CEO Overconfidence and Stock Price Crash Risk*

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ABSTRACT

This study examines the association between chief executive officer (CEO) overconfidence and future stock price crash risk. Overconfident managers overestimate the returns to their investment projects and misperceive negative net present value (NPV) projects as value creating. They also tend to ignore or explain away privately observed negative feedback. As a result, negative NPV projects are kept for too long and their bad performance accumulates, which can lead to stock price crashes. Using a large sample of firms for the period 1993–2010, we find that firms with overconfident CEOs have higher stock price crash risk than firms with nonoverconfident CEOs. The impact of managerial overconfidence on crash risk is more pronounced when the CEO is more dominant in the top management team and when there are greater differences of opinion among investors. Finally, it appears that the effect of CEO overconfidence on crash risk is less pronounced for firms with more conservative accounting policies.

Excès de confiance des chefs de la direction et risque d'effondrement du cours des actions

RÉSUMÉ

Les auteurs étudient le lien entre l'excès de confiance des chefs de la direction et le risque d'effondrement futur du cours des actions. Les gestionnaires trop confiants surestiment les rendements de leurs projets d'investissement et ont une perception erronée de projets dont la valeur actualisée nette (VAN) est négative qu'ils estiment pourtant créateurs de valeur. Ils tendent également à ignorer ou à justifier les résultats négatifs qu'ils observent personnellement. En conséquence, des projets dont la VAN est négative sont maintenus trop longtemps et leurs rendements médiocres s'accumulent, ce qui risque d'entraîner l'effondrement du cours des actions. En étudiant un vaste échantillon de sociétés au cours de la période s'échelonnant de 1993 à 2010, les auteurs constatent que les sociétés dont les chefs de la direction sont exagérément confiants s'exposent à des risques d'effondrement du cours des actions plus élevés que les sociétés dont les chefs de la direction n'affichent pas cet excès de confiance. L'incidence de l'excès de confiance de la direction sur le risque d'effondrement est davantage marqué lorsque le chef de la direction exerce une plus grande domination au sein de l'équipe de haute direction et lorsque les divergences d'opinion chez les investisseurs sont plus importantes. Enfin, il semble que l'incidence de l'excès de confiance des chefs de la direction sur le risque d'effondrement soit moins grande dans le cas de sociétés dont les méthodes comptables sont plus prudentes.

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1. Introduction

In this paper, we propose and test a new explanation for managerial bad news hoarding behavior and the resultant stock price crashes. Rather than focus on firm-level characteristics that encourage adverse but rational incentives (e.g., Jin and Myers 2006; Kothari, Shu, and Wysocki 2009), we investigate whether stock price crashes can be explained by executives' characteristics or psychological traits. Specifically, we focus on the impact of overconfidence, or overoptimism, defined as the tendency of individuals to overestimate their own acumen, mastery, and prospects for positive future outcomes. Prior literature finds that overconfidence is a strong and robust psychological trait across many samples of subjects, especially among top executives (Alicke and Govorun 2005; Graham, Harvey, and Puri 2013; Moore and Healy 2008; Taylor and Brown 1988; Weinstein 1980). Thus, it is important to understand the real impact of managerial overconfidence on investor welfare, as reflected by stock price crashes.

Overconfident managers tend to overestimate the future cash flows of their investment projects, as well as their own ability to bring about good performance (Heaton 2002; Malmendier and Tate 2005, 2008; Malmendier, Tate, and Yan 2011). As a result, they tend to misperceive ongoing negative NPV projects as value creating. They also cannot rationally process negative feedback about the projects they operate (Taylor and Brown 1988; Taylor and Gollwitzer 1995). Upon observing negative feedback, a rational CEO revises her expectation downward and may conclude that the projects are of negative NPV ex post, whereas an overconfident CEO fails to do so. Instead, the overconfident CEO tends to ignore negative feedback and still believes that the projects have a promising future. Moreover, the overconfident CEO who handpicks the investment projects believes that he has the ability to control their outcome and underestimates the likelihood of failure (Malmendier and Tate 2005). These manifestations of overconfidence lead the CEO to continue the negative NPV projects for extended periods. The poor performance of these bad projects will accumulate and eventually materialize at their final maturity, leading to a market crash of the stock price.

Overconfidence also affects managers' supply of financial information to the stock market. Because overconfident CEOs erroneously perceive poorly performing negative NPV projects as positive NPV projects, they can be reluctant to release privately observed negative feedback about the projects. This is because overconfident CEOs believe that impatient investors, who tend to act on short-term news, can force the termination of positive NPV projects that deliver negative interim news. Such CEOs may even use positive accounting accruals and voluntary disclosure to convey their (genuine yet flawed) optimistic beliefs about the firms' long-term prospects to the stock market. Thus, CEO overconfidence can lead to bad news hoarding, which in turn leads to future stock price crashes.[1]

To examine the relation between CEO overconfidence and crash risk, we construct a modified version of the Malmendier and Tate (2005) stock option-based overconfidence measure, following the methodology of Campbell, Gallmeyer, Johnson, Rutherford, and Stanley (2011). This measure captures the propensity for a manager to voluntarily retain in-the-money stock options after the vesting period. A CEO who voluntarily retains in-the-money options is likely to be overconfident about his own ability and the firm's prospects because the CEO's human capital is already highly exposed to firm-specific risk. In addition, following Campbell et al. (2011) and Schrand and Zechman (2012), we construct

1. It is important to emphasize that we are not arguing that the hiding of bad news is driven only by managerial overconfidence and not by conflicts of interest. Instead, we explore a potentially complementary theory of managerial behaviors and stock price crashes. Our point is that even if there is no conflict of interest, bad news hoarding can still happen because of overconfidence.

another two overconfidence measures by inferring managers' optimism from their various investing and financing decisions. Following Chen, Hong, and Stein (2001) and Hutton, Marcus, and Tehranian (2009), we measure firm-specific crash risk by the probability of extreme negative firm-specific weekly returns, the negative skewness of firm-specific weekly returns, and the asymmetric volatility of negative versus positive firm-specific weekly returns.

Using a large sample of firms in Standard & Poor's (S&P) ExecuComp database for the period 1993–2010, we find that firms with overconfident CEOs are more likely to experience firm-specific stock price crashes in the future, consistent with our prediction. The results are strong and robust across different measures of overconfidence and crash risk. Moreover, using a smaller sample of firms with CEO changes, we find evidence that changes in overconfidence resulting from CEO turnover are positively related to changes in future crash risk.

We next explore several potential moderating effects on the relation between overconfidence and crash risk. First, prior organizational theory suggests that the influence of a CEO's judgment errors on final decision outcomes should be greater when the decision-making power is more centralized in the hands of the CEO (Adams, Almeida, and Ferreira 2005; Sah and Stiglitz 1986, 1991). Consistent with this theory, we show that the impact of CEO overconfidence on crash risk is stronger for firms with more dominant CEOs, as proxied by a larger CEO pay slice (CPS). Second, we argue that overconfident managers may feel less of a need to address the concerns of bearish investors when there are greater differences of opinion among investors. As a result, investors' differences of opinion can exacerbate the effect of overconfidence on crash risk. Consistent with this argument, we show that the relation between overconfidence and crash risk is mainly driven by firms with greater differences of opinion among investors. Finally, Kim and Zhang (2015) show that accounting conservatism reduces crash risk by recognizing bad news in a more timely fashion. Consistent with this finding, we find that the impact of CEO overconfidence on crash risk is more pronounced for firms with less conservative accounting policies.

Our study relates to several strands of literature. First, we contribute to the literature on explanations for stock price crashes. Using a traditional agency theory framework, a growing body of recent theoretical and empirical research has identified a variety of firm characteristics that are determinants or precursors of stock price crashes (Benmelech, Kandel, and Veronesi 2010; Bleck and Liu 2007; DeFond, Hung, Li, and Li 2015; Hutton et al. 2009; Jin and Myers 2006; Kim, Li, and Zhang 2011a,b; Kim and Zhang 2015). Our study is the first to examine the impact of managerial personal traits on crash risk. We provide evidence that a benevolent but overconfident CEO can contribute to firm-specific crashes. Overconfident managers may well think that they are maximizing long-term shareholder value by continuing negative NPV projects and hiding negative feedback, because they cannot rationally evaluate the intrinsic value of the ongoing projects. This argument is in stark contrast to traditional theories that assume that managers are able to rationally observe the intrinsic value of investment projects at any point in time and that they choose to hide bad news to achieve private benefits (e.g., Bleck and Liu 2007). Thus our study constitutes an important complement to the traditional agency theory of bad news hoarding and stock price crashes by providing a related but fundamentally different explanation.

Second, our study relates to the emerging literature of behavioral corporate finance that examines the impact of managerial psychological traits, such as overconfidence, on various corporate policies and outcomes. Our study extends this line of research by examining the impact of CEO overconfidence on stock price crashes, the incidence of which often has a devastating impact on investor welfare. Our research is closely related to those

of Schrand and Zechman (2012) and Ahmed and Duellman (2013), who link managerial overconfidence to accounting manipulation and conservatism. However, our research provides additional insights into this literature because financial reporting quality is only one of many potential channels through which overconfidence affects crash risk (Hutton et al. 2009; Kim and Zhang 2015). For instance, one of our main arguments is that overconfident managers tend to stick to negative NPV projects for extended periods, leading to stock price crashes. As expected, we show that all of our results hold after controlling for accrual management and accounting conservatism, suggesting a direct impact of overconfidence on crash risk. Therefore, we argue that the findings of this study represent an important complement to the prior literature on overconfidence and accounting quality.

Finally, our study is related to a broader literature that examines the impact of managerial styles on firm behavior and performance. The key argument of this literature is that the individual manager matters for corporate decisions, in addition to firm-, industry-, and market-level characteristics. For example, the seminal paper by Bertrand and Schoar (2003) shows that individual managers affect corporate investment, financing, and organizational practices. We contribute to this literature by showing that one type of managerial style (i.e., overconfidence) can explain firm-specific stock price crash risk.

This paper proceeds as follows. Section 2 reviews the relevant literature and develops our hypotheses. Section 3 describes the data and explains the measurement of key variables. Section 4 presents the main empirical analysis. Section 5 conducts several cross-sectional analyses. Section 6 provides robustness checks and additional tests. Section 7 concludes the paper.

2. Related literature and empirical predictions

Financial economists have long been interested in stock price crashes or the negative skewness in stock returns. Earlier explanations for the sources of negative skewness focus on financial market mechanisms such as leverage effects, volatility feedback, and stochastic bubbles. While those studies build their models in a representative investor framework, a more recent study by Hong and Stein (2003) shows that investor heterogeneity is central to the phenomenon. Specifically, the authors argue that when differences in opinion among investors are initially large, bearish investors with unfavorable news who are subject to short-selling constraints will be forced into a corner solution; that is, they will sell all their shares and just sit out of the market. As a result, their information is not fully incorporated into share prices. The Hong-Stein model then shows that the accumulated hidden information tends to come out during market declines, resulting in large negative return outliers. Consistent with Hong and Stein (2003), Chen et al. (2001) provide empirical evidence that differences of opinion among investors are positively related to crash risk.

In contrast to financial market theories focusing on the investor side, recent corporate finance theories have begun to explore the firm side of the story for stock price crashes in an agency theory framework. Jin and Myers (2006) argue that opacity combined with limited investor protection enable a manager to capture part of a firm's operating cash flows. In the process, the manager absorbs and hides firm-specific bad news to protect his or her job. However, the amount of bad news that the manager is willing or able to absorb is limited. If a sufficiently long run of bad news is encountered, the manager exercises the abandonment option and releases the accumulated bad news all at once, resulting in a large negative firm-specific return outlier. Consistent with the prediction of Jin and Myers (2006), Hutton et al. (2009) and Kim et al. (2011b) show that opaqueness engendered by earnings management and complex tax planning facilitates managerial bad news hoarding and increases crash risk. Using the option implied volatility smirk as a proxy for expected crash risk, Kim and Zhang (2014) show that expected crash risk increases with financial

reporting opacity. In the same vein, DeFond et al. (2015) and Kim and Zhang (2015) show that International Financial Reporting Standards and accounting conservatism increase transparency and reduce crash risk.

Bleck and Liu (2007) offer a related but slightly different explanation for stock price crashes. They argue that the manager has an incentive to keep a bad project as long as possible to derive private benefits from it for longer periods. The manager is also able to do so because he or she can hide the project's poor performance under a historical cost accounting regime. The poor performance of the bad project can thus accumulate and only eventually materialize at its final maturity, resulting in a price crash. More recently, Benmelech et al. (2010) explicitly address the adverse incentives created by stock-based compensation. They argue that the extent of stock-based compensation induces CEOs to willingly drive stock prices up by hiding bad news about their firms' long-term growth. To keep the pretense of high growth, the CEOs overinvest, which eventually leads to undercapitalization and a stock price crash. Consistent with Benmelech et al. (2010), Kim et al. (2011a) show that managerial equity incentives are positively related to crash risk.

A common point of departure of the above traditional corporate finance explanations for stock price crashes is the notion that managers are homo economicus and that there is conflict of interest between managers and outside investors. In other words, these studies assume that managers can make rational and accurate judgments about a firm's intrinsic value and future growth options at any point in time. Because of bad incentives, managers knowingly keep bad projects and hide bad performance to benefit themselves at the expense of shareholders. However,

> A fundamental idea in social psychology is that people do not only want to make money—they also want to feel good about themselves, and it is hard to feel good about oneself if one is knowingly doing something that is potentially ruinous to others. (Barberis 2011, 7)

In addition, the economics and psychology literature suggests that people do not always gather data and form beliefs in an unbiased manner, nor do they always reach accurate inferences and decisions based on a given set of data and beliefs (Baker, Ruback, and Wurgler 2007; Barberis and Thaler 2003; Baker and Wurgler 2012; Nisbett and Ross 1980). Therefore, we argue that traditional agency theory explanations for stock price crashes are likely to be incomplete.

This study seeks to complement prior crash theories by examining an alternative, psychologically-founded explanation for managerial bad news hoarding and stock price crashes. Considerable evidence in the social psychology literature suggests that people have overly positive self-evaluations (i.e., the better-than-average effect), exaggerated perception of control, and unrealistic optimism about the future (for reviews, see Alicke and Govorun 2005; Moore and Healy 2008; Taylor and Brown 1988). This set of interrelated positive illusions is often called overconfidence in the behavioral economics and finance literature.[2] Prior literature has confirmed overconfidence or overoptimism in the thoughts of corporate managers and entrepreneurs (Ben-David, Graham, and Harvey 2010; Camerer and Lovallo 1999). In fact, Graham et al. (2013) find that overconfidence is more prevalent among CEOs than in the general population. This finding is not surprising, given the theoretical result of Goel and Thakor (2008), that overconfident managers are more likely to

2. In the psychology literature, overconfidence sometimes, especially refers to the overestimation of the accuracy of one's belief (i.e., underestimation of variance). However, we argue that this overestimation of accuracy can also be cast within a framework of positive illusions, because it can be seen as an overestimation of one's judgment skills.

be promoted to CEOs than rational managers are. Recent behavioral corporate finance literature links CEO overconfidence to lower investment efficiency (Ben-David et al. 2010; Malmendier and Tate 2005), higher investment in innovation (Galasso and Simcoe 2011; Hirshleifer, Low, and Teoh 2012), more value-destroying mergers (Ferris, Jayaraman, and Sabherwal 2013; Malmendier and Tate 2008; Roll 1986), more optimistic earnings forecasts (Hilary and Hsu 2011; Hribar and Yang 2014), a higher incidence of accounting fraud and lower accounting conservatism (Ahmed and Duellman 2013; Schrand and Zechman 2012), a higher level of short-term debt (Graham et al. 2013), and less use of external finance (Malmendier et al. 2011). Overall, this nascent and fast-growing literature provides useful insights into important corporate phenomena that have been traditionally explained by more established agency theories.

In this study, we posit that CEO overconfidence is positively related to stock price crash risk. It is important to first stress that our hypothesis does not depend on the existence of any rational moral hazard behavior, such as empire building, stealing, or other types of private interest seeking. Instead, we are concerned with situations where the interests of the manager and outside investors are perfectly aligned. Overconfident managers, being highly committed to their investment projects, tend to misperceive ex post negative NPV projects as value creating. As a result, they are more likely to stick to money-losing projects that rational managers would terminate. Keeping negative NPV projects for extended periods in turn leads to asset price crashes. This argument bears some resemblance to the model of Bleck and Liu (2007); however, there is a fundamental difference: In our theory, overconfident managers overestimate the future cash flows of ongoing (negative NPV) projects and simply think that they are acting in the best interest of shareholders by continuing them. In contrast, in the Bleck–Liu model, managers are rational, in the sense that they have unbiased estimates of the projects' intrinsic value and keep the bad projects to derive more private benefits.

The social psychology literature also suggests that overconfident people suffer from the so-called interpretational bias: Negative feedback is more likely to be perceived as inaccurate or uninformative than positive feedback. As a result, negative feedback is often explained away or ignored (Markus 1977; Snyder, Shenkel, and Lowery 1977; Swann and Read 1981). Taylor and Brown (1988) argue that this cognitive bias may be somewhat necessary to maintain overconfidence as a stable psychological trait. In addition, Taylor and Gollwitzer (1995) show that individuals in the post-decisional phase are more vulnerable to interpretational bias (as well as other positive illusions) than those in the pre-decisional phase. In the corporate setting, this means that overconfident CEOs are more likely to ignore negative feedback when they are in the process of operating the selected investment projects than when they are in the stage of choosing between potential projects. This interpretational bias, together with illusions that they can control the situation, hinders overconfident CEOs from rationally updating their beliefs in the face of negative feedback and thus leads them to persevere at negative NPV projects for extended periods.

Finally, interpretational bias and other positive illusions of overconfident CEOs also affect their supply of financial information to the stock market. Since overconfident CEOs tend to (unconsciously) exclude privately observed negative feedback from their minds, they also naturally ignore such information when they communicate with shareholders regarding firm performance. Moreover, to prevent the intervention of impatient investors, they may also consciously shift the reported information in a rosier direction to convince investors that their ongoing projects have a promising future. Thus, CEO overconfidence can lead to bad news hoarding behavior, which increases crash risk. The bad news hoarding behavior here is different from that in the Jin-Myers model, in that overconfident CEOs believe (irrationally) that they are conveying the firm's true performance to investors and are maximizing long-term firm value by doing so. In contrast, the assumption of

the Jin-Myers model is that managers have incentives to capture more cash flows than the necessary compensation for their firm-specific human capital. In fact, Jin and Myers (2006) argue that opaqueness does not increase crash likelihood if the opaque firm is run by a saintly manager who always acts in the shareholders' interest and never takes a dollar more or less than deserved.

3. Data and variable measurement

Data

The sample for our main analysis is based on all CEO firm-years in the ExecuComp database between 1993 and 2010. This database covers S&P 1500 index companies and companies that were once part of the S&P 1500 index. To compute the main CEO overconfidence indicator, we further require that CEO option holdings data be available from ExecuComp. We then delete observations with missing COMPUSTAT accounting data and missing Center for Research in Security Prices stock price, return, and trading volume data in estimating our crash risk measures and control variables. We also remove firms with a year-end share price that is lower than $1. The main sample includes 17,568 firm-year observations. Our second and third CEO overconfidence indicators require additional COMPUSTAT data items. Thus, the number of observations for the regression specifications with the second or third overconfidence measure is reduced to 16,229.

Measuring overconfidence

Our main measure of overconfidence is a stock option-based indicator constructed following the spirit of Malmendier and Tate (2005). This measure uses the timing of option exercises to identify CEO overconfidence. Typically, CEOs are highly exposed to the idiosyncratic risk of their firms because the value of their human capital is intimately linked to firm performance. Thus, it is generally optimal for risk-averse, undiversified CEOs to exercise their own firms' stock options early if the options are sufficiently in the money (Hall and Murphy 2002). However, Malmendier and Tate (2005) find that a subset of CEOs in their data persistently fails to do so. The authors argue that overconfidence induces these CEOs to postpone option exercise because they overestimate the future returns of their investment projects. Moreover, the authors carefully rule out the alternative inside information-based explanation of late exercise by showing that CEOs who hold excessive company stock options do not earn significant abnormal returns over the S&P 500 index.

Malmendier and Tate (2005) define CEOs as overconfident if they hold options at least twice during the sample period that are more than 67 percent in the money. Since we do not have the detailed package-level data of Malmendier and Tate (2005) for our large sample of CEOs, we use a modified version of their overconfidence measure, as developed by Campbell et al. (2011).[3] Specifically, we estimate the average CEO stock option moneyness for each year as follows. First, we compute the realizable value per option as the total realizable value of the exercisable options divided by the total number of exercisable options. Second, we estimate the average exercise price of the options by subtracting the realizable value per option from the stock price at the fiscal year-end. Finally, the average percent moneyness of the options is calculated as the per-option realizable value divided by the estimated average exercise price.

Campbell et al. (2011) argue that the harmful effects of overconfidence are likely driven by the subset of CEOs with relatively high levels of overconfidence. Since our study is

3. Detailed package-level option holdings data became available in ExecuComp after fiscal year 2006. For a smaller sample of firm-years after 2006, we estimate the original measure of Malmendier and Tate (2005) and find that all of our main results hold.

about one potential harmful effect, being classified as an overconfident CEO, we require that the CEOs hold stock options at least twice during our sample period that are more than 100 percent in the money.[4] Following Campbell et al. (2011), our first measure of overconfidence, *OC_CJRS*, takes the value of one beginning with the first time the CEO exhibits the above option-holding behavior and zero otherwise.

The second overconfidence measure we use is the firm-specific score developed by Schrand and Zechman (2012). The idea is that overconfident CEOs are consistently optimistic across different decision contexts because overconfidence is supposed to be a persistent trait. Thus, we can infer the CEO's overconfidence level from their various investing and financing decisions. Specifically, the second overconfidence measure, *OC_SZ*, takes the value of one if the firm meets at least three of the following five criteria and zero otherwise: (i) Excess investment is in the top quartile of firms within industry-years, where excess investment is the residual from a regression of total asset growth on sales growth; (ii) Net acquisitions from the statement of cash flows are in the top quartile of firms within industry-years; (iii) The debt-to-equity ratio is in the top quartile of firms within industry-years, where the debt-to-equity ratio is defined as long-term plus short-term debt divided by total market value; (iv) Either convertible debt or preferred stock is greater than zero; (v) The dividend yield is zero. These criteria are based on prior research that overconfident CEOs are more likely to overinvest, more likely to overpay and to engage in value-destroying acquisitions, more likely to use debt than equity, more likely to use risky debt of longer duration, and less likely to pay dividends. Schrand and Zechman (2012) use the industry median as a benchmark in criteria (i) to (iii), whereas we use the top quartile benchmark to capture high levels of overconfidence.[5] Following Schrand and Zechman (2012), the industry is defined as a three-digit Standard Industrial Classification code.

The Schrand and Zechman (2012) measure is a firm-level measure of overconfidence. Campbell et al. (2011) use a similar CEO-level measure of overconfidence based solely on firm investment decisions. Following the spirit of Campbell et al. we also convert the *OC_SZ* measure into a CEO-level measure. Specifically, our third measure of overconfidence, denoted *OC_MSZ*, takes the value of one beginning with the first time the CEO's firm has an *OC_SZ* score equal to one. All our results are replicated if we use exactly the same investment level-based measure of overconfidence as that of Campbell et al. (2011).

Measuring stock price crash risk

Following Hutton et al. (2009) and Kim et al. (2011a,b), we first estimate the firm-specific weekly returns for each firm and year because we are interested in firm-specific return crashes. Specifically, the firm-specific weekly return, denoted W, is defined as the natural log of one plus the residual return from the expanded index model regression:

$$r_{j\tau} = \alpha_j + \beta_{1j} r_{m(\tau-2)} + \beta_{2j} r_{m(\tau-1)} + \beta_{3j} r_{m\tau} + \beta_{4j} r_{m(\tau+1)} + \beta_{5j} r_{m(\tau+2)} + \beta_{6j} r_{i(\tau-2)} + \beta_{7j} r_{i(\tau-1)} + \beta_{8j} r_{i\tau} + \beta_{9j} r_{i(\tau+1)} + \beta_{10j} r_{i(\tau+2)} + \varepsilon_{j\tau}, \quad (1)$$

where $r_{j\tau}$ is the return on stock j in week τ, $r_{m\tau}$ is the return on the Center for Research in Security Prices value-weighted market index in week τ, and $r_{i\tau}$ is the return on the Fama-French value-weighted industry index in week τ. We include the lead and lag terms for the market and industry indexes to allow for nonsynchronous trading (Dimson 1979). The firm-specific weekly return for firm j in week τ is measured by the natural log of one plus

4. All the empirical results hold if we use the 67 percent threshold. As expected, the results are weaker but remain highly significant.
5. All the results are robust if we use industry median as the benchmark.

the residual return in equation (1), that is, $W_{j\tau} = \ln(1 + \varepsilon_{j\tau})$. To estimate equation (1), we require that at least 26 weekly return observations be available for each firm and year.

We define crash weeks in a given fiscal year for a given firm as those weeks during which the firm experiences firm-specific weekly returns that fall more than 3.2 standard deviations below the mean firm-specific weekly returns over the entire fiscal year, with 3.2 chosen to generate a frequency of 0.1 percent in the normal distribution. Our first measure of crash likelihood for each firm in each year, denoted *CRASH*, is an indicator variable that equals one for a firm-year that experiences one or more crash weeks (as defined above) during the fiscal year and zero otherwise.

Following Chen et al. (2001) and Jin and Myers (2006), our second measure of crash risk is calculated as the negative skewness of firm-specific weekly returns (*NCSKEW*). Specifically, we calculate *NCSKEW* for a given firm in a fiscal year by taking the negative of the third moment of firm-specific weekly returns for each sample year and dividing it by the standard deviation of firm-specific weekly returns raised to the third power.

Following Chen et al. (2001), our third measure is the asymmetric volatility of negative versus positive returns (*DUVOL*). For each firm j over a fiscal year t, we separate all the weeks with firm-specific weekly returns below the annual mean ("down" weeks) from those with firm-specific returns above the annual mean ("up" weeks) and calculate the standard deviation for each of these subsamples separately. The variable *DUVOL* is the log of the ratio of the standard deviation on the down weeks to the standard deviation on the up weeks.

4. Empirical analysis

Descriptive statistics and univariate analysis

Table 1, panel A, reports the descriptive statistics for our main variables. The Appendix provides definitions for all variables. The mean value of *CRASH* is 0.172, suggesting that the unconditional probability of a firm-specific crash over a year is 17.2 percent, based on our definition of a crash event. The average frequency of overconfident CEOs generated by the option-based measure (i.e., *OC_CJRS*) is 35.4 percent, which is almost identical to the 34.1 percent frequency reported by Campbell et al. (2011). The firm-level measure of overconfidence (i.e., *OC_SZ*) generates an average overconfidence frequency of 18.1 percent. However, after we convert the firm-level measure into a CEO-level measure (i.e., *OC_MSZ*), the frequency of overconfident CEOs becomes 35.3 percent, which is almost the same as the frequency generated by the option-based measure.

Panel B of Table 1 presents the univariate analysis on the relation between CEO overconfidence and crash risk. Consistent with our prediction, firms operated by overconfident CEOs have significantly higher crash risk according to all three measures of overconfidence and all three measures of crash risk. Table 2 displays the correlation matrix. As expected, all three measures of crash risk are highly positively correlated. The three measures of overconfidence are also significantly and positively correlated.

Main regression analysis

To formally test our prediction that CEO overconfidence is positively related to stock price crash risk, we use the general regression specification:

$$CrashRisk_{jt} = \beta_0 + \beta_1 OC_{j(t-1)} + \sum\nolimits_{q=2}^{m} \alpha_q (q^{th} ControlVar_{jt-1}) + \varepsilon_{jt}. \quad (2)$$

In equation (2), the dependent variable *CrashRisk*, measured in year t, is one of three crash risk proxies: *CRASH*, *NCSKEW*, and *DUVOL*. In estimating equation (2), we use logit regression when *CRASH* is the dependent variable and ordinary least squares (OLS)

TABLE 1
Descriptive statistics

Panel A: Full-sample statistics

Variables	*N*	Mean	SD	25%	Median	75%
$CRASH_t$	17,568	0.172	0.378	0.000	0.000	0.000
$NCSKEW_t$	17,568	0.068	0.740	−0.329	0.021	0.410
$DUVOL_t$	17,568	0.027	0.345	−0.197	0.012	0.236
OC_CJRS_{t-1}	17,568	0.354	0.478	0.000	0.000	1.000
OC_SZ_{t-1}	16,299	0.181	0.385	0.000	0.000	0.000
OC_MSZ_{t-1}	16,299	0.353	0.478	0.000	0.000	1.000
$DTURNOVER_{t-1}$	17,568	0.007	0.096	−0.019	0.004	0.033
$NCSKEW_{t-1}$	17,568	0.088	0.701	−0.311	0.030	0.410
$SIGMA_{t-1}$	17,568	0.118	0.119	0.051	0.083	0.140
RET_{t-1}	17,568	−1.083	3.106	−0.957	−0.340	−0.126
$SIZE_{t-1}$	17,568	7.251	1.590	6.157	7.090	8.220
MB_{t-1}	17,568	3.822	43.009	1.570	2.384	3.792
LEV_{t-1}	17,568	0.201	0.163	0.045	0.193	0.314
ROA_{t-1}	17,568	0.053	0.137	0.020	0.060	0.104
$INCENTIVE\_STK_{t-1}$	17,568	0.162	0.235	0.018	0.056	0.188
$INCENTIVE\_OPT_{t-1}$	17,568	0.161	0.163	0.048	0.113	0.221
$OPAQUE_{t-1}$	17,568	0.244	0.295	0.094	0.155	0.272

Panel B: Univariate tests of the difference in crash risk between firms with nonoverconfident CEOs and firms with overconfident CEOs

	Nonoverconfident CEO (*N* = 11,347)		Overconfident CEO (*N* = 6,221)	
	Mean	Median	Mean	Median
Overconfidence measure: *OC_CJRS*				
$CRASH_t$	0.163	0.000	0.190***	0.000***
$NCSKEW_t$	0.041	0.008	0.118***	0.046***
$DUVOL_t$	0.015	0.005	0.049***	0.028***
Overconfidence measure: *OC_SZ*				
	Nonoverconfident CEO (*N* = 13,357)		Overconfident CEO (*N* = 2,942)	
	Mean	Median	Mean	Median
$CRASH_t$	0.168	0.000	0.203***	0.000***
$NCSKEW_t$	0.056	0.013	0.128***	0.067***
$DUVOL_t$	0.021	0.008	0.057***	0.034***

(The table is continued on the next page.)

TABLE 1 (continued)

Overconfidence measure: *OC_MSZ*

	Nonoverconfident CEO (N = 13,656)		Overconfident CEO (N = 7,093)	
	Mean	Median	Mean	Median
$CRASH_t$	0.164	0.000	0.193***	0.000***
$NCSKEW_t$	0.049	0.004	0.106***	0.058***
$DUVOL_t$	0.016	0.003	0.047***	0.032***

Notes:

This table reports the descriptive statistics for stock price crash risk measures, CEO overconfidence measures, and control variables. The sample period is from 1993 to 2010. All variables are defined in the Appendix. Panel A reports the statistics of the full sample. Panel B presents univariate comparisons of crash risk between firms with overconfident CEOs and firms with nonoverconfident CEOs. In panel B, *t*-tests (Wilcoxon-Mann-Whitney tests) are conducted to test for differences in means (medians). Here *** indicates significance at the 1 percent level.

when either *NCSKEW* or *DUVOL* is the dependent variable. All the independent variables are measured in year $t - 1$. The key variable of interest, *OC*, is one of the three proxies for CEO overconfidence (i.e., *OC_CJRS*, *OC_SZ*, and *OC_MSZ*).

Following prior research on crash risk (Chen et al. 2001; Hutton et al. 2009; Kim et al. 2011a,b), we include a set of control variables in the regression model. Hong and Stein (2003) show that investor belief heterogeneity predicts future crash likelihood. To control for this effect, we include the detrended stock trading volume (*DTURNOVER*) in the regression, which is a proxy for differences of opinions between investors (Chen et al. 2001). To capture the potential persistence of the third moment of stock returns, we control for the negative skewness of past firm-specific stock returns (*NCSKEW*). Since more volatile stocks are potentially more crash prone, we control for past return volatility (*SIGMA*). In addition, to the extent that our option-based measure of overconfidence (*OC_CJRS*) may also reflect CEO risk attitudes (Malmendier and Tate 2005), *SIGMA* should help us to rule out the alternative explanation that any documented empirical relation between *OC_CJRS* and crash risk is caused by CEO risk-taking behaviors.

However, we want to stress that even if the risk tolerance attribute confounds our results to some extent, it does not overturn the key insight of the paper, that CEO personal attributes matter for crash risk (Hirshleifer et al. 2012). Moreover, one manifestation of overconfidence is greater risk tolerance (Baker and Wurgler 2012), which means that controlling for volatility makes our test more stringent. Malmendier et al. (2011) argue that it is important to control for past return performance when using *OC_CJRS* as a proxy for overconfidence because *OC_CJRS* may mix information about CEO beliefs with information about firm performance. Thus, we also include past return performance in our regression (*RET*).[6] Following Chen et al. (2001) and Hutton et al. (2009), we also control the following firm characteristics: firm size (*SIZE*), the market-to-book ratio (*MB*), financial leverage (*LEV*), and return on assets (*ROA*). Finally, Hutton et al. (2009) find that financial reporting opacity has a nonlinear effect on crash risk. Thus, we also include

6. Following prior research, past return performance is estimated over the past fiscal year. However, our results are the same if we expand the past return measurement window to the past three or five years. Note that controlling for past returns (as well as *ROA* and *MB*) make our test more stringent, since the CEO may become overconfident as a consequence of experiencing strong past performance.

TABLE 2
Correlations

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
$CRASH_t$	A	1.00																
$NCSKEW_t$	B	**0.63**	1.00															
$DUVOL_t$	C	**0.56**	**0.96**	1.00														
OC_CJRS_{t-1}	D	**0.03**	**0.05**	**0.05**	1.00													
OC_SZ_{t-1}	E	**0.04**	**0.04**	**0.04**	**0.06**	1.00												
OC_MSZ_{t-1}	F	**0.04**	**0.04**	**0.04**	**0.15**	**0.64**	1.00											
$DTURNOVER_{t-1}$	G	**0.03**	**0.03**	**0.03**	**0.02**	**0.03**	0.01	1.00										
$NCSKEW_{t-1}$	H	**0.03**	**0.05**	**0.05**	**0.04**	**0.04**	**0.04**	**0.05**	1.00									
$SIGMA_{t-1}$	I	**0.09**	**0.16**	**0.17**	**0.02**	**0.09**	**0.09**	**0.08**	**0.25**	1.00								
RET_{t-1}	J	**−0.07**	**−0.11**	**−0.12**	0.00	**−0.06**	**−0.05**	**−0.03**	**−0.19**	**−0.65**	1.00							
$SIZE_{t-1}$	K	**−0.03**	**0.02**	**0.03**	**0.11**	0.01	**0.06**	**0.06**	**−0.03**	**−0.20**	**0.13**	1.00						
MB_{t-1}	L	0.00	0.00	0.00	**0.02**	**0.02**	0.01	0.00	−0.01	0.00	0.00	**0.02**	1.00					
LEV_{t-1}	M	**−0.02**	−0.01	0.00	**−0.08**	**0.31**	**0.31**	**0.05**	0.00	**0.09**	**−0.04**	**0.05**	**0.03**	1.00				
ROA_{t-1}	N	0.00	**0.02**	**0.02**	**0.11**	**−0.08**	**−0.08**	**0.09**	**−0.03**	**−0.18**	**0.11**	**0.23**	0.00	**−0.15**	1.00			
$INCENTIVE\_STK_{t-1}$	O	0.00	0.01	0.01	**0.14**	−0.01	**0.03**	0.00	−0.01	**−0.06**	**0.04**	**0.14**	0.01	**−0.13**	**0.14**	1.00		
$INCENTIVE\_OPT_{t-1}$	P	**0.02**	**0.03**	**0.03**	**0.29**	**0.06**	**0.14**	**0.02**	0.01	**−0.06**	**0.03**	**0.47**	**0.03**	**−0.05**	**0.10**	**0.21**	1.00	
$OPAQUE_{t-1}$	Q	**0.04**	**0.03**	**0.03**	**0.05**	**0.07**	**0.04**	**−0.05**	**0.04**	**0.13**	**−0.08**	**−0.07**	0.01	**−0.11**	**−0.16**	**0.03**	**0.08**	1.00

Notes:

This table presents the correlation of the main variables. The sample period is from 1993 to 2010. All variables are defined in Appendix. The values in bold are significant at better than the 5 percent level.

their financial reporting opacity measure (*OPAQUE*) and its squared term as additional control variables. In all regressions, we also include industry and fiscal year indicators to control for industry and time fixed effects.

It is important to distinguish our theory from traditional agency theory explanations for stock price crashes (Baker and Wurgler 2012). Thus, following most of the empirical research on overconfidence, we also control for the potential conflict of interest between managers and shareholders. In particular, we calculate and include the strength of CEO stock incentives (*INCENTIVE_STK*) and option incentives (*INCENTIVE_OPT*) following the methodology of Bergstresser and Philippon (2006). Benmelech et al. (2010) argue that equity incentives induce CEOs to hide bad firm performance and lead to future crashes. Kim et al. (2011a) show that executive option incentives are stronger than stock incentives in inducing bad news hoarding. Our main measure of overconfidence, *OC_CJRS*, is also derived from CEO option holdings data and thus is naturally correlated with the option incentive measure. However, it is important to note that these two measures capture sufficiently different things: *INCENTIVE_OPT* is a firm–year measure that captures the features of a firm's incentive system over the fiscal year, whereas *OC_CJRS* is a CEO fixed effect measure that captures the CEO's persistent overconfidence trait.[7]

Table 3 reports the regression results. The *t*-statistics below the coefficients are based on standard errors corrected for firm and year double clustering (Petersen 2009; Thompson 2011). Columns (1) to (3) of Table 3 present the results of the logit model regressions with *CRASH* as the dependent variable. As shown in column (1), when *OC_CJRS* is used as our test variable, the coefficient of *OC_CJRS* is positive and significant, consistent with our prediction that firms with overconfident CEOs have higher crash risk. In columns (2) and (3), the overconfidence proxies *OC_SZ* and *OC_MSZ* are based on multiple CEO–firm overconfident behaviors regarding various investing and financing decisions.[8] Consistent with the results in column (1), we find that the coefficients of both *OC_SZ* and *OC_MSZ* are significantly positive, supporting our prediction. To assess the economic significance of the results, we estimate the marginal effect of each overconfidence variable on crash risk, which is the expected difference in crash likelihood between firms with and without highly overconfident CEOs holding all other variables at their sample mean. The marginal effects range from 1.4 percent to 2.3 percent. Given that the unconditional probability of a crash in our sample is 17.2 percent, these results suggest that the association between CEO overconfidence and crash risk is economically significant.

Columns (4) to (9) of Table 3 report the results of OLS regressions with *NCSKEW* and *DUVOL* as the dependent variables, respectively. The coefficients of the overconfidence proxies continue to be positive and are significant, consistent with our prediction. Overall, the results in Table 3 support our prediction that CEO overconfidence is positively associated with future crash risk. The main analysis in Table 3 uses a one-year window to estimate future firm-specific stock price crash risk. Following Kim et al. (2011b), we also calculate the three crash risk measures using firm-specific weekly returns over the future two- and three-year periods and find that the relation between CEO overconfidence and future crash risk continues to be positive and significant.

7. The results are qualitatively similar if we include both CEO and CFO equity incentives as control variables.
8. We also use each individual component of *OC_SZ* and *OC_MSZ* as a proxy for overconfidence. Untabulated results show that excess investment-, net acquisition-, and dividend yield-based measures are significantly and positively related to future crash risk, whereas the two capital structure-based proxies are not significantly related to future crash risk. Consistent with Kim, Luo, and Xie (2014), we find that firms that do not pay dividend have higher crash risk.

TABLE 3
The impact of CEO overconfidence on crash risk

Dependent variable	$CRASH_t$			$NCSKEW_t$			$DUVOL_t$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CEO Overconfidence									
OC_CJRS_{t-1}	0.103*			0.049***			0.022***		
	(1.92)			(4.37)			(4.17)		
OC_SZ_{t-1}		0.162***			0.045**			0.023***	
		(3.02)			(2.50)			(2.64)	
OC_MSZ_{t-1}			0.144***			0.033***			0.019***
			(3.62)			(3.17)			(3.99)
Control variables									
$DTURNOVER_{t-1}$	0.315**	0.326*	0.340*	0.082	0.080	0.084	0.025	0.024	0.026
	(2.41)	(1.88)	(1.95)	(1.05)	(0.86)	(0.91)	(0.65)	(0.53)	(0.57)
$NCSKEW_{t-1}$	0.014	0.018	0.018	0.004	0.005	0.005	0.002	0.002	0.002
	(0.61)	(0.72)	(0.70)	(0.43)	(0.51)	(0.51)	(0.49)	(0.43)	(0.43)
$SIGMA_{t-1}$	1.412***	1.423***	1.407***	0.901***	0.926***	0.922***	0.466***	0.477***	0.474***
	(8.35)	(8.98)	(8.89)	(9.68)	(10.27)	(10.35)	(9.73)	(10.28)	(10.34)
RET_{t-1}	−0.007***	−0.006***	−0.007***	−0.004***	−0.004***	−0.004***	−0.002***	−0.002***	−0.002***
	(−4.13)	(−3.47)	(−3.53)	(−2.94)	(−2.85)	(−2.89)	(−3.13)	(−3.35)	(−3.42)
$SIZE_{t-1}$	−0.025	−0.019	−0.021	0.024***	0.026***	0.026***	0.013***	0.015***	0.014***
	(−1.02)	(−0.73)	(−0.78)	(3.31)	(3.71)	(3.65)	(3.55)	(3.89)	(3.84)
MB_{t-1}	−0.000	−0.000	−0.000	−0.000**	−0.000	−0.000	−0.000***	−0.000**	−0.000**
	(−1.02)	(−1.06)	(−1.04)	(−2.14)	(−1.57)	(−1.42)	(−3.13)	(−2.43)	(−2.21)
LEV_{t-1}	0.000	−0.162	−0.168	−0.027	−0.078*	−0.073	−0.005	−0.031	−0.031
	(0.00)	(−1.24)	(−1.28)	(−0.64)	(−1.81)	(−1.63)	(−0.28)	(−1.49)	(−1.46)
ROA_{t-1}	0.302	0.338	0.351	0.174*	0.199*	0.200*	0.104**	0.118**	0.119**
	(1.05)	(1.02)	(1.04)	(1.86)	(1.91)	(1.91)	(2.33)	(2.35)	(2.35)
$INCENTIVE\_STK_{t-1}$	0.078	0.047	0.035	−0.005	−0.008	−0.010	0.000	−0.004	−0.006
	(0.85)	(0.51)	(0.38)	(−0.20)	(−0.34)	(−0.44)	(0.02)	(−0.38)	(−0.52)

(The table is continued on the next page.)

TABLE 3 (continued)

Dependent variable	$CRASH_t$			$NCSKEW_t$			$DUVOL_t$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$INCENTIVE\_OPT_{t-1}$	0.042	0.109	0.088	−0.027	0.002	−0.002	−0.023	−0.013	−0.016
	(0.32)	(0.80)	(0.67)	(−0.50)	(0.03)	(−0.04)	(−0.87)	(−0.45)	(−0.55)
$OPAQUE_{t-1}$	0.447***	0.403***	0.413***	0.093**	0.072	0.076*	0.039**	0.029	0.030*
	(3.34)	(3.01)	(3.15)	(2.20)	(1.63)	(1.74)	(2.21)	(1.55)	(1.65)
$OPAQUE_{t-1} \times$	−0.176***	−0.164***	−0.165***	−0.030**	−0.023*	−0.023**	−0.010**	−0.006	−0.007*
$OPAQUE_{t-1}$	(−2.81)	(−3.41)	(−3.58)	(−2.30)	(−1.90)	(−2.05)	(−2.20)	(−1.53)	(−1.66)
Constant	−1.764***	−1.830***	−1.854***	−0.053	−0.566	−0.569	−0.058*	−0.171	−0.172
	(−5.35)	(−8.13)	(−8.31)	(−0.73)	(−1.13)	(−1.14)	(−1.72)	(−1.30)	(−1.29)
Observations	17,513	16,254	16,254	17,568	16,299	16,299	17,568	16,299	16,299
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo-R^2/adjusted R^2	0.027	0.026	0.026	0.043	0.044	0.044	0.051	0.053	0.053

Notes:

This table reports the regression results of the impact of CEO overconfidence on crash risk. The sample contains firms in ExecuComp from 1993 to 2010 with nonmissing values for the CEO overconfidence measures and all control variables. All variables are defined in the Appendix. The *Z*-statistics (*t*-statistics) reported in parentheses are based on standard errors clustered by both firm and time. Here ***, **, and * indicate statistical significance at the 1 percent, 5 percent and 10 percent levels, respectively.

Endogeneity

One concern for our empirical findings is reverse causality. One may argue, for some reason, that more crash-prone firms are more likely to hire overconfident CEOs. In our regressions, the independent variables are lagged by one year relative to the crash risk measures. We also control for lagged crash risk ($NCSKEW_{t\text{-}1}$) in the regression, partially addressing the reverse causality issue. Importantly, because crashes are rare events, it is unlikely that a firm can accurately estimate its crash risk and choose an overconfident CEO to reduce it. Overconfident managers may self-select (or be selected) into companies with high growth or business risk (e.g., Graham et al. 2013) and high-growth (risk) firms may have higher crash risk than low-growth firms. This overconfidence–growth matching issue is addressed by including control variables of growth and risk (market-to-book, return volatility). We also use past sales growth and earnings growth as additional control variables and find similar results.[9] In addition, following Hirshleifer et al. (2012), we reexamine the effects of overconfidence after eliminating firm-years in which the manager is new (with less than a three- or five-year tenure). Because the matching effects between CEO overconfidence and firm characteristics are strongest when the CEO is first appointed, removing firm-years with short-tenure CEOs should help us further rule out the alternative explanations of endogenous matching. The results are almost identical to previous findings.

Our measures of overconfidence can capture decisions undertaken by previous CEOs. For instance, capital structure and dividend policies are generally very sticky and the observed levels of these proxies during the current CEO's tenure can be due to the decisions of previous CEOs. One comfortable result is that our main results based on *OC_SZ* (*OC_MSZ*) are mainly driven by the proxy's investment-related components, which are arguably less sticky than capital structure and dividend policies. Moreover, removing CEOs with short tenure can also help address the policy stickiness issue.

To further address the above concerns of endogeneity, we next conduct a change analysis. Specifically, we examine whether changes in overconfidence following CEO turnovers are positively related to changes in stock price crash risk. Toward this end, we use the two CEO-level measures of overconfidence, which are theoretically more appropriate and powerful in the CEO turnover tests.[10] In our sample period of 1993 to 2010, we identify 3,323 (3,238) CEO changes with nonmissing data on *OC_CJRS* (*OC_MSZ*). We require the outgoing CEO to have been in office for at least three years prior to the CEO change and the incoming CEO to have remained in office for at least three years subsequent to the CEO change. We lose a total of 1,657 (1,607) CEO changes for the *OC_CJRS* (*OC_MSZ*) measure due to this requirement. For each CEO turnover case, we next estimate crash risk measures over the three-year window before the turnover and the same measures over the three-year window after the turnover.[11] In this process, we lose 774 (745) CEO changes for the *OC_CJRS* (*OC_MSZ*) sample. Lastly, we require nonmissing data for the control variables in the first year after the CEO change and three years before the CEO change and thus lose 227 (221) CEO changes for the *OC_CJRS* (*OC_MSZ*) sample. The final sample consists of 655 (655) CEO changes for the *OC_CJRS* (*OC_MSZ*) sample.

9. The results are also robust to controlling for additional variables, including CEO compensation vega, firm location fixed effects, and the number of business/geographic segments.
10. For example, using the firm-level measure in the CEO turnover design entails the problem of firm policy stickiness. In fact, we do not find a significant result when using the firm-level measure in the change analysis.
11. We measure crash risk using a three-year window to allow sufficient time for bad news or bad performance to materialize under the current CEO's leadership.

We estimate a change specification of equation (2) using the two samples (based on the two measures of overconfidence) of CEO changes and report the results in Table 4. Columns (1) and (2) of Table 4 show that changes in CEO overconfidence are not significantly related to future crash risk in regressions where $\Delta CRASH$ is the dependent variable. In contrast, for both measures of CEO overconfidence, columns (3) to (6) show that changes in CEO overconfidence are significantly and positively related to future crash risk when we use the continuous crash risk measures (i.e., $\Delta NCSKEW$ and $\Delta DUVOL$). The insignificant results in columns (1) and (2) are likely to be due to the lack of variation in within-firm changes of the indicator variable *CRASH*, which are, by definition, outlier events. Overall, the results in Table 4 suggest that changes in overconfidence following CEO turnovers are positively related to changes in stock price crash risk, further alleviating the variety of concerns about endogeneity or self-selection.

5. Cross-sectional analysis

In this section, we conduct several cross-sectional analyses. Baker and Wurgler (2012) argue that for less than fully rational managers to have an impact, corporate governance must be limited in its ability to constrain them into making rational decisions. This argument suggests that corporate governance mechanisms that are designed to solve traditional agency problems can also help constrain overconfident managers.[12]

CEO dominance and governance

Sah and Stiglitz (1986, 1991) argue that the architecture of an economic system or organization affects the judgment errors made by individuals within the system or organization, as well as how those errors are aggregated. This is because the members in the system or organization may disagree, creating the so-called diversification of opinions effect. The social psychology literature on group decision making draws similar conclusions (Kogan and Wallach 1966). This section examines whether the relation between CEO overconfidence and crash risk is affected by CEO dominance within the top management team. Following Bebchuk, Cremers, and Peyer (2011), we use the CPS to capture the CEO's centrality or dominance within the top management team. Specifically, the CPS is the fraction of the aggregate compensation of the top-five executive team captured by the CEO. According to the findings of Bebchuk et al. (2011) and Chen, Huang, and Wei (2013), the CPS can also be seen as a proxy of "bad governance" or CEO entrenchment, in that CEO behaviors (both rational opportunistic and irrational optimistic behaviors) are less constrained in firms with a higher CPS.[13]

Table 5 presents the subsample analysis for firms with dominant (above-median CPS) and nondominant (below-median CPS) CEOs.[14] Consistent with our prediction, the impact of CEO overconfidence on crash risk is generally more pronounced for firms with

12. We are not trying to differentiate the traditional agency problem from overconfidence using these tests.
13. The CPS can also be installed by the board as a mechanism to encourage risk taking (i.e., tournament theory). Overconfident managers, who are more risk tolerant, are more likely to become CEOs when a firm has a larger CPS. Thus, the CPS can be correlated with both CEO overconfidence and crash risk. In untabulated robustness tests, we find that the impact of overconfidence on crash risk continues to be positive and significant after controlling for the CPS. Moreover, we find no evidence that the subsample of firms with a high CPS have more overconfident CEOs.
14. Throughout this section, we conduct cross-sectional analysis using subsamples instead of interaction terms because subsample analysis allows all coefficients (including coefficients of fixed effects) to vary, conditioning on the partitioning variable. We test the equality of the regression coefficients between the two subsamples using seemingly unrelated estimations. Using interaction terms with continuous variables, we find qualitatively similar results. We also split samples using tertiles or quartiles and the results are again qualitatively similar to those based on median cuts.

TABLE 4
Change analysis

Dependent variable	*ΔCRASH*		*ΔNCSKEW*		*ΔDUVOL*	
	(1)	(2)	(3)	(4)	(5)	(6)
CEO overconfidence						
Δ*OC_CJRS*	−0.116		0.135**		0.044**	
	(−0.77)		(2.57)		(2.48)	
Δ*OC_MSZ*		0.169		0.131*		0.041*
		(1.34)		(1.70)		(1.70)
Control variables						
ΔDTURNOVER	−0.116	0.169	−0.923**	−0.762*	−0.249**	−0.211*
	(−0.77)	(1.34)	(−2.25)	(−1.75)	(−2.32)	(−1.89)
ΔLNCSKEW	−2.025**	−1.897**	−0.291***	−0.288***	−0.099***	−0.099***
	(−2.17)	(−2.02)	(−5.79)	(−5.42)	(−5.77)	(−5.43)
ΔSIGMA	−0.063	−0.048	0.592	0.324	0.265	0.310
	(−0.50)	(−0.37)	(0.64)	(0.44)	(1.13)	(1.31)
ΔRET	−0.108	0.124	−0.023***	−0.044	−0.003	−0.003
	(−0.11)	(0.15)	(−2.72)	(−0.64)	(−1.31)	(−1.00)
ΔSIZE	0.016	0.022	0.319***	0.305***	0.113***	0.112***
	(0.58)	(0.87)	(6.27)	(5.61)	(5.97)	(6.21)
ΔMB	0.137	0.165	0.020**	0.022***	0.007**	0.008**
	(1.05)	(1.28)	(2.47)	(2.78)	(2.26)	(2.47)
ΔLEV	−0.029	−0.026	0.098	0.138	0.097	0.092
	(−1.07)	(−0.94)	(0.18)	(0.24)	(0.58)	(0.54)
ΔROA	0.077	−0.038	0.429	0.484	0.170	0.144
	(0.10)	(−0.05)	(0.68)	(0.79)	(0.72)	(0.63)
ΔINCENTIVE_STK	0.035	−0.096	−0.277	−0.317	−0.161	−0.177
	(0.04)	(−0.12)	(−0.57)	(−0.65)	(−1.06)	(−1.19)
ΔINCENTIVE_OPT	−0.589	−0.566	−0.256	−0.082	−0.077	−0.026
	(−0.99)	(−0.94)	(−0.91)	(−0.29)	(−0.74)	(−0.26)
ΔOPAQUE	1.385	1.361	0.025	−0.005	−0.018	−0.022
	(1.35)	(1.40)	(0.19)	(−0.04)	(−0.34)	(−0.47)
ΔOPAQUE × *ΔOPAQUE*	0.251	0.252	0.020	0.007	−0.002	−0.002
	(1.05)	(1.09)	(0.48)	(0.17)	(−0.12)	(−0.11)
Constant	−1.611***	−0.860***	0.296	−0.060	0.045	−0.032
	(−2.97)	(−2.80)	(1.00)	(−0.65)	(0.49)	(−0.74)
Observations	653	655	665	665	665	665
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo-/adjusted R^2	0.067	0.063	0.105	0.106	0.117	0.117

Notes:

This table reports the results of the impact of changes in overconfidence associated with CEO turnovers on changes in crash risk. In our sample period from 1993 to 2010, we identify 665 firms that experience a change in CEOs where the outgoing CEO has been in office for at least three years and the incoming CEO remains in office for at least three years. We subtract the value of the crash risk proxies measured over the three-year window prior to the CEO turnover from the value of the same proxies measured over the three-year window subsequent to the CEO turnover. For the control variables, we take their values measured at the beginning of the first year during the incoming CEO's term and subtract the values three years before the CEO change. All variables are defined in the Appendix. The *Z*-statistics (*t*-statistics) reported in parentheses are based on standard errors clustered by both firm and time. Here ***, **, and * indicate statistical significance at the 1 percent, 5 percent and 10 percent levels, respectively.

dominant CEOs than those with nondominant CEOs. The CEO dominance results support the conjecture that corporate governance has a moderating effect on the relation between overconfidence and crash risk. To further examine the governance effect, we also analyze subsamples partitioned by the G-Index of Gompers, Ishii, and Metrick (2003) and the percentage of outside directors. Consistent with the findings of Ahmed and Duellman (2013) and Schrand and Zechman (2012), we find no meaningful moderating effects for these governance variables.

The effect of conditional conservatism

Prior research argues that accounting conservatism constrains managers' ability to hide bad news and accelerate good news recognition in audited financial reports and voluntary disclosures (Kothari et al. 2009; Watts 2003). Kim and Zhang (2015) find evidence that conditional conservatism in financial reporting lowers the likelihood of a firm's future stock price crashes. In this section, we examine whether conditional conservatism can limit overconfident CEOs' tendency to withhold bad news and mitigate the impact of CEO overconfidence on stock price crashes. Table 6 presents the subsample analysis for firms with above-median conservatism levels and below-median conservatism levels. We measure conditional conservatism using the conservatism ratio of Callen, Segal, and Hope (2010).[15] Consistent with our prediction, the impact of CEO overconfidence on crash risk is more pronounced for firms with less conservative accounting policies than for firms with more conservative accounting policies. The results suggest that conditional conservatism, designed as a governance mechanism to discipline managerial opportunistic behaviors, also helps to mitigate the adverse effect of overconfidence.

Differences of opinion among investors

Hong and Stein (2003) show that investor heterogeneity is a central contributor to stock price crashes. In this section, we examine whether the effect of overconfidence is exacerbated by investor heterogeneity. We conjecture that, when differences of opinion among investors are greater, overconfident CEOs should have less pressure to address the concerns of bearish investors. The argument is logically similar to the diversification of opinion effect of Sah and Stiglitz (1986, 1991), in that when the investors themselves disagree, overconfident CEOs are less constrained or they perceive themselves to be less constrained. To conduct the subsample analysis, we use analyst forecast dispersion as a proxy for differences of opinion among investors. The results in Table 7 show that the effect of overconfidence on crash risk is generally more pronounced for the subsample of firms with higher levels of differences of opinions among investors, consistent with our conjecture.[16]

6. Robustness checks and discussions

Discussions on the option-based measure

Our main measure of overconfidence captures a manager's propensity to delay the exercise of in-the-money options. Voluntarily holding in-the-money options, however, may also be consistent with other interpretations, involving, for example, inside information and risk tolerance. In this section, we discuss these interpretations and their impact on the inferences drawn from our empirical results.

15. Please refer to Callen et al. (2010) for detailed procedures for constructing the conservatism ratio. Following Callen et al. we restrict the sample to observations with negative unexpected returns because conservatism is likely to be manifested when news is bad. To increase the sample size, we retain a firm in our sample if the firm experiences at least one negative shock during the past three years. The results are qualitatively similar if we use the Basu (1997) measure of conservatism.
16. The results are qualitatively similar if we use the breadth of ownership as the proxy for differences of opinion.

TABLE 5
Subsample analyses: Cut on CEO dominance

	OC_CJRS_{t-1}		OC_SZ_{t-1}		OC_MSZ_{t-1}	
	Low CPS (1)	High CPS (2)	Low CPS (3)	High CPS (4)	Low CPS (5)	High CPS (6)
Panel A: Logistic regression of $CRASH_t$ on CEO overconfidence						
CEO overconfidence	0.056	0.217**	−0.112	0.282***	0.035	0.120
	(0.50)	(2.25)	(−0.94)	(2.75)	(0.38)	(1.26)
Observations	4,825	4,841	4,518	4,517	4,518	4,517
Pseudo-R^2	0.035	0.044	0.036	0.046	0.035	0.064
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 1.80 (p-value = 0.180)		Chi-square = 5.60 (p-value = 0.018)		Chi-square = 0.40 (p-value = 0.528)	
Panel B: OLS regression $NCSKEW_t$ on CEO overconfidence						
CEO overconfidence	0.014	0.077***	0.036	0.075**	0.027	0.037*
	(0.59)	(3.35)	(1.42)	(2.47)	(1.24)	(1.64)
Observations	4,902	4,902	4,587	4,578	4,587	4,578
Adjusted R^2	0.042	0.043	0.044	0.044	0.044	0.045
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 3.50 (p-value = 0.061)		Chi-square = 0.78 (p-value = 0.377)		Chi-square = 0.02 (p-value = 0.884)	
Panel C: OLS regression of $DUVOL_t$ on CEO overconfidence						
CEO overconfidence	−0.001	0.033***	0.015	0.037***	0.013	0.018*
	(−0.05)	(3.32)	(1.02)	(2.65)	(1.29)	(1.78)
Observations	4,902	4,902	4,587	4,578	4,587	4,578
Adjusted R^2	0.048	0.053	0.050	0.054	0.050	0.053
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 4.95 (p-value = 0.026)		Chi-square = 1.16 (p-value = 0.281)		Chi-square = 0.08 (p-value = 0.775)	
Control variables	Included	Included	Included	Included	Included	Included
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Percent overconfident CEOs	33.8	37.9	16.8	17.6	33.6	36.7

Notes:

This table reports the results of the subsample analyses of the impact of CEO dominance on the relation between CEO overconfidence and crash risk. The sample period is from 1993 to 2010. We measure CEO dominance as the ratio of CEO compensation over the aggregate compensation of the top-five executive team in a firm-year (CPS). The total compensation of each top five executive is the ExecuComp data item TDC1. A low CPS indicates below-median CEO dominance and a high CPS indicates above-median CEO dominance. We conduct seemingly unrelated estimation to test the equality of the regression coefficients between the two subsamples (chi-squares and p-values are reported). All other variables are defined in the Appendix. The Z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time. Here ***, **, and * indicate statistical significance at the 1 percent, 5 percent and 10 percent levels, respectively.

TABLE 6
Subsample analyses: Cut on accounting conservatism

	OC_CJRS_{t-1}		OC_SZ_{t-1}		OC_MSZ_{t-1}	
	Low CC (1)	High CC (2)	Low CC (3)	High CC (4)	Low CC (5)	High CC (6)
Panel A: Logistic regression of $CRASH_t$ on CEO overconfidence						
CEO overconfidence	0.356***	0.060	0.178*	0.193*	0.312***	0.033
	(2.99)	(0.58)	(1.86)	(1.65)	(4.06)	(0.38)
Observations	4,214	4,242	3,933	3,964	3,995	4,003
Pseudo-R^2	0.039	0.039	0.036	0.041	0.038	0.041
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 3.69 (p-value = 0.055)		Chi-square = 0.05 (p-value = 0.828)		Chi-square = 3.46 (p-value = 0.063)	
Panel B: OLS regression $NCSKEW_t$ on CEO overconfidence						
CEO overconfidence	0.085***	0.013	0.046	0.034	0.072***	0.007
	(2.60)	(0.46)	(1.27)	(1.03)	(3.56)	(0.25)
Observations	4,280	4,281	3,995	4,003	3,995	4,003
Adjusted R^2	0.038	0.048	0.029	0.048	0.030	0.047
Percent overconfident CEOs	33.6	29.4	17.5	18.4	35.1	35.2
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 3.63 (p-value = 0.057)		Chi-square = 0.06 (p-value = 0.806)		Chi-square = 2.85 (p-value = 0.092)	
Panel C: OLS regression of $DUVOL_t$ on CEO overconfidence						
CEO overconfidence	0.035**	0.010	0.023	0.016	0.035***	0.009
	(2.42)	(0.73)	(1.27)	(1.02)	(3.42)	(0.72)
Observations	4,280	4,281	3,995	4,003	3,995	4,003
Adjusted R^2	0.038	0.058	0.034	0.057	0.036	0.057
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 2.19 (p-value = 0.139)		Chi-square = 0.08 (p-value = 0.776)		Chi-square = 2.05 (p-value = 0.152)	
Control variables	Included	Included	Included	Included	Included	Included
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Percent overconfident CEOs	33.6	29.4	17.5	18.4	35.1	35.2

Notes:

This table reports the results of the subsample analyses of the impact of conditional conservatism on the relation between CEO overconfidence and crash risk. The sample period is from 1993 to 2010. We measure conditional conservatism (CC) using the average of Callen et al. (2010) firm year conservatism measure for bad news during the past three years. A low CC indicates a below-median level of conditional conservatism and a high CC indicates an above median level of conditional conservatism. We conduct seemingly unrelated estimation to test the equality of the regression coefficients between the two subsamples (chi-squares and p-values are reported). All other variables are defined in the Appendix. The Z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time. Here ***, **, and * indicate statistical significance at the 1 percent, 5 percent and 10 percent levels, respectively.

TABLE 7
Subsample analyses: Cut on analyst forecast dispersion

	OC_CJRS_{t-1}		OC_SZ_{t-1}		OC_MSZ_{t-1}	
	Low dispersion (1)	High dispersion (2)	Low dispersion (3)	High dispersion (4)	Low dispersion (5)	High dispersion (6)
Panel A: Logistic regression of $CRASH_t$ on CEO overconfidence						
CEO overconfidence	0.035	0.172**	0.126	0.208**	0.135**	0.209***
	(0.52)	(2.16)	(1.38)	(2.22)	(2.53)	(2.68)
Observations	7,546	7,550	7,200	7,212	7,200	7,212
Pseudo-R^2	0.027	0.030	0.028	0.029	0.028	0.029
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 2.10 (p-value = 0.148)		Chi-square = 0.49 (p-value = 0.484)		Chi-square = 0.55 (p-value = 0.460)	
Panel B: OLS regression $NCSKEW_t$ on CEO overconfidence						
CEO overconfidence	0.013	0.070***	0.027	0.056**	0.023	0.048***
	(1.11)	(3.85)	(0.95)	(2.52)	(1.62)	(2.94)
Observations	7,595	7,594	7,248	7,247	7,248	7,247
Adjusted R^2	0.029	0.040	0.032	0.040	0.032	0.041
Percent overconfident CEOs	42.3	31.5	16.2	19.5	33.1	37.3
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 4.32 (p-value = 0.038)		Chi-square = 0.62 (p-value = 0.431)		Chi-square = 0.80 (p-value = 0.381)	
Panel C: OLS regression of $DUVOL_t$ on CEO overconfidence						
CEO overconfidence	0.005	0.029***	0.015	0.026**	0.013**	0.025***
	(0.77)	(3.92)	(1.22)	(2.35)	(1.96)	(3.35)
Observations	7,595	7,594	7,248	7,247	7,248	7,247
Adjusted R^2	0.036	0.046	0.040	0.048	0.041	0.049
Subsample comparison of coefficients on CEO overconfidence	Chi-square = 3.73 (p-value = 0.053)		Chi-square = 0.44 (p-value = 0.509)		Chi-square = 0.77 (p-value = 0.380)	
Control variables	Included	Included	Included	Included	Included	Included
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Percent overconfident CEOs	42.3	31.5	16.2	19.5	33.1	37.3

Notes:

This table reports the results of the subsample analyses of the impact of analyst forecast dispersion on the relation between CEO overconfidence and crash risk. The sample period is from 1993 to 2010. We measure analyst forecast dispersion using the standard deviation of analyst forecasts on the annual earnings of the past year. Low dispersion indicates a below-median level of forecast dispersion and high dispersion indicates an above median level of forecast dispersion. We conduct seemingly unrelated estimation to test the equality of the regression coefficients between the two subsamples (chi-squares and p-values are reported). All other variables are defined in the Appendix. The Z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time. Here *** and ** indicate statistical significance at the 1 percent and 5 percent levels, respectively.

Past performance and tax

The option-based measure of overconfidence depends on option moneyness. Since stock options are normally granted with exercise prices equal to the stock prices on the grant dates, the moneyness threshold for the option-based measure (e.g., 100 percent in the money) is more likely to be crossed if a firm experiences strong stock performance since the grant dates. Therefore the option-based measure can reflect both a manager's tendency to delay option exercise and the firm's past stock performance. If strong past stock performance is due to some pricing bubble, we will observe a positive relation between the option-based measure and future crashes, even without the overconfidence effect. In addition, CEOs may delay the exercise of in-the-money options because of personal tax concerns (Jin and Kothari 2008). A manager whose firm experiences strong past performance should have a higher tax burden and be more likely to delay option exercise. Thus, asset pricing bubbles can lead to both option exercise delay and future crashes. To rule out alternative explanations related to past performance, we control for past stock returns, return on assets, and the market-to-book ratio in our regression analyses. In addition, our CEO turnover test of Table 4 further alleviates the above concern because the influence of past performance on the option-based measure (as well as crash risk) is essentially removed by the design of the change analysis.

As an additional robustness check, we identify a subsample of firms meeting the following two criteria: (i) The current CEO has been in office over the past three years; and (ii) the firm has experienced a significant increase in stock price over the past three years (stock returns are positive and in the top quartile of the industry). This subsample makes it possible to compare overconfident CEOs with executives that have had the requisite stock price increase to be classified as overconfident but exercised their options upon vesting rather than holding onto them. Table 8 reports the results of estimating the main regression using the subsample. In Table 8, the coefficient of *OC_CJRS* is positive and significant across all three measures of crash risk, even though the subsample is much smaller than the full sample used in Table 3. This result provides further assurance that the increased crash risk is driven by overconfidence and not by past performance.

Inside information and signaling

Managers can delay the exercise of options because they have favorable inside information about future firm performance. By retaining options, they can personally profit from the expected stock price appreciation or signal the favorable information to investors. However, Malmendier and Tate (2005) find that, on average, CEOs do not beat the market by holding in-the-money options. More importantly, the favorable inside information interpretation of the option-based measure contradicts our findings that the measure is positively related to future stock price crashes.

Risk tolerance

Managers with high risk tolerance can also hold their options beyond the threshold because they are less affected by underdiversification. High risk tolerance can result in greater risk taking and higher future crash risk. In our main tests, we control for annual stock return volatility to rule out the risk-taking effect. In addition, the *CRASH* measure of crash risk is calculated relative to contemporaneous volatility, further ruling out the risk-taking explanation. In an unreported robustness check, we include R&D expenditures as an additional control variable and find that all the results hold. However, to the extent that investment risk cannot be fully captured by these control variables, our research should be interpreted with some caveats.

TABLE 8
Robustness: Subsample of firms with superior performance during the CEO's tenure

Dependent variable	$CRASH_t$	$NCSKEW_t$	$DUVOL_t$
CEO overconfidence			
OC_CJRS_{t-1}	0.204*	0.076**	0.038**
	(1.78)	(2.37)	(2.55)
Control variables			
$DTURNOVER_{t-1}$	0.092	0.100	0.079
	(0.19)	(0.79)	(1.37)
$LNCSKEW_{t-1}$	−0.160	−0.036	−0.012
	(−1.23)	(−0.89)	(−0.64)
$SIGMA_{t-1}$	1.134	0.851	0.443
	(0.48)	(1.22)	(1.52)
RET_{t-1}	−0.052	−0.019	−0.010
	(−0.51)	(−0.69)	(−0.82)
$SIZE_{t-1}$	−0.078	−0.001	0.002
	(−1.51)	(−0.08)	(0.32)
MB_{t-1}	−0.019	0.009**	0.004**
	(−1.01)	(2.15)	(2.14)
LEV_{t-1}	0.080	−0.078	−0.021
	(0.22)	(−0.79)	(−0.41)
ROA_{t-1}	1.329**	0.464**	0.246***
	(2.45)	(2.20)	(2.80)
$INCENTIVE\_STK_{t-1}$	0.112	−0.079	−0.040
	(0.47)	(−1.32)	(−1.38)
$INCENTIVE\_OPT_{t-1}$	0.188	−0.031	−0.021
	(0.51)	(−0.30)	(−0.40)
$OPAQUE_{t-1}$	0.316	−0.020	0.003
	(1.18)	(−0.25)	(0.08)
$OPAQUE_{t-1} \times OPAQUE_{t-1}$	−0.071	0.017	0.005
	(−0.76)	(0.73)	(0.47)
Constant	−1.831***	−0.714***	−0.447***
	(−2.76)	(−7.81)	(−11.59)
Percent overconfident CEOs	0.518	0.518	0.518
Observations	2,227	2,319	2,319
Industry fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Pseudo-/adjusted R^2	0.052	0.053	0.062

Notes:

This table reports the results of the impact of CEO overconfidence on crash risk for a subsample of good performance CEOs. The "good" performance is defined as a positive return that exceeds industry quartile in the past three years. The sample period is from 1993 to 2010. All variables are defined in the Appendix. The *Z*-statistics (*t*-statistics) reported in parentheses are based on standard errors clustered by both firm and time. Here ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Other robustness checks

Our main model includes a measure of financial reporting opacity (*OPAQUE*) to make sure that our results are not simply driven by the effect of overconfidence on financial reporting quality. Note, however, that financial reporting quality is one channel through

which overconfidence has an impact on crash risk. For robustness, we include conditional conservatism as an additional control variable in the regression.[17] As expected, the impact of overconfidence on crash risk is significant and positive even if both accrual quality and conditional conservatism are controlled for. Callen and Fang (2013) find that institutional ownership is associated with crash risk. Our results continue to hold if we include institutional ownership (or different classifications of institutional ownership) as an additional control variable (Table S1).[18]

A more powerful method to control for time-invariant omitted variables is to include firm fixed effects. However, in our setting, we are interested in a stable trait of CEOs and within-firm changes in CEO overconfidence are infrequent in our sample. Nonetheless, we run the main model by including firm fixed effects and the effect of overconfidence on crash risk is generally insignificant when using a one-year window to measure crash risk. However, the effect is significantly positive when we use a three-year measure of crash risk. Another potential issue is that some unknown CEO-level effects may confound our findings. However, it is more problematic to control for CEO fixed effects because we are interested in a stable trait of the CEOs. As discussed before, even if some unknown CEO fixed effect is driving our results, it does not overturn the key insight of the paper, that CEOs' personal attributes matter for crash risk. To partially address this issue, we explicitly include some CEO-level variables (age, gender, and education) as additional control variables in the regression. The effect of overconfidence on crash risk is unaffected by these CEO-level control variables.

7. Conclusions and limitations

This study examines the impact of CEO overconfidence on firm-specific stock price crash risk. Overconfidence is defined as a set of interrelated positive illusions: positive self-evaluations, an exaggerated perception of mastery or control, and unrealistic optimism about future outcomes. We infer CEO overconfidence from their personal portfolio decisions, as well as their firms' investing and financing decisions. Using a large sample of CEOs from the ExecuComp database over the period 1993–2010, we find that overconfidence is significantly and positively associated with firm-specific stock price crash risk.

Our research is the first to show that managerial personal traits are a contributing factor to stock price crashes, which represents an important complement to traditional agency theory explanations for stock price crashes. Unlike CEOs in the traditional agency theory framework, overconfident CEOs believe that they are maximizing long-term firm value by continuing negative NPV projects and hiding the "temporary" bad performance of those projects. Thus traditional governance mechanisms that align the interests of managers and outside investors are likely to be less useful in reducing overconfidence-induced crashes. Our subsample analysis, however, does suggest that a better organizational structure of the top management team and a higher level of conditional conservatism in a firm's financial reporting can help mitigate the adverse impacts of individual managers' personal traits.

The results of our study cannot be taken as evidence that firms should avoid overconfident CEOs. On the contrary, CEO overconfidence can be beneficial, because overconfident managers can be more innovative and innovation is a key driver of economic growth. The takeaway from our study is that the board should consider installing mechanisms (such as conservative accounting policy) to mitigate the adverse side effects of CEO overconfidence, to the extent that these side effects are not within the acceptable set of outcomes for the board or investors.

17. We use both the firm–year measure of Callen et al. (2010) and Basu's (1997) firm-specific coefficient to measure conservatism.
18. Please see supporting information, "Table S1: Controlling for accounting conservatism and institutional ownership" as an addition to the online article.

Our study has at least three limitations. First, while we interpret our findings as evidence of managerial optimism, we cannot completely rule out the possibility that the results are driven by managerial opportunism. Second, the implications of this study are limited by the validity of our proxies of overconfidence, which is notoriously difficult to measure. Finally, although we have conducted a battery of robustness checks, the issue of endogeneity remains, given the lack of an exogenous shock in our research designs. The limitations of our study can be fruitful avenues for future research.

Appendix

Variable definitions

Dependent variables: Crash risk measures	
CRASH	An indicator variable that equals one for a firm-year that experiences one or more crash weeks during the fiscal year period and zero otherwise. Crash weeks are defined as those weeks during which the firm experiences firm-specific weekly returns 3.2 standard deviations below the mean firm-specific weekly returns over the entire fiscal year, with 3.2 standard deviations chosen to generate a frequency of 0.1 percent in the normal distribution
NCSKEW	The negative skewness of firm-specific weekly returns over the fiscal year period
DUVOL	The log of the ratio of the standard deviation of firm-specific weekly returns for down weeks to the standard deviation of firm-specific weekly returns for up weeks. For each firm j over a fiscal year period t, we define down weeks as all the weeks with firm-specific weekly returns below the annual mean and up weeks as those with firm-specific returns above the annual mean
CEO overconfidence measures	
OC_CJRS	The modified Malmendier and Tate (2005) option-based measure of CEO overconfidence. Following Campbell et al. (2011), we define a CEO as overconfident if the CEO holds options at least twice during the sample period that are more than 100 percent in the money. The measure *OC_CJRS* takes the value of one beginning with the first time the CEO exhibits the above option-holding behavior and zero otherwise
OC_SZ	A firm-specific overconfidence score constructed following Schrand and Zechman (2012). It takes the value of one if the firm meets the requirements of at least three of the following five criteria and zero otherwise: (i) Excess investment is in the top quartile within industry-years, where excess investment is the residual from a regression of total asset growth on sales growth; (ii) net acquisitions from the statement of cash flows are in the top quartile within industry-years; (iii) the debt-to-equity ratio is in the top quartile within industry-years, where the debt-to-equity ratio is defined as long-term plus short-term debt divided by total market value; (iv) either convertible debt or preferred stock is greater than zero; and (v) the dividend yield is zero
OC_MSZ	A CEO-level overconfidence measure modified from *OC_SZ*. If in one year the CEO's firm has a score of *OC_SZ* equal to one, starting from that year the CEO is considered overconfident

(The appendix is continued on the next page.)

Appendix (continued)

Control variables	
DTURNOVER	The average monthly share turnover over the current fiscal year period minus the average monthly share turnover over the previous fiscal year period, where monthly share turnover is calculated as the monthly trading volume divided by the total number of shares outstanding during the month
SIGMA	The standard deviation of firm-specific weekly returns over the fiscal year period
RET	The mean of firm-specific weekly returns over the fiscal year period, times 100
SIZE	The log of the market value of equity
MB	The market value of equity divided by the book value of equity
LEV	The total long-term debt divided by total assets
ROA	The income before extraordinary items divided by lagged total assets
INCENTIVE_OPT	The incentive ratio for executive option holdings, which is measured as *ONEPCT_OPT*/(*ONEPCT_OPT* + *SALARY* + *BONUS*). The variable *ONEPCT_OPT* is the dollar change in the value of executive option holdings resulting from a 1 percent increase in the firm's stock price measured as 0.01 × share price × option delta × number of options, assuming the option delta equals one
INCENTIVE_STK	The incentive ratio for executive stock holdings, defined similarly to *INCENTIVE_OPT*
OPAQUE	The prior three years' moving sum of the absolute value of discretionary accruals (Hutton et al. 2009)

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:
Table S1. Controlling for accounting conservatism and institutional ownership