the last trading day of the year. Again, we see no changes in any of our models. Splitting the sample at the median of market capitalization instead of total assets also shows no changes.

This supports our two main findings: First, the two governance mechanisms that show the strongest most robust effect on volatility as well as the vol-of-vol are the E index and board size. In line with our expectations both reduce the volatility when they increase, where an increase is associated with less control of management. Second, against our expectations, the corporate governance mechanisms affect the vol-of-vol in the same way as the volatility. It is conceivable that either management does not actively manage the vol-of-vol or that it is simply influenced through the same channels as the volatility. We analyze two possible channels next.

4.3 Possible channels affecting the volatility and the vol-of-vol

To determine in what way the corporate governance mechanisms affect the volatility and vol-of-vol of corporate performance, we test three channels through which governance could possibly influence volatility and vol-of-vol: expenditures for research and development (R&D), capital expenditures, and analyst forecast inaccuracy.

R&D and capital expenditures both are long-term expenditures. As investors may not be able to assess their future outcomes in detail, high levels of those activities leaves them with a considerabel amount of uncertainty about the firm's future (Chan et al., 2001). While both types are associated with increased stock return volatility, Kothari et al. (2002) show that, compared to investments property, plants, and equipment (i.e., capital expenditures), R&D expenses are the far more important driver of uncertainty. However, Amir et al. (2007) argue that this is only the case in R&D heavy industries. In this section both types will be considered.

Another potential channel that can be expected to influence volatility and vol-of-vol is the extend to which analysts are able to reasonably forecast the firm's future earnings. In the presence of great information asymmetries between the firm and its analysts, deviations from forecasted earnings are likely to occur. This can have severe consequences for a firm's future stock performance (Degeorge et al., 1999) and therefore affect stock

return volatility and vol-of-vol as well. As the quality of corporate governance can have an impact on the information environment between management and outsiders of a firm (Kanagaretnam et al., 2007), it can be expected to influence the accuracy of analysts' forecasts.

In order to empirically examine the relationship between our governance measures and the channels explained here, we reestimate Model (1) using measures for R&D and capital expenditures as well as for analyst forecast inaccuracy as the dependent variables. The first two are scaled by the book value of assets at the beginning of the fiscal year. Data are obtained from COMPUSTAT.[16] Analyst forecast inaccuracy is measured as the difference between actual and forecasted earnings per share, divided by the actual earnings per share. Data are derived from the I/B/E/S database. Results of our model estimations are reported in Table 7.

[*Insert Table 7 about here.*]

As can be seen, both the E index and board size show significant negative coefficients on R&D expenditures meaning that higher entrenchment and greater board size lead to a reduction in R&D. Additionally, duality also has a negative ceofficient in this model, yet only with a $p-$value of 0.0682. The results indicate that entrenched managers do not want to invest in research and development because of the uncertain outcome. Moreover, larger boards may be incapable of forcing the issue because of an inability to coordinate. Contrarily, the results for capital expenditures do not show any significant relation to corporate governance.[17] These results are in line with the findings of Amir et al. (2007) and Kothari et al. (2002) who emphasize that it is mostly R&D expenses that are responsible for an increase in uncertainty about a firm's future. Hence, the

[16] In line with reference studies, we set missing values of R&D and capital expenditures equal to zero (e.g., Amir et al., 2007; Cheng, 2008).

[17] We also do not find any significance regarding the governance variables when exchanging CAPEX/sales by the market-to-book ratio or simply excluding CAPEX/sales from the model.

less risky capital expenditures do not seem to be a channel through which governance can influence volatility and vol-of-vol.

With respect to analyst forecast inaccuracy board size is the only governance variable to show a significant and negative coefficient. A larger board apparently enables analysts to better evaluate the companies' prospects, which in turn can be expected to reduce volatility and vol-of-vol. Entrenchment and duality do not seem to be related to analyst forecast inaccuracy. Overall, especially board size has been shown to be associated with R&D expenditures and analyst forecast inaccuracy, which could be recognized as possible channels.[18] For now, we leave it to future research to identify ways in which managers can influence the vol-of-vol.

5 Conclusion

In the past, the overwhelming focus of the corporate governance literature has been on the effect on stock returns or firm value, with near unanimous results saying that 'good' corporate governance leads to positive abnormal returns. But as these returns faded (Bebchuk et al., 2013), the focus shifted to the effect that corporate governance can have on the risk, that is on the volatility of performance. Insights into this relationship are much more limited, however. Several papers have used the introduction of the Sarbanes-Oxley Act to investigate how changes made to governance structures in its wake affect risk taking behavior by managers, yet only two studies have looked at individual governance provisions: Adams et al. (2005) finds that CEO power can increase the volatility, while Cheng (2008) finds that board size has a decreasing effect. Despite the importance of the volatility of the volatility, no study so far has analyzed the effects corporate governance can have on that measure of uncertainty.

[18] In unreported analysis we also estimate the models using industry-adjusted measures for R&D, capital expenditures, and analyst forecast inaccuracy. With the exception of an insignificant relation between the E Index and R&D expenditures, the results confirm the findings illustrated in this section.

Our study fills both gaps, as we investigate not only the combined effect of external and internal governance mechanisms on volatility of returns but also on the vol-of-vol. Our analyses are the first to show that firms where managers exhibit a high degree of entrenchment have a lower volatility. This finding is in line with the observation by Bebchuk et al. (2009) that these firms also achieve comparably lower returns. We also corroborate Cheng's (2008) finding that greater boards will lead to lower volatility. These results are robust to a variety of model specifications as well as endogeneity tests.

We also demonstrate that the mechanisms that influence the volatility also impact the vol-of-vol in the same direction. Firms with high growth opportunities and high financial leverage exhibit stronger uncertainty about future returns. In terms of our corporate governance measures especially board size turns out to be linked to the vol-of-vol. We find strong evidence that having larger boards leads to a less erratic levels of risk, a result that is robust across all our model specifications and endogeneity tests. Additionally, we find evidence that higher entrenchment and a larger fraction of independent directors on the board can reduce this kind of uncertainty, although the evidence for independent directors is only weak. Given that a high vol-of-vol can have extremely negative consequences on stock returns and liquidity, it may be an option for such firms to provide top management with more insulation from the market for corporate control in order to reduce some of the uncertainty. We leave it up to future research to investigate in which situations the positive effects on the vol-of-vol of greater entrenchment will outweigh the negative consequences for performance.

Our results provide a first step in understanding how corporate governance structures can influence the vol-of-vol and two such channels appear to be R&D investment and the accuracy of analysts' forecasts. Considering the extremely negative effects that this type of uncertainty brings for future returns, it is surprising that not more attention has been paid to it in the past. Increasing managerial entrenchment and board size can both counteract high vol-of-vol. Since both are considered to be 'bad' governance with

negative effects for stock returns, it is up to future research to investigate the trade-off between this negative side and the positive side of reducing the vol-of-vol.

The findings presented here are not just relevant to managers in firms suffering from erratic risk levels, they can also be used by low-volatility investors who may want to base their portfolio allocations on corporate governance characteristics linked to low risk. We leave it up to future research to set up trading and evaluate trading strategies based on these findings.

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Appendix

Table A.1 Variable Definitions

Variable	Definition	Data Source
Volatility measures		
Volatility	Annualized standard deviation of daily stock returns	*CRSP*
Vol-of-vol	Annualized standard deviation of monthly standard deviations of stock returns, whereas the monthly standard deviations are calculated on the basis of daily stock returns for every month in a given year.	*CRSP*
Idiosyncratic volatility	Annualized standard deviation of daily residuals from the Fama-French (1993) three-factor model. For each firm the model is estimated yearly using data from Kenneth R. French's data library, which is available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.	*CRSP, French's data library*
Idiosyncratic vol-of-vol	Annualized standard deviation of monthly standard deviations of Fama-French residuals, where the monthly standard deviations are calculated on the basis of daily residuals for every month in a given year. The model estimation is done as for the idiosyncratic volatility.	*CRSP, French's data library*
Option-implied volatility	Model-based implied volatility provided by OptionMetrics, which is obtained from the binomial model due to Cox et al. (1979). For each firm-year we calculate the average implied volatility from the one call option and the one put option that are closest to being at the money and have a time to maturity of one year.	*Ivy DB OptionMetrics*
Option-implied vol-of-vol	Calculated from model-based implied volatility provided by OptionMetrics. For each company we first calculate the average implied volatility from the one call option and the one put option that are closest to being at the money and have a time to maturity of one month. We then calculate the option-implied vol-of-vol for each firm-year as the standard deviation of the previously calculated monthly option-implied volatilities.	*Ivy DB OptionMetrics*
External governance		
E Index	Index measuring the presence of six governance provisions associated with managerial entrenchment, namely a staggered board, limitations on amending bylaws or the charter, the requirement of a supermajority to approve a merger, golden parachutes, and poison pills. Used as a measure of external governance.	*ISS Governance*
Internal governance		
Ln(board size)	Natural log of the number of directors on the board.	*ISS Directors*
Duality	Dummy variable equal to one if the CEO is also the chairperson of the board, and zero otherwise.	*ISS Directors*
Further controls		
Firm age	Number of years since the first trading in CRSP, with 1925 as the earliest year possible.	*CRSP*
Business segments	Number of different two-digit SIC code industries in which the firm operates.	*Compustat*
Ln(total assets)	Natural log of total assets.	*Compustat*
Return on Assets (ROA)	Income before interest and taxes (EBIT) divided by the book value of assets at the beginning of the fiscal year.	*Compustat*
ROA prior year	ROA of the previous year.	*Compustat*
Leverage	Total liabilities divided by total assets.	*Compustat*
CAPEX/Sales	Capital expenditures divided by net sales.	*Compustat*
CEO ownership	Percentage of a company's shares owned by the CEO, options excluded.	*ExecuComp*

This table provides an overview of the different variables used, their definitions as well as their source.

Table 1 Summary statistics of board and firm characteristics

	Number of observations	Mean	Standard deviation	Minimum	25th percentile	Median	75th percentile	Maximum
Volatility Measures								
Volatility	24,208	0.4273	0.2324	0.0198	0.2734	0.3697	0.5152	3.6694
Vol-of-vol	24,208	0.1487	0.1203	0.0074	0.0764	0.1173	0.1824	3.3478
Idiosyncratic volatility	24,208	0.3644	0.2167	0.0180	0.2246	0.3113	0.4405	3.6256
Idiosyncratic vol-of-vol	24,208	0.1293	0.1127	0.0074	0.0642	0.1005	0.1570	3.2968
Option-implied volatility	5,466	0.3655	0.1526	0.1159	0.2561	0.3346	0.4319	1.3621
Option-implied vol-of-vol	12,453	0.0807	0.0584	0.0038	0.0422	0.0645	0.1006	0.9730
External Governance								
E Index	25,513	2.9167	1.4531	0.0000	2.0000	3.0000	4.0000	6.0000
Internal Governance								
Board size	22,202	9.1770	2.3119	3.0000	7.0000	9.0000	11.0000	22.0000
Duality	22,202	0.5781	0.4939	0.0000	0.0000	1.0000	1.0000	1.0000
Further Controls								
Firm age	24,208	26.1723	20.1352	0.0000	11.0000	20.0000	36.0000	90.0000
Business segments	22,704	1.5832	0.8977	1.0000	1.0000	1.0000	2.0000	10.0000
Total assets	20,623	7,855.7	27,025.4	1.9050	653.0440	1,761.11	5,633.0	797,769.0
ROA	22,661	0.1029	0.1231	−1.9213	0.0542	0.0973	0.1538	1.7899
ROA prior year	22,651	0.1088	0.1276	−3.5315	0.0575	0.1008	0.1597	1.2219
Leverage	22,677	0.5361	0.2510	0.0224	0.3818	0.5386	0.6749	11.3832
CAPEX/Sales	22,740	0.1028	1.6203	−0.1242	0.0223	0.0404	0.0811	233.9899
CEO ownership	20,640	0.0176	0.0506	0.0000	0.0000	0.0016	0.0093	0.6769

The sample covers all firms in the Institutional Investors Service (ISS) Governance and Directors database (formerly RiskMetrics) over the years 1996 to 2015, excluding financial firms (SIC 6000 to 6799) and firms with a dual class share structure. Data on stock returns are from the Center for Research in Security Prices (CRSP), data on option-implied volatility are from IVY DB OptionMetrics, and data on financial items are from COMPUSTAT. Data on CEO ownership are obtained from ExecuComp. Idiosyncratic volatility and vol-of-vol are based on residuals from the Fama and French (1993) three factor model. Following Bebchuk et al. (2009) the E Index takes values between zero and six indicating how many of the governance provisions staggered board, limitations on bylaw or charter amendments, supermajority to approve a merger, golden parachutes, and poison pills are in place. Board size is the number of directors on the board. Duality is a dummy variable that is one if the CEO is also the chairperson of the board. Firm age is the number of years since the first trading on CRSP. Business segments is the number of different two-digit SIC code industries in which the firm operates. Return on assets (ROA) is income before interest and taxes (EBIT) divided by the book value of assets at the beginning of the fiscal year. Leverage is total debt over total assets and CAPEX is capital expenditures. CEO ownership is the percentage of a company's shares owned by the CEO (options excluded).

Table 2 Analysis of volatility and vol-of-vol of performance

	(1) Volatility of stock returns	(2) Vol-of-vol of stock returns	(3) Idiosyncratic volatility	(4) Idiosyncratic vol-of-vol
E Index	−0.0086***	−0.0024***	−0.0080***	−0.0024***
	(0.0000)	(0.0011)	(0.0000)	(0.0008)
Ln(board size)	−0.0868***	−0.0305***	−0.0729***	−0.0264***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Duality	−0.0042	−0.0011	−0.0035	−0.0008
	(0.2296)	(0.5158)	(0.2647)	(0.6236)
Firm age	−0.0010***	−0.0004***	−0.0010***	−0.0004***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Business segments	−0.0084***	−0.0025***	−0.0093***	−0.0032***
	(0.0000)	(0.0074)	(0.0000)	(0.0003)
Ln(total assets)	−0.0242***	−0.0114***	−0.0274***	−0.0130***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ROA	−0.4777***	−0.2313***	−0.4328***	−0.2213***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ROA prior year	−0.0020	0.0421***	−0.0071	0.0400***
	(0.9269)	(0.0008)	(0.7114)	(0.0011)
Leverage	0.0748***	0.0616***	0.0888***	0.0616***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CAPEX/Sales	0.0998***	0.0328***	0.0754***	0.0162*
	(0.0000)	(0.0009)	(0.0001)	(0.0639)
CEO ownership	−0.0738*	−0.0279	−0.0571	−0.0267
	(0.0874)	(0.1099)	(0.1389)	(0.1297)
Fixed Effects	Industry, Year	Industry, Year	Industry, Year	Industry, Year
Sample Size	19,717	19,717	19,717	19,717
R-Squared	0.5370	0.3807	0.5209	0.2927

This table presents results for regressing the volatility and the vol-of-vol of stock returns on various measures of internal and external governance. Columns one and two use overall volatility while columns three and four use idiosyncratic values obtain from the Fama-French three-factor model. The E index is constructed from ISS (formerly RiskMetrics) according to Bebchuk et al. (2009). Ln(board size) is the natural log of the number of directors on the firm's board. Duality is an indicator variable that is one if the CEO is also the chairperson of the board. Firm age is the number of years since the first trading in CRSP. Business Segments is the number of different two-digit SIC code industries in which the firm operates. Size is measured as the natural log of total assets. ROA is the return on assets measured as earnings before interest and taxes (EBIT) over book value of total assets at the beginning of the fiscal year. Leverage is total debt over total assets. CAPEX/Sales is capital expenditures divided by total sales and CEO ownership is the percentage of a company's shares owned by the CEO (options excluded). All models include industry and time fixed effects and a constant term that is not reported. Cluster robust $p-$values are reported in parentheses under the estimates, with *, **, and *** indicating significance levels of 10%, 5%, and 1% levels, respectively.

Table 3 Analysis of volatility and vol-of-vol of performance with lagged values

	(1) Volatility of stock returns	(2) Vol-of-vol of stock returns	(3) Idiosyncratic volatility	(4) Idiosyncratic vol-of-vol
E Index$_{t-3}$	−0.0052***	−0.0014*	−0.0052***	−0.0017**
	(0.0026)	(0.0926)	(0.0010)	(0.0335)
Ln(board size)$_{t-3}$	−0.0661***	−0.0217***	−0.0520***	−0.0194***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Duality$_{t-3}$	0.0008	0.0011	0.0022	0.0014
	(0.8423)	(0.5508)	(0.5198)	(0.4241)
ROA	−0.4757***	−0.2286***	−0.4222***	−0.2115***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ROA prior year	−0.1170***	0.0025	−0.1253***	−0.0053
	(0.0000)	(0.8610)	(0.0000)	(0.7002)
Ln(total assets)	−0.0252***	−0.0117***	−0.0275***	−0.0128***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Leverage	0.1181***	0.0768***	0.1290***	0.0775***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CAPEX/Sales	0.0834***	0.0285**	0.0631***	0.0159
	(0.0007)	(0.0149)	(0.0037)	(0.1357)
Business segments	−0.0086***	−0.0022**	−0.0100***	−0.0034***
	(0.0002)	(0.0434)	(0.0000)	(0.0014)
Firm age	−0.0008***	−0.0003***	−0.0008***	−0.0003***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CEO ownership	−0.0628	−0.0231	−0.0464	−0.0211
	(0.2258)	(0.2669)	(0.3111)	(0.3125)
Fixed Effects	Industry, Year	Industry, Year	Industry, Year	Industry, Year
Sample Size	14,080	14,080	14,080	14,080
R-Squared	0.5386	0.3874	0.5091	0.2883

This table presents results for regressing volatility and the vol-of-vol of stock returns on various lagged measures of internal and external governance. The E index is constructed from ISS (formerly RiskMetrics) according to Bebchuk et al. (2009). Ln(board size) is the natural log of the number of directors on the firm's board. Duality is an indicator variable that is one if the CEO is also the chairperson of the board. Firm age is the number of years since the first trading in CRSP. Business Segments is the number of different two-digit SIC code industries in which the firm operates. Size is measured as the natural log of total assets. ROA is the return on assets measured as earnings before interest and taxes (EBIT) over book value of total assets at the beginning of the fiscal year. Leverage is total debt over total assets. CAPEX/Sales is capital expenditures divided by total sales and CEO ownership is the percentage of a company's shares owned by the CEO (options excluded). All models include industry and time fixed effects and a constant term that is not reported. Cluster robust $p-$values are reported in parentheses under the estimates, with *, **, and *** indicating significance levels of 10%, 5%, and 1% levels, respectively.

Table 4 Analysis of option-implied volatility and vol-of-vol of performance

	(1) Option-implied volatility	(2) Option-implied vol-of-vol
E Index	−0.0034∗	−0.0010∗∗
	(0.0700)	(0.0323)
Ln(board size)	−0.0577∗∗∗	−0.0149∗∗∗
	(0.0000)	(0.0000)
Duality	−0.0046	−0.0008
	(0.2500)	(0.4526)
Firm age	−0.0008∗∗∗	−0.0002∗∗∗
	(0.0000)	(0.0000)
Business segments	−0.0065∗∗∗	−0.0007
	(0.0041)	(0.2865)
Ln(total assets)	−0.0309∗∗∗	−0.0036∗∗∗
	(0.0000)	(0.0000)
ROA	−0.2712∗∗∗	−0.0829∗∗∗
	(0.0000)	(0.0000)
ROA prior year	−0.0215	0.0229∗∗∗
	(0.4406)	(0.0036)
Leverage	−0.0129	0.0117∗∗∗
	(0.3352)	(0.0008)
CAPEX/Sales	0.0023	0.0180∗∗∗
	(0.9190)	(0.0008)
CEO ownership	0.1267∗	0.0076
	(0.0636)	(0.5923)
Fixed Effects	Industry, Year	Industry, Year
Sample Size	4,899	10,918
R-Squared	0.7026	0.5124

This table presents results for regressing the implied volatility and the implied vol-of-vol on various measures of internal and external governance. The E index is constructed from ISS (formerly RiskMetrics) according to Bebchuk et al. (2009). Ln(board size) is the natural log of the number of directors on the firm's board. Duality is an indicator variable that is one if the CEO is also the chairperson of the board. Firm age is the number of years since the first trading in CRSP. Business Segments is the number of different two-digit SIC code industries in which the firm operates. Size is measured as the natural log of total assets. ROA is the return on assets measured as earnings before interest and taxes (EBIT) over book value of total assets at the beginning of the fiscal year. Leverage is total debt over total assets. CAPEX/Sales is capital expenditures divided by total sales and CEO ownership is the percentage of a company's shares owned by the CEO (options excluded). All models include industry and time fixed effects and a constant term that is not reported. Cluster robust $p-$values are reported in parentheses under the estimates, with *, **, and *** indicating significance levels of 10%, 5%, and 1% levels, respectively.

Table 5 Analysis of volatility and vol-of-vol of performance by size

	Large firms		Small firms	
	(1) Volatility of stock returns	(2) Vol-of-vol of stock returns	(3) Volatility of stock returns	(4) Vol-of-vol of stock returns
E Index	−0.0044**	−0.0003	−0.0087***	−0.0026**
	(0.0275)	(0.7229)	(0.0005)	(0.0208)
Ln(board size)	−0.0961***	−0.0360***	−0.0708***	−0.0218***
	(0.0000)	(0.0000)	(0.0000)	(0.0011)
Duality	−0.0085**	−0.0031	−0.0005	0.0008
	(0.0428)	(0.1045)	(0.9281)	(0.7717)
Firm age	−0.0009***	−0.0003***	−0.0020***	−0.0007***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Business segments	−0.0112***	−0.0032***	−0.0058	−0.0026
	(0.0000)	(0.0019)	(0.1418)	(0.1394)
Ln(total assets)	−0.0080***	−0.0038***	−0.0494***	−0.0240***
	(0.0024)	(0.0009)	(0.0000)	(0.0000)
ROA	−0.4247***	−0.2031***	−0.4870***	−0.2373***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ROA prior year	0.0336	0.0451***	−0.0263	0.0373**
	(0.2955)	(0.0049)	(0.3553)	(0.0293)
Leverage	0.0552***	0.0528***	0.1206***	0.0813***
	(0.0036)	(0.0000)	(0.0000)	(0.0000)
CAPEX/Sales	0.0658***	0.0189*	0.1337***	0.0481***
	(0.0061)	(0.0756)	(0.0000)	(0.0033)
CEO ownership	0.2035***	0.0713**	−0.1671***	−0.0641***
	(0.0074)	(0.0138)	(0.0001)	(0.0005)
Fixed Effects	Industry, Year	Industry, Year	Industry, Year	Industry, Year
Sample Size	10,557	10,557	9,160	9,160
R-Squared	0.5469	0.4168	0.4898	0.3345

This table presents results for regressing the volatility and the vol-of-vol of stock returns on various measures of internal and external governance after a sample split. Columns one and two show the results for firms that are larger than the median firm, columns three and four show results for firms smaller than the median. The E index is constructed from ISS (formerly RiskMetrics) according to Bebchuk et al. (2009). Ln(board size) is the natural log of the number of directors on the firm's board. Duality is an indicator variable that is one if the CEO is also the chairperson of the board. Firm age is the number of years since the first trading in CRSP. Business Segments is the number of different two-digit SIC code industries in which the firm operates. Size is measured as the natural log of total assets. ROA is the return on assets measured as earnings before interest and taxes (EBIT) over book value of total assets at the beginning of the fiscal year. Leverage is total debt over total assets. CAPEX/Sales is capital expenditures divided by total sales and CEO ownership is the percentage of a company's shares owned by the CEO (options excluded). All models include industry and time fixed effects and a constant term that is not reported. Cluster robust $p-$values are reported in parentheses under the estimates, with *, **, and *** indicating significance levels of 10%, 5%, and 1% levels, respectively.

Table 6 Analysis of volatility and vol-of-vol of performance with firm fixed effects

	(1) Volatility of stock returns	(2) Vol-of-vol of stock returns	(3) Idiosyncratic volatility	(4) Idiosyncratic vol-of-vol
E Index	−0.0043**	−0.0002	−0.0031*	0.0001
	(0.0242)	(0.8697)	(0.0544)	(0.9055)
Ln(board size)	−0.0663***	−0.0199***	−0.0549***	−0.0149***
	(0.0000)	(0.0002)	(0.0000)	(0.0036)
Duality	−0.0032	−0.0027	−0.0046	−0.0030*
	(0.3459)	(0.1519)	(0.1213)	(0.0881)
Firm age	−0.0047**	−0.0002	−0.0041*	−0.0012
	(0.0314)	(0.8688)	(0.0541)	(0.3261)
Business segments	−0.0006	−0.0008	−0.0014	−0.0009
	(0.8121)	(0.5514)	(0.5096)	(0.4662)
Ln(total assets)	−0.0342***	−0.0088***	−0.0367***	−0.0106***
	(0.0000)	(0.0005)	(0.0000)	(0.0000)
ROA	−0.2561***	−0.1360***	−0.2319***	−0.1347***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ROA prior year	0.0259	0.0479***	0.0117	0.0412***
	(0.2328)	(0.0001)	(0.5281)	(0.0007)
Leverage	0.1397***	0.0812***	0.1534***	0.0875***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CAPEX/Sales	0.1006***	0.0356***	0.0716***	0.0200*
	(0.0001)	(0.0038)	(0.0006)	(0.0691)
CEO ownership	0.0573	−0.0053	0.0560	−0.0018
	(0.2213)	(0.8230)	(0.1657)	(0.9359)
Fixed Effects	Firm, Year	Firm, Year	Firm, Year	Firm, Year
Sample Size	19,717	19,717	19,717	19,717
R-Squared	0.4996	0.3465	0.4466	0.1768

This table presents results for regressing the volatility and the vol-of-vol of stock returns on various measures of internal and external governance with firm fixed effects. The E index is constructed from ISS (formerly RiskMetrics) according to Bebchuk et al. (2009). Ln(board size) is the natural log of the number of directors on the firm's board. Duality is an indicator variable that is one if the CEO is also the chairperson of the board. Firm age is the number of years since the first trading in CRSP. Business Segments is the number of different two-digit SIC code industries in which the firm operates. Size is measured as the natural log of total assets. ROA is the return on assets measured as earnings before interest and taxes (EBIT) over book value of total assets at the beginning of the fiscal year. Leverage is total debt over total assets. CAPEX/Sales is capital expenditures divided by total sales and CEO ownership is the percentage of a company's shares owned by the CEO (options excluded). All models include firm and time fixed effects and a constant term that is not reported. Cluster robust $p-$values are reported in parentheses under the estimates, with *, **, and *** indicating significance levels of 10%, 5%, and 1% levels, respectively.

Table 7 Analysis of channels affecting volatility and vol-of-vol of performance

	(1) R&D expenditures	(2) Capital expenditures	(3) Forecast inaccuracy
E Index	−0.0013**	−0.0002	0.0030
	(0.0391)	(0.6794)	(0.2742)
Ln(board size)	−0.0188***	0.0033	−0.0483***
	(0.0000)	(0.2161)	(0.0053)
Duality	−0.0025*	−0.0003	−0.0071
	(0.0682)	(0.7096)	(0.2877)
Firm age	−0.0001***	−0.0000	−0.0002
	(0.0048)	(0.4620)	(0.2522)
Business segments	−0.0055***	0.0001	−0.0027
	(0.0000)	(0.8889)	(0.4310)
Ln(total assets)	0.0016**	−0.0025***	0.0035
	(0.0428)	(0.0000)	(0.2549)
ROA	−0.0136	0.1260***	0.1627**
	(0.1227)	(0.0000)	(0.0323)
ROA prior year	−0.0370***	0.0146**	−0.3476***
	(0.0000)	(0.0139)	(0.0000)
Leverage	−0.0403***	−0.0032	−0.0011
	(0.0000)	(0.2901)	(0.9550)
CAPEX/Sales	0.0127*	0.3574***	−0.0398
	(0.0785)	(0.0000)	(0.2155)
CEO ownership	−0.0519***	0.0203	−0.1036*
	(0.0062)	(0.1485)	(0.0662)
Fixed Effects	Industry, Year	Industry, Year	Industry, Year
Sample Size	19,717	19,717	18,314
R-Squared	0.3844	0.6908	0.0123

This table presents results for regressing R&D expenditures, capital expenditures, and forecast inaccuracy on various measures of internal and external governance. The E index is constructed from ISS (formerly RiskMetrics) according to Bebchuk et al. (2009). Ln(board size) is the natural log of the number of directors on the firm's board. Duality is an indicator variable that is one if the CEO is also the chairperson of the board. Firm age is the number of years since the first trading in CRSP. Business Segments is the number of different two-digit SIC code industries in which the firm operates. Size is measured as the natural log of total assets. ROA is the return on assets measured as earnings before interest and taxes (EBIT) over book value of total assets at the beginning of the fiscal year. Leverage is total debt over total assets. CAPEX/Sales is capital expenditures divided by total sales and CEO ownership is the percentage of a company's shares owned by the CEO (options excluded). All models include industry and time fixed effects and a constant term that is not reported. Robust $p-$values are reported in parentheses under the estimates, with *, **, and *** indicating significance levels of 10%, 5%, and 1% levels, respectively.