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Chief financial officer overconfidence and stock price crash risk☆

Lu Qiao [a], Emmanuel Adegbite [b], Tam Huy Nguyen [c,*]

[a] Nottingham University Business School, University of Nottingham, UK; and University of Leicester School of Business, University of Leicester, UK
[b] Nottingham University Business School, University of Nottingham, UK; and James Cook University, Singapore
[c] Nottingham University Business School, University of Nottingham, UK

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A B S T R A C T

Numerous studies have shown the prevalence of overconfidence among Chief Financial Officers (CFOs). Surprisingly, the real effect of CFO overconfidence is under-researched. Using data from a large sample of US-listed firms over the period 1993–2019 and adopting an eclectic theoretical approach, we find that overconfident CFOs are more likely to increase stock price crash risk than non-overconfident CFOs through risk-taking and bad news hoarding. These findings pass a series of robustness tests. Furthermore, departing from most overconfident studies that merely examine one type of top managers (i.e., Chief Executive Officer (CEO)), we consider the influence of CEO and CFO overconfidence jointly. Interestingly, we find that CFO overconfidence outweighs CEO overconfidence in influencing stock price crash risk. Moreover, the overconfidence effect is intensified when overconfident CFOs collaborate with overconfident CEOs, thus raising stock price crash risk. However, stronger governance and a transparent information environment constrain overconfident CFOs' effect on stock price crash risk. Overall, our findings highlight the importance of CFO overconfidence in determining stock return tail risks.

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ORCID ID: 0000-0002-3810-2614
ORCID ID: 0000-0002-7370-2818
ORCID ID: 0000-0001-7170-5882

> "Because CFOs are not actually superhuman, but just people like everyone else, they too are subject to a lengthy list of cognitive biases that influence our decisions and actions. In the corporate finance context, these biases, if unchecked, can have devastating consequences for company performance."
>
> McCann (2014), the deputy editor of CFO magazine.

1. Introduction

Stock price crash risk refers to when firms' bad news reaches a specific threshold and is revealed to the market all at once, causing a significant drop in stock price (e.g., Kim, Li, Lu, and Yu, 2016; Kim, Li, and Zhang, 2011a, 2011b). As Chief Financial Officers (CFOs) are primarily responsible for the quality and timely disclosure of financial information (Mian, 2001), the increasing number of studies on stock price crash risks examine the influence of CFOs. For instance, adopting the agency theory framework, Kim et al. (2011a) find that CFOs with high equity incentives are more likely to conceal bad news, raising future stock price crash risk. Relying on upper echelons theory that managers' cognitive biases significantly affect their decisions (Hambrick and Mason, 1984), Li and Zeng (2019) find that female CFOs have a low-risk tolerance and promptly abandon money-losing projects, reducing numbers of negative news and the possibility of stock price crashes.

In contrast to most studies from an agency perspective, Kim, Wang, and Zhang (2016), relied on the overconfidence theory to shed light on the relationship between managers' psychological characteristics (i.e., overconfidence) and stock price crash risks. They show that overconfidence amplifies Chief Executive Officers' (CEOs)' cognitive biases on their own ability and their firms' prospects, thereby increasing their willingness to continue negative net present value (NPV) projects and consequently raising the risk of their firms' future stock price crash.

However, the impact of CFO overconfidence and stock price crash risks remains unknown, motivating us to explore it for two reasons. First, CFOs' cognitive biases are superior to other traits in explaining their

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* Corresponding author.
E-mail addresses: lq33@leicester.ac.uk (L. Qiao), Emmanuel.adegbite@nottingham.ac.uk (E. Adegbite), Tam.nguyen@nottingham.ac.uk (T.H. Nguyen).

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decisions. Specifically, Ge, Matsumoto, and Zhang (2011) argue that CFOs' observable and demographic characteristics (e.g., age, gender, and educational background) cannot explain their styles sufficiently. However, a series of studies document the significant effects of CFO overconfidence on corporate decisions (e.g., investment, financing choice, and cost management) (Ben-David, Graham, and Harvey, 2013; Chen, Gores, Nasev, and Wu, 2022; Malmendier, Pezone, and Zheng, 2019). Second, the nascent literature on CFO overconfidence demonstrates that overconfident CFOs have incentives to take risks and conceal negative news from investors, which are the most common causes of sharp stock price drops (e.g., Kim and Zhang, 2016; Li and Zeng, 2019; Long, Tian, Hu, and Yao, 2020), making it reasonable to link CFO overconfidence and stock price crash risk. We, therefore, predict that CFO overconfidence leads to a higher stock price crash risk.

Empirically, we employ three widely used methods to capture stock price crash risk, the chance of a crash, negative conditional return skewness, and down-to-up volatility (Chen, Hong, and Stein, 2001; Hutton, Marcus, and Tehranian, 2009; Kim et al., 2011a, 2011b), reducing the possibility of mismeasurement and increasing the robustness of results. Following a majority of overconfidence studies (e.g., Campbell, Gallmeyer, Johnson, Rutherford, and Stanley, 2011; Chen et al., 2022; Kim, Wang, and Zhang, 2016; Malmendier et al., 2019), we use options exercise behavior to measure CFO overconfidence. By analyzing US-listed firms' information from 1993 to 2019, we discover a significant and positive relationship between overconfident CFOs and stock price crash risk. This finding is solid in a difference-in-difference framework based on the propensity score matching sample (PSM-DID), under an alternative measure of overconfidence, and rules out another explanation of our overconfidence measure (i.e., inside trading).

Following that, we examine a series of moderating effects on the association between CFO overconfidence and stock price crash risk. Firstly, we conduct two tests to examine the channels through which overconfident CFOs affect stock price crashes. We observe that overconfident CFOs increase stock price crash risk due to their risk-taking and bad news hoarding incentives.

Secondly, merely investigating one type of managerial overconfidence would underestimate the impact of the top management team's overconfidence on corporate decisions (Black and Gallemore, 2013; Malmendier et al., 2019). Thus, we further analyzed the influence of CEO overconfidence on the link between CFO overconfidence and the likelihood of stock price crashes. Interestingly, we find that CFO overconfidence dominates CEO overconfidence in determining stock price crash risks, which is consistent with the notion that CFOs play a more vital role in information reporting than other executives (Jiang, Petroni, and Wang, 2010; Kim et al., 2011a; Mian, 2001). Besides, we find that the overconfidence effect on stock price crashes is magnified when firms simultaneously have overconfident CFOs and CEOs. In the last two cross-sectional tests, we provide evidence that strong governance and a transparent information environment curb overconfident CFOs' biased decisions, lowering firms' stock price crash risk.

Our study contributes to prior literature in several aspects. Early studies on stock price crash risk demonstrate the influence of firm characteristics (e.g., Hutton et al., 2009; Kim et al., 2011b; Kim, Li, et al., 2016; Kim and Zhang, 2014, 2016). In particular, a growing body of current studies sheds light on the effect of managerial traits on stock price crash risk. However, most of these studies mainly focus on CEOs (e.g., Chen, Fan, Yang, and Zolotoy, 2021; Kim, Wang, and Zhang, 2016; Long et al., 2020). For example, Kim, Wang, and Zhang (2016) only studied the effect of one type of managerial style (i.e., CEO overconfidence), which might underestimate the influence of top management overconfidence. We extend their study by testing the effect of CEO overconfidence on the relationship between CFO overconfidence and stock price crash risk, which also responds to the call made by Black and Gallemore (2013) and Malmendier et al. (2019) that additional research is critical for understanding joint effects of CEO and CFO overconfidence.

While we make a contribution to studies on managerial overconfidence and stock price crash risk, our study also contributes to overconfidence, upper echelons, power circulation, and false consensus effect theories. Specifically, we find that CFOs affect stock price crashes due to biased estimations about themselves and firms, supporting the upper echelons and overconfidence theories. Besides, our findings that CFO overconfidence exceeds CEO overconfidence in determining stock price crashes validates the power circulation theory. Our discovery of the interaction impact of CEO and CFO overconfidence aligns with the false consensus effect theory.

In addition, we argue that overconfident CFOs' risk-taking and bad news hoarding behaviors result from cognitive biases rather than the seeking of private gains. However, we finally find the undesirable consequences of CFOs' cognitive bias (i.e., increasing stock price crash risk) (see also: McCann (2014) and provide implications for board members, investors, and other users of financial reports to monitor the information disclosure of overconfident CFOs in a timely way.

The rest of the paper is structured as follows. Section 2 discusses the related theories, literature, and hypotheses development. Sections 3 and 4 describe the empirical design and findings, respectively. Section 5 presents a series of cross-sectional tests, while Section 6 concludes the paper.

2. Theoretical framework, literature review, and hypothesis development

2.1. Managerial traits and stock price crash risk

From an agency theory perspective, a large number of studies document that managerial bad news hoarding activities increase firms' future stock price crash risk.[1] These studies assume that managers can make rational and accurate judgments about their firm value and future performance. To pursue their own benefits (e.g., high compensation and stable jobs) at the expense of shareholders, managers have an incentive to hide bad news from outside investors for an extended period (e.g., Al Mamun, Balachandran, and Duong, 2020; Andreou, Louca, and Petrou, 2017; Benmelech, Kandel, and Veronesi, 2010; He, 2015; Kim et al., 2011a; Shahab, Ntim, Ullah, Yugang, and Ye, 2020). When bad news accumulates at a certain level, it is exposed to the market all at once, resulting in a sharp decrease in stock price (e.g., Bleck and Liu, 2007; Hutton et al., 2009; Kim et al., 2011b).

Unlike studying the managerial bad news hoarding behaviors within the traditional agency theory scope, Kim, Wang, and Zhang (2016) test the link between irrational CEOs (i.e., overconfident CEOs) and stock price crash risk based on the upper echelons and overconfidence theories. Upper echelons theory demonstrates the impact of managerial cognitive bias on firms' decisions (Hambrick and Mason, 1984). Overconfidence is the root of all cognitive biases (Bazerman and Moore, 2013; Malmendier et al., 2019; Meikle, Tenney, and Moore, 2016). Overconfidence theory has four manifestations, including over-optimism, the above-average effect, miscalibration, and the illusion of control. Weinstein (1980) suggests that over-optimistic people believe that the likelihood of fortunate events exceeds the likelihood of unfortunate events. The above-average effect refers to people who feel they are superior to their reference group regarding a certain trait (Alicke, 1985). The miscalibration and illusion of control mean people overestimate the precision of their own forecasts and overestimate their ability to control events, respectively (Langer, 1975; Ronis and Yates, 1987).

Overconfident CEOs, in the study of Kim, Wang, and Zhang (2016),

[1] Agency theory states that asymmetric information between shareholders and managers leads to managers not acting in the best interests of shareholders (Jensen and Meckling, 1976).

are defined as CEOs' tendency to overestimate their own intelligence, mastery, and possibilities for favorable future outcomes. Thus, Kim, Wang, and Zhang (2016) state that overconfident CEOs are less likely to terminate negative NPV projects because they misperceive these projects as value-creating and believe that they are in the best interests of shareholders to continue these projects, rather than because they tend to pursue private benefits. Accordingly, negative NPV projects are held for a long period of time, and bad news accumulates, potentially leading to stock price crashes. Kim, Wang, and Zhang (2016) provide a novel explanation of stock price crash risks from managerial cognitive bias (i.e., CEO overconfidence), which distinguishes and extends the traditional agency theory. However, the relationship between CFO overconfidence and stock price crash risk remains unknown.

2.2. CFO overconfidence and stock price crash risk

Through the lens of upper echelons and overconfidence theories, we predict that overconfident CFOs might increase stock price crash risk as they are risk-takers. It is well documented in the literature and theory that overconfident CFOs are more likely to pursue risks than their less confident counterparts. To be specific, according to the overconfidence theory, the miscalibration and illusion of control cause overconfident people to overestimate their own decisions' precision and their ability to control events, respectively (Langer, 1975; Ronis and Yates, 1987). These biases might lead overconfident CFOs to overestimate their capacity to forecast and control risks in their decisions, causing them to make risky decisions. Besides, overconfident people feel that the possibility of lucky events outweighs the likelihood of terrible happenings (Weinstein, 1980). Thus, overconfident CFOs might underestimate the consequences of taking risks. Empirical studies confirm these theoretical predictions that overconfident CFOs have a high-risk tolerance. For example, Ben-David et al. (2013) suggest that overconfident CFOs are more likely to overestimate their prediction ability and firms' prospects, thus adopting more risky investment strategies. Besides, overconfident CFOs positively correlate with firms' risky strategies, such as, tax avoidance and cost management (Chen et al., 2022; Hsieh, Wang, and Demirkan, 2018).

Managerial risk-taking behavior is a main determinant of stock price crash risk. Specifically, many empirical studies relying on upper echelons theory suggest that firms with higher risk-tolerant managers are more likely to invest in risky projects initially and are not willing to terminate negative NPV projects early, which may lead to a poor operating performance in the first place. When bad news accumulates to a tipping point, terrible news is disclosed all at once in the market, resulting in a stock price crash. For instance, Long et al. (2020) find that CEOs with early-life experience of the Great Chinese Famine become risk aversion, lowering stock price crash risk. Li and Zeng (2019) suggest that female CFOs decrease the probability of stock price crash risk due to their low-risk tolerance. Fu and Zhang (2019) find that CFOs with cultural backgrounds emphasizing uncertainty avoidance reduce firms' future stock price crash risk.

Thus, we predict that overconfident CFOs, due to high risk-taking incentives, might raise the likelihood of bad news in the first place, thus increasing the probability of a future stock price crash. The foregoing discussion leads to the following hypotheses:

H1. : There is a positive relationship between CFO overconfidence and stock price crash risk.

H2. : The positive relationship between CFO overconfidence and stock price crash risk is more profound for overconfident CFOs with a high-risk tolerance.

In addition, we predict that overconfidence affects CFOs' bad news' disclosure to the market. According to upper echelons and overconfidence theories, overconfident CFOs believe in their abilities and the firm's prospects (Ben-David et al., 2013; Malmendier et al., 2019). To persuade investors that their beliefs are reliable, overconfident CFOs might conceal bad news to optimistically adjust their reported information. Empirical findings are consistent with this prediction. For example, Malmendier et al. (2019) find that overconfident CFOs overestimate firms' intrinsic value and deem their firms undervalued by the market; thus, overconfident CFOs perceive the cost of capital as costly. To increase cash inflows and meet firm high investment demands, overconfident CFOs might have incentives to lower the cost of capital (Ben-David et al., 2013), particularly if internal financing is insufficient.

Prior studies document that managers tend to lower the cost of capital by hoarding bad news. For instance, to reduce the cost of equity, managers have incentives to withhold bad news by using income-increasing earnings management (Dechow and Skinner, 2000; Rangan, 1998; Teoh, Welch, and Wong, 1998). Moreover, managers can smoothen earnings via earnings management to hide bad news and improve firms' credit ratings, thus lowering the cost of borrowing (Jung, Soderstrom, and Yang, 2013). Thus, we predict that overconfident CFOs have incentives to reduce the cost of capital by hoarding bad news. Bad news piled up reaches a tipping point and is exposed all at once in the market, leading to a stock price crash. The foregoing discussion leads to our next hypothesis:

H3. : The positive relationship between CFO overconfidence and stock price crash risk is more profound for overconfident CFOs with bad news hoarding behaviors.

2.3. CEO overconfidence, CFO overconfidence, and stock price crash risk

Many studies suggest that only studying one type of managerial overconfidence would underestimate the influence of the top management team's overconfidence in firm decisions (Black and Gallemore, 2013; Malmendier et al., 2019). Thus, we further explore the effect of CEO overconfidence on the relationship between CFO overconfidence and stock price crash risk.

Although CEOs set the tone at the top, power circulation theory states that CEO influence may be diffused, partly due to competition from other executives who are perceived as competitors for the CEO position (Baker, Lopez, Reitenga, and Ruch, 2019; Ocasio, 1994; Shen and Cannella Jr, 2002). As CFOs are competitive candidates for future CEOs, a growing number of studies find that CFOs dominate CEOs in reporting and financing decisions for which CFOs are responsible. For example, CFO equity incentives dominate CEO equity incentives in determining earnings management (Jiang et al., 2010). CFO overconfidence plays a more vital role than CEO overconfidence in making the external financing choice (Malmendier et al., 2019). Given that stock price crash risk is related to bad news disclosures, some studies document that CFO gender and equity incentives have more explanatory power than those characteristics of CEOs in explaining stock price crash risk (Kim et al., 2011a; Li and Zeng, 2019). Adopting the power circulation theory framework, we predict that CFO overconfidence outweighs

CEO overconfidence in influencing stock price crash risk. The foregoing discussion leads to our hypothesis:

H4. : CFO overconfidence outweighs CEO overconfidence in influencing stock price crash risk.

In addition, we explore the joint effects of CEO and CFO overconfidence on stock price crash risk. The false consensus effect theory posits that people are more likely to connect with those who have similar personalities and who share similar opinions and values (Bahns, Crandall, Gillath, and Preacher, 2017). Applying this theory to management research, some studies find that managers with common characteristics are able to reach consensus. For instance, Hsieh et al. (2018) find that firms are more likely to engage in tax-avoidance activities when they have both overconfident CEOs and CFOs. In the same vein, Black and Gallemore (2013) document the joint influence of overconfident CEOs and CFOs on delayed expected loan loss recognition. However, the interactive effect of overconfident CFOs and CEOs on stock price crash risks remains unclear. Based on the false consensus effect theory and the finding of Kim, Wang, and Zhang (2016) that overconfident CEOs have incentives to hoard bad news, we predict that firms with overconfident CEOs and CFOs are more likely to withhold bad news from the investors for an extended period, thus increasing future stock price crash risk. The foregoing discussion leads to our hypothesis:

H5. : The positive relationship between CFO overconfidence and stock price crash risk is more profound for firms with overconfident CFOs and overconfident CEOs working together.

3. Empirical design

3.1. Variable measurement

3.1.1. The measurement of stock price crash risk

We use three measures of firm-specific crash risk following previous studies (Chen et al., 2001; Hutton et al., 2009; Kim et al., 2011a, 2011b; Kim, Li, and Li, 2014). All measurements are based on firm-specific weekly returns calculated based on the residuals from the following market model.

$$r_{i,\tau} = \alpha_i + \beta_{1i} r_{m,\tau-2} + \beta_{2i} r_{m,\tau-1} + \beta_{3i} r_{m,\tau} + \beta_{4i} r_{m,\tau+1} + \beta_{5i} r_{m,\tau+2} + \varepsilon_{i,\tau}, \tag{1}$$

where, $r_{i,\ \tau}$ and $r_{m,\ \tau}$ denote the return of stock i and the return on the CRSP value-weighted market index in week τ, respectively. To enable nonsynchronous trading, we include lead and lag terms for the market index return (Dimson, 1979).

To compute firm-specific weekly returns ($w_{i,\ \tau}$), we use the natural log of one plus the residual from eq. (1) (i.e., $w_{i,\ \tau} = \ln (1 + \varepsilon_{i,\tau})$) (Kim et al., 2011a, 2011b; Kim et al., 2014).

The first measure is the chance of a crash for each firm in each year. For any given fiscal year, a firm's crash week is defined as a week where the firm's weekly returns are 3.2 standard deviations below the mean firm-specific weekly returns during the year, with 3.2 chosen to give a frequency of 0.1% in the normal distribution (Kim et al., 2011b).

Our first measure, $SCR\_Crash_{i,t}$, is an indicator variable that equals one if a firm has one or more crash weeks (as indicated above) in a year, and zero otherwise (Hutton et al., 2009; Kim et al., 2011a, 2011b).

Our second measure is negative conditional return skewness ($SCR\_Ncskew_{i,t}$), which is defined as the negative of the third moments of the firm-specific weekly returns divided by the standard deviation of firm-specific weekly returns raised to the third power (Chen et al., 2001; Kim et al., 2014). Specifically, for each firm i in year t, we calculate $SCR\_Ncskew_{i,t}$ as follows:

$$SCR\_Ncskew_{i,t} = -\frac{N(N-1)^{\frac{3}{2}} \sum W^3{}_{i,\tau}}{(N-1)(N-2)\left(\sum W^2{}_{i,\tau}\right)^{\frac{3}{2}}}, \tag{2}$$

where, N is the number of firm-specific weekly returns generated by firm i in a fiscal year. Higher $SCR\_Ncskew_{i,t}$ values indicate a greater crash risk.

The third measurement is down-to-up volatility ($SCR\_Duvol_{i,t}$) following prior studies (Chen et al., 2001; Kim et al., 2014). Specifically, weekly results are divided into up and down weeks. Down (up) weeks are defined as those in which firm-specific weekly returns are less than (greater than) the yearly average weekly return. $SCR\_Duvol_{i,t}$ is the natural logarithm of the ratio of the standard deviation in the down weeks to the standard deviation in the up weeks (Kim et al., 2014). Specifically, for each firm i in year t, we calculate $SCR\_Duvol_{i,t}$ as follows:

$$SCR\_Duvol_{i,t} = ln\left(\frac{(N_U - 1)\sum W^2{}_{iD,\tau}}{(N_D - 1)\sum W^2{}_{iU,\tau}}\right), \tag{3}$$

where, $W_{iD,\tau}$ ($W_{iU,\tau}$) denotes firm i's firm-specific weekly return in a down-(up-) week, and N_D (N_U) is the number of down-(up-) weeks in a fiscal year. Higher $SCR\_Duvol_{i,t}$ values indicate a greater crash risk.

3.1.2. The measurement of overconfidence

The option-based technique suggested by Malmendier and Tate (2005) is the most widely used managerial overconfidence measure in the existing literature (Campbell et al., 2011; Chen et al., 2022; Huang, Tan, and Faff, 2016; Kim, Wang, and Zhang, 2016; Lin, Chen, Ho, and Yen, 2020) and is most robust to alternative interpretations (Malmendier et al., 2019; Malmendier and Tate, 2015). According to Malmendier and Tate (2005), when managers are unwilling to exercise options that are more than 67% in the money, they are considered overconfident managers. Because ExecuComp does not have specific data on CFOs' option holdings and exercise prices prior to 2006, we use the average moneyness of CFOs' option portfolios as proxies for overconfident CFOs (Campbell et al., 2011). The following is how the average moneyness is calculated.

$$The\ realizable\ value\ per\ option_{i,t} = \frac{The\ total\ realizable\ value\ of\ the\ exercisable\ options_{i,t}}{The\ number\ of\ exercisable\ options_{i,t}} \tag{4}$$

$$The\ \text{estimate of the average exercise}\ price of options_{i,t} = The stock price\ at\ the fiscal year end_{i,t} - The realizable value\ per\ option_{i,t} \tag{5}$$

$$The\ average\ percent\ moneyness\ of\ the\ options_{i,t} = \frac{The\ \ realizable\ value\ per\ option_{i,t}}{The\ estimate\ of\ the\ average\ exercise\ price\ of\ the\ options_{i,t}} \tag{6}$$

Therefore, $Holder67CFO_{i,t-1}$, an indicator variable, equals one when CFOs hold vested options that are at least 67% in the money (the lagged value of the *average percent moneyness of the option*$_{i,t}$) for the first time until the end of their tenure, and zero otherwise (Chen et al., 2022).[2]

3.2. Baseline regression model

This section investigates the association between CFO overconfidence and firm-specific stock price crash risk using the following model.

[2] Results remain robust if we require CFOs to retain vested options that are at least 67% in the money at least twice.

$$
\begin{aligned}
SCR_{i,t} = \beta_0 \; & +\beta_1 Holde67CFO_{i,t-1} + \beta_2 CFO\_equityincentive_{i,t-1} + \beta_3 CFO\_female_{i,t-1} \\
& +\beta_4 Dturn_{i,t-1} + \beta_5 SCR\_Ncskew_{i,t-1} + \beta_6 Sigma_{i,t-1} \\
& +\beta_7 Ret_{i,t-1} + \beta_8 MTB_{i,t-1} + \beta_9 ROA_{i,t-1} + \beta_{10} FirmSize_{i,t-1} \\
& +\beta_{11} Leverage_{i,t-1} + \beta_{12} AbsAEM_{i,t-1} + Firm\ Fixed\ Effects \\
& + Year\ Fixed\ Effects + \varepsilon_{i,t},
\end{aligned} \tag{7}
$$

Table 1
Sample selection.

Steps	Details	Observations
Step 1	Initial data of US-listed firms from CCM database from 1993 to 2019	178,295
Step 2	Minus observations that do not include CFOs' compensation information in the ExecuComp database	(137,142)
	Observations with data available in CCM and ExecuComp databases	41,153
Step 3	Minus observations in the financial industry (SIC: 6000–6999)	(7154)
Step 4	Minus observations in the utility sector (SIC: 4900–4999)	(2151)
	Observations before deleting the missing values in various regressions	31,848
Step 5	Number of observations after deleting observations with missing values	17,519

where, $SCR_{i,t}$ is one of three stock price crash risk proxies ($SCR\_Crash_{i,t}$, $SCR\_Ncskew_{i,t}$, and $SCR\_Duvol_{i,t}$); The variable of interest is $Holder67\text{-}CFO_{i,t-1}$, a proxy of overconfident CFOs; β_1 captures the relationship between CFO overconfidence and stock price crash risk. As we predict that there is a positive relationship between CFO overconfidence and stock price crash risk, we expect that β_1 is significantly positive.

In the regression, we also include control variables based on previous stock price crash risk studies. We control for some CFO characteristics. Given that prior studies find that CFOs with high equality incentives (Kim et al., 2011a) and male CFOs (Li and Zeng, 2019) are able to increase future stock price crash risks, we control CFOs' equality incentives ($CFO\_equityincentive_{i,t-1}$) and gender ($CFO\_male_{i,t-1}$). Besides, following previous studies on crash risk (Chen et al., 2001; Hutton et al., 2009; Kim et al., 2011a, 2011b), we control for the proxy of differences of opinions between investors, the detrended stock trading volume ($Dturn_{i,t-1}$), as investor belief heterogeneity predicts future crash likelihood (Hong and Stein, 2003). Chen et al. (2001) find the probable persistence of the third moment of stock returns (i.e., return skewness in the current year is related to return skewness in the last year.) To account for the potential serial correlation of negative skewness of firm-specific weekly returns ($SCR\_Ncskew_{i,t}$), we include the lag value of $SCR\_Ncskew_{i,t}$ (i.e., $SCR\_Ncskew_{i,t-1}$) (Kim et al., 2011a, 2011b; Kim et al., 2014; Kim, Wang, and Zhang, 2016). The reason for controlling prior return volatility ($Sigma_{i,t-1}$) is that more volatile stocks are more likely to crash (Chen et al., 2001). We further control for the average firm-specific weekly return over the past year ($Ret_{i,t-1}$) as firms with high past returns are potentially more crash-prone (Chen et al., 2001). Moreover, following Hutton et al. (2009), we control for the standard control variables, market-to-book ratio ($MTB_{i,t-1}$), return on assets ($ROA_{i,t-1}$), firm size ($FirmSize_{i,t-1}$), and financial leverage ($Leverage_{i,t-1}$). In addition, we control for earnings management as accrual-based earnings management increases the future crash risk (Hutton et al., 2009). Firm and year dummies are included in all regressions to control for the firm- and time-fixed effects. The Appendix contains detailed variable measurements.

3.3. Data and descriptive statistics

3.3.1. Sample selection

We collect information on US-listed firms from numerous databases. Accounting information is gathered from the CRSP/Compustat merged (CCM) and CRSP databases. Information from the ExecuComp database is used to calculate the compensation of CFOs and CEOs. In the cross-sectional tests, the E index is downloaded from Bebchuk, Cohen, and Ferrell (2009), and the analyst forecast information is collected from the I/B/E/S database. Because CFO and CEO compensation information has been accessible in the ExecuComp database since 1992, our study's sample period in the main tests runs from 1993 to 2019.[3] Following previous studies (Bellemare, Masaki, and Pepinsky, 2017; Conyon and He, 2012; Kim, Wang, and Zhang, 2016), we use the lagged values of independent and control variables in the regressions to mitigate the reverse causality concern.[4] We exclude financial institutions (SIC: 6000–6999) and utility firms (SIC: 4900–4999). Finally, all continuous variables are winsorized at the 1st and 99th percentiles. The detailed steps of sample generation are shown in Table 1.

3.3.2. Descriptive statistics

The descriptive statistics of all variables included in our model (eq. (7)) are shown in Table 2.

Panel A of Table 2 displays the summary statistics for the full sample. The mean value of $SCR\_Crash_{i,t}$ is 0.212, indicating about 21.2% unconditional likelihood of a firm-specific stock price crash in a year. The average values of $SCR\_Crash_{i,t}$, $SCR\_Ncskew_{i,t}$, and $SCR\_Duvol_{i,t}$ are slightly higher than those reported by Kim et al. (2011b), implying that our sample of firm-years is more crash-prone than that of Kim et al. (2011b).[5] The mean and standard deviation values of $Holder67CFO_{i,t-1}$ are comparable to those reported in Chen et al. (2022). Over half of CFOs are overconfident, indicating that overconfidence is a common trait of top managers (Goel and Thakor, 2008). The distribution of the control variables is similar to what has been observed in previous studies. For example, we find the male dominant in CFO gender (mean value: 0.920), consistent with the findings of Barua, Davidson, Rama, and Thiruvadi (2010). Panel B of Table 2 shows the results of t-tests for differences between the overconfident CFO sample and the non-overconfident CFO sample. The significant difference in the means of stock price crash risk, measured by $SCR\_Crash_{i,t}$, $SCR\_Ncskew_{i,t}$, and $SCR\_Duvol_{i,t}$, between non-overconfident and overconfident CFO samples shows that firms run by overconfident CFOs have a significantly higher crash risk than firms run by non-overconfident CFOs, supporting our hypothesis 1.

3.3.3. Pairwise correlations

Table 3 shows the correlation matrix. Without considering other factors, the $Holder67CFO_{i,t-1}$ shows significant positive associations with

[3] The sample for the cross-sectional test of governance ends in 2006 due to the limited availability of E index data prior to 2006.

[4] Thanks for the anonymous reviewer's suggestion. We realize that overconfident CFOs might self-select into risky firms. Specifically, candidates might choose firms (or firms might hire candidates) with similar characteristics (Graham et al., 2013). Overconfident candidates have a higher risk tolerance than non-overconfident candidates (Ben-David et al., 2013; Chen, Gores, Nasev, and Wu, 2022; Hsieh et al., 2018). Thus, overconfident CFOs (i.e., risk-tolerant CFOs) might seek jobs in riskier firms, raising the concern of reverse causality. To further mitigate reverse causality, we also conduct PSM-DID in section 4.2.1.

[5] The sample period of Kim et al. (2011b) is 1995–2008.

Table 2
Summary statistics.

Panel A: Full sample descriptive statistics.

Variable	N	Mean	St.Dev	p25	Median	p75
$SCR\_Crash_{i,t}$	**17,519**	**0.212**	**0.408**	**0**	**0**	**0**
$SCR\_Ncskew_{i,t}$	**17,519**	**0.141**	**0.714**	**−0.280**	**0.121**	**0.538**
$SCR\_Duvol_{i,t}$	**17,519**	**0.097**	**0.476**	**−0.219**	**0.091**	**0.412**
$Holder67CFO_{i,t\text{-}1}$	**17,519**	**0.550**	**0.497**	**0**	**1**	**1**
$CFO\_equityincentive_{i,t\text{-}1}$	17,519	0.156	0.125	0.065	0.122	0.211
$CFO\_male_{i,t\text{-}1}$	17,519	0.920	0.271	1	1	1
$Dturn_{i,t\text{-}1}$	17,519	0.004	0.082	−0.028	0.002	0.033
$SCR\_Ncskew_{i,t\text{-}1}$	17,519	0.154	0.687	−0.270	0.125	0.537
$Sigma_{i,t\text{-}1}$	17,519	0.045	0.020	0.030	0.041	0.056
$Ret_{i,t\text{-}1}$	17,519	−0.116	0.106	−0.152	−0.082	−0.043
$MTB_{i,t\text{-}1}$	17,519	3.343	3.195	1.579	2.411	3.848
$ROA_{i,t\text{-}1}$	17,519	0.046	0.091	0.021	0.055	0.090
$FirmSize_{i,t\text{-}1}$	17,519	7.284	1.555	6.145	7.148	8.300
$Leverage_{i,t\text{-}1}$	17,519	0.201	0.163	0.043	0.193	0.312
$AbsAEM_{i,t\text{-}1}$	17,519	0.040	0.040	0.013	0.028	0.054

Panel B: Mean differences in proxies of stock price crash risks and control variables for non-overconfident and overconfident CFOs samples.

Variable	$Holder67CFO_{i,t\text{-}1} = 0$ ($N = 7875$)	$Holder67CFO_{i,t\text{-}1} = 1$ ($N = 9644$)	T-statistics for tests of difference in means (non-OverCFO-OverCFO)
$SCR\_Crash_{i,t}$	0.201	0.220	**−0.019****
$SCR\_Ncskew_{i,t}$	0.105	0.171	**−0.066*****
$SCR\_Duvol_{i,t}$	0.066	0.122	**−0.057*****
$CFO\_equityincentive_{i,t\text{-}1}$	0.124	0.183	−0.059***
$CFO\_male_{i,t\text{-}1}$	0.921	0.920	0.002
$Dturn_{i,t\text{-}1}$	−0.001	0.007	−0.008***
$SCR\_Ncskew_{i,t\text{-}1}$	0.154	0.154	0.001
$Sigma_{i,t\text{-}1}$	0.044	0.045	−0.001*
$Ret_{i,t\text{-}1}$	−0.115	−0.118	0.003
$MTB_{i,t\text{-}1}$	2.701	3.868	−1.166***
$ROA_{i,t\text{-}1}$	0.028	0.061	−0.033***
$FirmSize_{i,t\text{-}1}$	7.356	7.225	0.131***
$Leverage_{i,t\text{-}1}$	0.212	0.192	0.020***
$AbsAEM_{i,t\text{-}1}$	0.039	0.042	−0.003***

Notes: Panel A of Table 2 contains the descriptive statistics for the entire sample. The descriptive statistics for the subsample sample are shown in Panel B of Table 2. t-tests are used to determine whether there are differences in the means between the overconfident and non-overconfident CFOs samples. The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

Table 3
Correlation matrix.

	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	$SCR\_Crash_{i,t}$	1							
(2)	$SCR\_Ncskew_{i,t}$	0.623***	1						
(3)	$SCR\_Duvol_{i,t}$	0.471***	0.887***	1					
(4)	**$Holder67CFO_{i,t\text{-}1}$**	**0.024*****	**0.046*****	**0.059*****	1				
(5)	$CFO\_equityincentive_{i,t\text{-}1}$	0.022***	0.036***	0.041***	0.236***	1			
(6)	$CFO\_male_{i,t\text{-}1}$	−0.015**	−0.009	−0.015**	−0.003	−0.003	1		
(7)	$Dturn_{i,t\text{-}1}$	0.002	0.011	0.018**	0.049***	0.015*	−0.008	1	
(8)	$SCR\_Ncskew_{i,t\text{-}1}$	0.009	0.005	0.004	0	−0.015**	−0.008	0.055***	1
(9)	$Sigma_{i,t\text{-}1}$	−0.087***	0.018**	0.030***	0.021***	−0.215***	0.020***	0.186***	0.113***
(10)	$Ret_{i,t\text{-}1}$	0.093***	−0.011	−0.023***	−0.014*	0.179***	−0.018**	−0.186***	−0.089***
(11)	$MTB_{i,t\text{-}1}$	0.014*	0.037***	0.045***	0.182***	0.333***	−0.011	0.045***	−0.029***
(12)	$ROA_{i,t\text{-}1}$	0.063***	0.060***	0.068***	0.180***	0.220***	−0.037***	0.044***	−0.014*
(13)	$FirmSize_{i,t\text{-}1}$	0.014*	−0.003	−0.004	−0.042***	0.379***	−0.017**	0.001	−0.003
(14)	$Leverage_{i,t\text{-}1}$	−0.030***	−0.031***	−0.034***	−0.062***	0.009	0.053***	0.040***	−0.008
(15)	$AbsAEM_{i,t\text{-}1}$	−0.020***	0.024***	0.031***	0.033***	−0.053***	0.014*	0.057***	0.016**

	Variable	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(9)	$Sigma_{i,t\text{-}1}$	1						
(10)	$Ret_{i,t\text{-}1}$	−0.973***	1					
(11)	$MTB_{i,t\text{-}1}$	−0.077***	0.051***	1				
(12)	$ROA_{i,t\text{-}1}$	−0.336***	0.346***	0.230***	1			
(13)	$FirmSize_{i,t\text{-}1}$	−0.466***	0.412***	0.048***	0.119***	1		
(14)	$Leverage_{i,t\text{-}1}$	−0.079***	0.065***	0.082***	−0.150***	0.353***	1	
(15)	$AbsAEM_{i,t\text{-}1}$	0.261***	−0.248***	0.052***	−0.083***	−0.198***	−0.080***	1

Notes: Pearson correlation coefficients are shown in Table 3. The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

Table 4
Baseline regression result- CFO overconfidence and stock price crash risk.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$
$Holder67CFO_{i,t-1}$	**0.019****	**0.047*****	**0.037*****	**0.018****	**0.042****	**0.034*****
	(0.009)	**(0.016)**	**(0.011)**	**(0.009)**	**(0.016)**	**(0.011)**
$CFO\_equityincentive_{i,t-1}$				0.026	0.116	0.076
				(0.043)	(0.077)	(0.050)
$CFO\_male_{i,t-1}$				−0.015	−0.020	−0.027
				(0.018)	(0.035)	(0.023)
$Dturn_{i,t-1}$	0.123***	0.073	0.073	0.123***	0.072	0.072
	(0.040)	(0.065)	(0.046)	(0.040)	(0.065)	(0.046)
$SCR\_Ncskew_{i,t-1}$	−0.032***	−0.102***	−0.062***	−0.032***	−0.101***	−0.062***
	(0.005)	(0.009)	(0.006)	(0.005)	(0.009)	(0.006)
$Sigma_{i,t-1}$	−0.193	2.993*	1.009	−0.166	3.115*	1.088
	(0.964)	(1.645)	(1.098)	(0.969)	(1.648)	(1.100)
$Ret_{i,t-1}$	0.252	0.533**	0.192	0.256	0.553**	0.206
	(0.158)	(0.260)	(0.178)	(0.159)	(0.261)	(0.178)
$MTB_{i,t-1}$	0.003**	0.014***	0.011***	0.003*	0.013***	0.010***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)
$ROA_{i,t-1}$	0.197***	0.525***	0.389***	0.195***	0.517***	0.384***
	(0.049)	(0.085)	(0.058)	(0.049)	(0.085)	(0.058)
$FirmSize_{i,t-1}$	0.046***	0.103***	0.062***	0.045***	0.098***	0.059***
	(0.009)	(0.015)	(0.010)	(0.009)	(0.016)	(0.010)
$Leverage_{i,t-1}$	−0.076**	−0.205***	−0.149***	−0.074*	−0.195***	−0.142***
	(0.039)	(0.070)	(0.047)	(0.039)	(0.071)	(0.047)
$AbsAEM_{i,t-1}$	−0.033	0.166	0.120	−0.033	0.165	0.119
	(0.093)	(0.149)	(0.103)	(0.092)	(0.149)	(0.103)
Constant	0.031	−0.578***	−0.372***	0.052	−0.539***	−0.331**
	(0.131)	(0.178)	(0.137)	(0.132)	(0.182)	(0.139)
Observations	17,519	17,519	17,519	17,519	17,519	17,519
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.042	0.027	0.040	0.042	0.027	0.040

Notes: The associations between CFO overconfidence and stock price crash risk are shown in Table 4. The standard errors clustering at the firm level are displayed in parentheses. The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

three stock price crash risk proxies, supporting our hypothesis that overconfident CFOs are more likely to increase stock crash risk relative to non-overconfident CFOs. In addition, the correlations between the independent and control variables do not exceed 0.5, and the untabulated values of variance-inflating factors (VIFs) are less than the threshold of 10, suggesting that multicollinearity is not a concern when examining the regression findings (Gujarati, Porter, and Gunasekar, 2012).

4. Main empirical analysis results

4.1. Baseline regression results

The relationship between CFO overconfidence and the stock price crash risk is examined using fixed-effect models.[6]

The findings of the impact of CFO overconfidence and stock price crash risk (eq. (7)) are shown in Table 4. The first three columns show the regression results without controlling for $CFO\_equityincentive_{i,t-1}$ and $CFO\_male_{i,t-1}$. The coefficient on $Holder67CFO_{i,t-1}$ is positive at a 5% significance level in column (1), suggesting a positive relationship between $Holder67CFO_{i,t-1}$ and $SCR\_Crash_{i,t}$. Similarly, in columns (2) and (3), $Holder67CFO_{i,t-1}$ has a significantly positive coefficient, showing that the positive relationship between CFO overconfidence and stock price crash risk holds across different measures of crash risk. In columns (4) to (6), we include $CFO\_equityincentive_{i,t-1}$ and $CFO\_male_{i,t-1}$ as prior studies document that CFO equity incentive and gender have a substantial impact on stock crashes (Kim et al., 2011a; Li and Zeng, 2019). As shown in columns (4) to (6), $Holder67CFO_{i,t-1}$ remains with a significantly positive coefficient, showing that our findings on the influence of CFO overconfidence are not driven by the CFOs' equity incentive and gender.

So far, we have documented that a positive relationship between CFO overconfidence and stock price crash risk is statistically significant. In addition, we find that our results have economic significance. Using the coefficient on $Holder67CFO_{i,t-1}$ in columns (5) and (6) as examples, we find that an overconfident CFO will lead to a 29.787% (= 0.042/0.141) increase in $SCR\_Ncskew_{i,t}$ at the mean and a 35.052% (=0.034/0.097) increase in $SCR\_Duvol_{i,t}$ at the mean. We provide statistically and economically significant evidence that overconfident CFOs increase the risk of future stock price crashes, supporting our hypothesis 1. These findings are consistent with the idea of McCann (2014) that CFOs' cognitive biases might lead to devastating effects on firm performance.

The coefficients on control variables are broadly consistent with prior research findings. Specifically, consistent with Chen et al. (2001), we find that the coefficient on $Dturn_{i,t-1}$ is significantly positive in columns (1) and (4), implying that investors' belief heterogeneities increase stock price crash probability. Besides, in consonance with the findings of Callen and Fang (2015b), we find the negative coefficients on $SCR\_Ncskew_{i,t}$, showing that stock price crash risk is negatively autocorrelated over adjacent years. Moreover, return volatility ($Sigma_{i,t-1}$) has a positive coefficient on columns (2) and (5), confirming that volatile stocks are more likely to crash (Chen et al., 2001). We also find the positive coefficients on historical return ($Ret_{i,t-1}$) in columns (2) and (5), indicating that firms with high past returns are potentially more crash-prone (Chen et al., 2001).

[6] To adjust for the effects of time-invariant firm characteristics and factors that are common to all firms for a given fiscal year, we employ two-way fixed-effect models: firm-fixed effect and year-fixed effect. Furthermore, when compared to random effect and pooled OLS models, the untabulated F, Breusch-Pagan Lagrange Multiplier, and Hausman tests show that fixed-effect models are the best choice for our investigation. For the same reasons, the fixed-effect models are employed in the subsequent regressions, which we will not repeat for brevity.

Regarding firm characteristics, market-to-book ratio (*$MTB_{i,t-1}$*), return on assets (*$ROA_{i,t-1}$*) and firm size (*$FirmSize_{i,t-1}$*) are positively associated with the probability of crashes, whereas the leverage level (*$Leverage_{i,t-1}$*) is negatively related to the stock price crash risk, which is in line with the findings of Callen and Fang (2015a) and Hutton et al. (2009).

4.2. Robustness tests

In this section, we conduct several tests to mitigate the endogeneity problems. Specifically, we conduct the PSM-DID to alleviate the potential reverse causality, change the overconfidence measurement to lessen the mismeasurement, and rule out another explanation for the option-based measure.

4.2.1. PSM-DID

Although we find that CFO overconfidence positively correlates with future stock price crash risk, we recognize that overconfident CFOs might not be hired by firms randomly. Specifically, candidates might self-select into firms (or firms might hire candidates) with similar characteristics (Graham, Harvey, and Puri, 2013). Overconfident candidates have a higher risk tolerance than non-overconfident candidates (Ben-David et al., 2013; Chen et al., 2022; Hsieh et al., 2018). Thus, overconfident CFOs (i.e., risk-tolerant CFOs) might seek work in risky firms, leading to the potential reverse causality concern. While we alleviate the reverse causation issue by predicting stock price crash risk using lagged CFO overconfidence, the concern may remain if CFO overconfidence is persistent over time. Thus, we use PSM-DID to mitigate the potential endogeneity concern.

We use a difference-in-difference approach to test the influence of overconfident CFOs on crash risks around turnover. We, following Ahmed and Duellman (2013) and Lin et al. (2020), utilize CFO turnover as a shock. To ensure that CFOs have enough time to impact firms' choices, we demand that former CFOs work for at least four years, and new CFOs are at least three years in office. As previous studies document that CEOs have the power to influence CFOs' decisions (Feng, Ge, Luo, and Shevlin, 2011; Friedman, 2014) and that overconfident CEOs significantly affect stock price risk (Kim, Wang and Zhang, 2016), we delete the concurrent CEO and CFO changes to reduce the potential impact of CEOs. We define a firm in the treatment group when the former CFO is non-overconfident and the new CFO is overconfident. The control groups include firms where former and new CFOs are non-overconfident. We use the one-to-one nearest neighbor approach with a caliper of 5% to verify that firms in the treatment and control groups are comparable. We match treatment and control groups based on the control variable provided in eq. (7). This process leaves 150 observations.

Panel A of Table 5 reports the result of PSM. As shown in column (7), the *P*-values of *$SCR\_Ncskew_{i,t-1}$*, *$ROA_{i,t-1}$*, *$FirmSize_{i,t-1}$*, and *$Leverage_{i,t-1}$* are less than 1 in the unmatched sample and larger than 1 in the matched

Table 5
PSM-DID.

Panel A: PSM

Variable	Sample type (U = unmatched sample; M = matched sample)	Mean		Bias		T-test	
		Treated	Control	%bias	%reduct |bias|	t	p > |t|
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$CFO\_equityincentive_{i,t-1}$	U	0.132	0.121	10.500		0.920	0.358
	M	0.124	0.118	6.200	40.900	0.420	0.672
$CFO\_male_{i,t-1}$	U	0.103	0.094	3.100		0.260	0.793
	M	0.095	0.083	4	−30	0.270	0.788
$Dturn_{i,t-1}$	U	−0.010	−0.001	−10.500		−0.900	0.370
	M	−0.009	−0.007	−2.100	79.600	−0.140	0.888
$SCR\_Ncskew_{i,t-1}$	**U**	**−0.030**	**0.144**	**−24.500**		**−2.100**	**0.036**
	M	**0.002**	**−0.012**	**1.900**	**92.200**	**0.130**	**0.900**
$Sigma_{i,t-1}$	U	0.041	0.042	−6.400		−0.540	0.593
	M	0.041	0.042	−3.600	43.600	−0.240	0.811
$Ret_{i,t-1}$	U	−0.102	−0.109	6.700		0.540	0.586
	M	−0.103	−0.106	3.100	53.600	0.200	0.840
$MTB_{i,t-1}$	U	2.935	2.698	10.200		0.780	0.434
	M	2.887	2.703	7.900	22.200	0.510	0.611
$ROA_{i,t-1}$	**U**	**0.048**	**0.018**	**31.300**		**2.360**	**0.019**
	M	**0.046**	**0.042**	**3.900**	**87.500**	**0.300**	**0.767**
$FirmSize_{i,t-1}$	**U**	**7.291**	**7.666**	**−23.100**		**−1.900**	**0.058**
	M	**7.307**	**7.258**	**3**	**86.800**	**0.220**	**0.827**
$Leverage_{i,t-1}$	**U**	**0.179**	**0.220**	**−26.900**		**−2.240**	**0.026**
	M	**0.181**	**0.170**	**6.800**	**74.500**	**0.460**	**0.643**
$AbsAEM_{i,t-1}$	U	0.039	0.034	12.700		1.120	0.265
	M	0.040	0.042	−6.300	50.300	−0.420	0.678

Panel B: DID.

Variables	(1)	(2)	(3)
	$SCR\_Crash_{i,t}$	*$SCR\_Ncskew_{i,t}$*	*$SCR\_Duvol_{i,t}$*
$Treat_i$* × *$Post_{i,t}$	**0.232**	**0.697*****	**0.522*****
	(0.140)	**(0.232)**	**(0.181)**
Constant	−0.274	−6.927***	−6.361***
	(1.553)	(2.352)	(1.851)
Observations	150	150	150
Controls in eq. (7)	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Adj. R^2	0.002	0.022	0.069

Notes: Panel A of Table 5 summarizes the results of PSM. The results of DID are shown in Panel B of Table 5. The standard errors clustering at the firm level are displayed in parentheses. The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

Table 6
Alternative measurement: $Holder100CFO_{i,t-1}$.

	(1)	(2)	(3)
Variables	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$
$Holder100CFO_{i,t-1}$	**0.025****	**0.043****	**0.032*****
	(0.010)	**(0.017)**	**(0.011)**
Constant	0.060	−0.522***	−0.318**
	(0.132)	(0.182)	(0.139)
Observations	17,410	17,410	17,410
Controls in eq. (7)	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Adj. R^2	0.043	0.027	0.041

Notes: $Holder100CFO_{i,t-1}$ is an alternative measurement of CFO overconfidence. The standard errors clustering at the firm level are displayed in parentheses. The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

sample. Thus, there is no significant difference in control variables between the control and treatment groups in the matched sample. Next, we generate the difference-in-difference regression model as follows:

$$SCR_{i,t} = \beta_0 + \beta_1 Treat_i \times Post_{i,t} + Controls + Firm\ Fixed\ Effects + Year\ Fixed\ Effects + \varepsilon_{i,t}, \tag{8}$$

where, $Treat_i$ equals one if the former CFO is not overconfident and the new CFO is, and zero if both the former and new CFOs are not overconfident; $Post_{i,t}$ equals one if observations exist in the first year following the CFO's departure. $Post_{i,t}$ equals zero when observations exist in the last year before the CFO's departure. We include firm fixed effect and year fixed effect, so we exclude $Treat_i$ and $Post_{i,t}$ to avoid multiple collinearities. Control variables are consistent with eq. (7). Detailed variable information is shown in the Appendix.

Panel B of Table 5 displays the result of DID estimation based on the PSM matched sample. In columns (2) and (3), the interaction term, $Treat_i \times Post_{i,t}$, has a significantly positive coefficient, indicating that overconfident CFOs tend to increase firms' stock price crash risk.

4.2.2. The alternative overconfidence measurement

In the main regression, following Malmendier and Tate (2005), we use $Holder67CFO_{i,t-1}$ to capture overconfident CFOs. The threshold, 67%, is from the theoretical framework of Hall and Murphy (2002). However, some studies (i.e., Campbell et al., 2011) use a different threshold, 100%. To mitigate the measurement error, we adopt 100% as an alternative threshold of overconfidence measure. Specifically, we define $Holder100CFO_{i,t-1}$ as equals one from the time when CFOs are reluctant to exercise their options that are more than 100% in the money, and zero otherwise. Table 6 reports the regression results of using the alternative measurement. The coefficient on $Holder100CFO_{i,t-1}$ is significantly positive in columns (1) to (3) in Table 6, suggesting that the positive relationship between overconfident CFOs and stock price crash risk holds under alternative overconfidence measurement.

Table 7
Rule out-private information.

	(1)	(2)	(3)
Variables	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$
$Holder67CFO_{i,t-1}$	**0.023****	**0.045****	**0.031****
	(0.011)	**(0.020)**	**(0.013)**
$AbEarnings_{i,t-1}$	−0.036	−0.196***	−0.125***
	(0.035)	(0.057)	(0.043)
Constant	−0.356***	−0.881***	−0.591***
	(0.090)	(0.195)	(0.136)
Observations	13,527	13,527	13,527
Controls in eq. (7)	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Adj. R^2	0.051	0.035	0.048

Notes: We add additional control variable, $AbEarnings_{i,t-1}$, in this regression. The standard errors clustering at the firm level are displayed in parentheses. The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

4.2.3. Rule out another explanation of option-based overconfidence measurement

Another possible explanation for the late option exercise behavior is that CFOs have insider information regarding the firm's future performance. In this case, CFOs keep the deeply in-the-money options to pursue their own benefits rather than overconfidence.

Persistence is a key difference between the concept of overconfidence used in our paper and private information (Huang et al., 2016; Malmendier and Tate, 2005). Our definition of overconfidence ($Holder67CFO_{i,t-1}$) is when CFOs hold vested options that are at least 67% in the money for the first time until the end of their tenure, whereas private information is often short-lived and random (Huang et al., 2016; Malmendier and Tate, 2005). We would not expect CFOs to receive positive news on a regular basis. Therefore, the option-based overconfident measurement ($Holder67CFO_{i,t-1}$) should be different from insider trading.

Given that abnormal earnings can capture favorable private information, we empirically include abnormal earnings ($AbEarnings_{i,t-1}$) into our main regression (eq. (7)) in accordance with Huang et al. (2016).[7] If our measure of CFO overconfidence also captures the influence of private information, we anticipate the estimated coefficient on $Holder67CFO_{i,t-1}$ to be smaller and less significant if we include AbEarningsi,t-1 in our main regression.

However, as shown in Table 7, when $AbEarnings_{i,t-1}$ is included, the estimated coefficient on $Holder67CFO_{i,t-1}$ is negligibly affected compared to our documented findings in the column (4) to (6) of Table 4. In light of the above, we dismiss the private information alternate explanation.[8]

5. Cross-sectional tests

This section will identify channels, analyze the joint effect of CEO overconfidence and CFO overconfidence, and discuss the influence of governance and information asymmetry.

5.1. Underpinning mechanisms

5.1.1. Risk-taking activities

We have found a positive relationship between CFO overconfidence and stock price crash risk. This section examines whether overconfident CFOs positively affect stock price crash risk due to their risk tolerance. We use aggressive tax avoidance as a proxy for CFOs' risk-taking attitude. According to Hanlon and Heitzman (2010), aggressive tax avoidance refers to the most extreme type of tax avoidance activity that challenges tax law. Firms that successfully challenge tax laws might face large penalties and political costs (Lisowsky, 2009; Mills, Nutter, and

[7] Detailed variable information is shown in the Appendix.

[8] Thanks for the anonymous reviewer's suggestion. We also use the decomposition method to rule out this explanation. Specifically, we first regress $Holder67CFO_{i,t-1}$ (dependent variable) on $AbEarnings_{i,t-1}$ (independent variable) to get the residual. This residual represents that the effect of $Holder67CFO_{i,t-1}$ cannot be explained by $AbEarnings_{i,t-1}$. Next, we replace $Holder67CFO_{i,t-1}$ with this residual in equation (7). Unreported results find that the coefficient of residual is significantly positive, indicating that CFO overconfidence positively affects stock price crash risk after controlling for the effect of insider information.

Table 8
Channels.

Variables	(1) $SCR\_Crash_{i,t}$	(2) $SCR\_Ncskew_{i,t}$	(3) $SCR\_Duvol_{i,t}$	(4) $SCR\_Crash_{i,t}$	(5) $SCR\_Ncskew_{i,t}$	(6) $SCR\_Duvol_{i,t}$	(7) $SCR\_Crash_{i,t}$	(8) $SCR\_Ncskew_{i,t}$	(9) $SCR\_Duvol_{i,t}$
$Holder67CFO_{i,t-1}$	0.013	0.015	0.013	0.018	0.012	0.022	0.008	0.015	0.016
	(0.012)	(0.021)	(0.014)	(0.012)	(0.021)	(0.014)	(0.012)	(0.022)	(0.014)
$LowCETR_{i,t-1}$	0.003	−0.001	−0.011						
	(0.011)	(0.019)	(0.013)						
$Holder67CFO_{i,t-1} \times LowCETR_{i,t-1}$	**0.010**	**0.052****	**0.040****						
	(0.014)	**(0.026)**	**(0.017)**						
$LowETR_{i,t-1}$				−0.007	−0.044**	−0.015			
				(0.011)	(0.019)	(0.013)			
$Holder67CFO_{i,t-1} \times LowETR_{i,t-1}$				**−0.000**	**0.057****	**0.021**			
				(0.014)	**(0.025)**	**(0.017)**			
$PositiveAEM_{i,t-1}$							−0.016	−0.024	−0.016
							(0.010)	(0.018)	(0.012)
$Holder67CFO_{i,t-1} \times PositiveAEM_{i,t-1}$							**0.017**	**0.047****	**0.031****
							(0.014)	**(0.024)**	**(0.016)**
Constant	0.032	−0.584***	−0.335**	0.044	−0.501***	−0.309**	0.060	−0.519***	−0.318**
	(0.137)	(0.191)	(0.148)	(0.132)	(0.185)	(0.143)	(0.132)	(0.183)	(0.140)
Observations	16,860	16,860	16,860	17,231	17,231	17,231	17,519	17,519	17,519
Controls in eq. (7)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R2	0.042	0.029	0.041	0.041	0.026	0.040	0.042	0.027	0.041
Observations	16,860	16,860	16,860	17,231	17,231	17,231	17,519	17,519	17,519

Notes: The tables show the moderating effects of risk-taking and bad news hoarding on the relationship between CFO overconfidence and stock price crash risk. The standard errors clustering at the firm level are displayed in parentheses. Controls include control variables in eq. (7). Please note that when examining the effect of $PositiveAEM_{i,t-1}$, we remove one control variable from eq. (7), $AbsAEM_{i,t-1}$, to avoid multicollinearity. Our results remain similar when controlling for CEO characteristics ($Holder67CEO_{i,t-1}$, $CEO\_equityincentive_{i,t-1}$, and $CEO\_male_{i,t-1}$). The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

Schwab, 2013; Wilson, 2009). In addition, aggressive tax avoidance might damage the reputations of firms, board members, and top managers (Graham, Hanlon, Shevlin, and Shroff, 2014; Lanis, Richardson, Liu, and McClure, 2019). Aggressive tax avoidance is, therefore, more likely to reflect CFOs' attitude to risk.

We, following McGuire, Wang, and Wilson (2014), use firms' cash effective tax rate ($CETR_{i,t-1}$) and effective tax rate ($ETR_{i,t-1}$) to capture firms' aggressive tax avoidance behaviors.[9] Lower values of $CETR_{i,t-1}$ and $ETR_{i,t-1}$ represent higher level of tax avoidance. We generate an indicator variable, $Low\_CETR_{i,t-1}$ ($Low\_ETR_{i,t-1}$) equals one if $CETR_{i,t-1}$ ($ETR_{i,t-1}$) is lower than the mean tax avoidance level of industry in the same year, and zero otherwise. Columns (1) to (3) of Table 8 show the result of the moderating effect of the high level of tax avoidance proxied by $LowCETR_{i,t-1}$ on the relationship between CFO overconfidence and stock price crash risk. In columns (2) and (3), $Holder67CFO_{i,t-1} \times LowCETR_{i,t-1}$ has a significant and positive coefficient. Similarly, we find that the coefficient on $Holder67CFO_{i,t-1} \times LowETR_{i,t-1}$, is significantly positive in column (5), indicating that overconfident CFOs who adopt aggressive tax strategies raise stock crash risk. Overall, we find evidence to support that overconfident CFOs increase stock price crash risk due to risk-taking, confirming our hypothesis 2.

5.1.2. Bad news hoarding

This section tests another potential channel, bad news hoarding. Previous research supports the notion that bad news hoarding causes firm stock price crashes. Bad news accumulated over a long period of time can cause share prices to fall when a tipping point is breached suddenly. Income-increasing earnings management is the most common way for managers to conceal bad news (Hutton et al., 2009; Loureiro and Silva, 2022). Therefore, overconfident CFOs may increase crash risk by manipulating earnings upward. We use the modified Jones model to measure accrual-based earnings management ($AEM_{i,t-1}$).[10] The modified Jones model is introduced by Dechow, Sloan, and Sweeney (1995), which is widely used in accrual-based earnings management studies. We define income-increasing accrual-based earnings management, $Positive\_AEM_{i,t-1}$, as an indicator variable that equals one if $AEM_{i,t-1}$ is positive, and zero otherwise. Columns (7) to (9) of Table 8 report the result of the moderating effect of income-increasing accrual-based earnings management on the relationship between CFO overconfidence and stock price crash risk under different measures of stock price crash risk. In columns (8) and (9), $Holder67CFO_{i,t-1} \times PositiveAEM_{i,t-1}$ has a significant and positive coefficient, showing that overconfident CFOs increase stock price crash risk via the bad news hoarding channel, confirming our hypothesis 3.

5.2. CEO overconfidence, CFO overconfidence, and stock price crash risk

This section firstly compares the effect of CEO and CFO overconfidence on stock price crash risk. Relying on the power circulation theory framework, we predict that CFO overconfidence outweighs CEO overconfidence in influencing stock price crash risk. Empirically, to consider the effect of CEOs, we add CEO overconfidence ($Holder67CEO_{i,t-1}$), CEO equity incentives ($CEO\_equityincentive_{i,t-1}$), and CEO gender ($CEO\_male_{i,t-1}$) into our main regression (eq. (7)). As shown in Table 9, $Holder67CFO_{i,t-1}$ has a positive and significant coefficient in columns (1) to (3). The coefficient on $Holder67CEO_{i,t-1}$ is insignificant in columns (1) and (2).[11] The coefficient on $Holder67CFO_{i,t-1}$ is larger than that on $Holder67CEO_{i,t-1}$ in column (3). This evidence shows that CFO overconfidence has more explanatory power for stock price crash risk than CEO overconfidence, which is in line with our hypothesis 4.

[9] Detailed variable information is shown in the Appendix.

[10] Detailed variable information is shown in the Appendix.

[11] Unreported results show that the coefficient on $Holder67CEO_{i,t-1}$ is significantly positive when we remove the $Holder67CFO_{i,t-1}$ from the regression, which is in line with the findings of Kim, Wang, and Zhang (2016).

Table 9
CEO overconfidence, CFO overconfidence, and stock price crash risk.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$
$Holder67CFO_{i,t-1}$	**0.019***	**0.037****	**0.027****	0.013	−0.013	−0.005
	(0.010)	**(0.018)**	**(0.012)**	(0.016)	(0.028)	(0.019)
$Holder67CEO_{i,t-1}$	**−0.000**	**0.021**	**0.024****	−0.002	−0.003	0.008
	(0.010)	**(0.018)**	**(0.012)**	(0.012)	(0.022)	(0.015)
$Holder67CFO_{i,t-1} \times Holder67CEO_{i,t-1}$				**0.007**	**0.068****	**0.044****
				(0.018)	**(0.033)**	**(0.022)**
$CEO\_equityincentive_{i,t-1}$	−0.010	0.021	0.029	−0.006	0.022	0.030
	(0.030)	(0.054)	(0.037)	(0.030)	(0.055)	(0.037)
$CEO\_male_{i,t-1}$	−0.012	0.017	0.016	−0.017	0.016	0.016
	(0.033)	(0.062)	(0.036)	(0.032)	(0.060)	(0.035)
Constant	−0.075	−0.716***	−0.390***	0.067	−0.551***	−0.343**
	(0.084)	(0.145)	(0.093)	(0.138)	(0.192)	(0.143)
Observations	17,519	17,519	17,519	17,519	17,519	17,519
Controls in eq. (7)	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.043	0.027	0.041	0.042	0.027	0.041

Notes: This table shows the effect of CEO overconfidence on the relationship between CFO overconfidence and stock price crash risk. The standard errors clustering at the firm level are displayed in parentheses. The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

In addition, based on the false consensus effect theory, we predict that the stock price crashes increase when both CFOs and CEOs are overconfident. Table 9 shows the regression results for the joint effect of CEO overconfidence and CFO overconfidence on stock price crash risk. The variable of interest is the interaction term, $Holder67CFO_{i,t-1} \times Holder67CEO_{i,t-1}$. In columns (5) and (6), $Holder67CFO_{i,t-1} \times Holder67CEO_{i,t-1}$ has a significantly positive coefficient, showing that overconfident CEOs amplify the positive relationship between CFO overconfidence and stock price crash risk, which is in line with our prediction and confirm our hypothesis 5.

5.3. Stronger governance, CFO overconfidence, and stock price crash risk

This section analyzes how governance affects the link between overconfident CFOs and stock price crash risk. Baker and Wurgler (2013) suggest that to make managers who are not completely rational have a positive impact, corporate governance should limit their ability. In the same vein, Kim, Wang, and Zhang (2016) find that corporate governance mechanisms designed to solve traditional agency problems also aid in the restraint of overconfident managers' behaviors.

Therefore, we anticipate that overconfident CFOs will reduce risk-taking and bad news hoarding behaviors under strong governance monitoring (e.g., Brennan and Solomon, 2008; Stein, 2008). However, we might get a different result if strong governance cannot change the overconfident CFOs' decisions as some studies argue that governance has a limited effect on overconfident managers' behaviors (e.g., Ahmed and Duellman, 2013). Thus, whether effective corporate governance might influence the behaviors of overconfident CFOs is an open empirical question. We employ the management entrenchment index (E index) to capture monitoring following previous research. Bebchuk et al. (2009) award each firm a score ranging from zero to six. Lower E index values indicate better corporate governance. Following Hsu, Novoselov, and Wang (2017), we define strong monitoring ($LowEindex_{i,t-1}$) as an indicator variable that equals one if E index is less than three, and zero otherwise.

The results are reported in the first three columns of Table 10. In columns (1) to (3), the coefficient on $Holder67CFO_{i,t-1} \times LowEindex_{i,t-1}$ is negative. However, the coefficient on $Holder67CFO_{i,t-1} \times LowEindex_{i,t-1}$ is only significant in column (1), suggesting that we find limited evidence to support that strong governance alters the positive relationship between CFO overconfidence and stock price crash risk. Our findings differ from those of Ahmed and Duellman (2013), who find that overconfident CEOs insist on their decisions under strong governance. It may be because CFOs have a higher turnover rate than CEOs when firms have low reporting quality (Hennes, Leone, and Miller, 2008), which raises overconfident CFOs' career concerns. Thus, overconfident CFOs tend to reduce bad news hoarding and risk-taking behaviors under strong governance.

5.4. Information asymmetry, CFO overconfidence, and stock price crash risk

We have found that overconfident CFOs affect stock price crash risk via making risky decisions and hoarding bad news. As a transparent information environment reduces CFOs' motivations, opportunities, and capacity to take more risks and delay disclosing bad news (LaFond and Watts, 2008), CFOs are less likely to take risky actions and hide bad news when firms have lower asymmetric information. Accordingly, we predict that a low level of information asymmetry mitigates the influence of CFO overconfidence on stock price crash risk.

Our study uses two proxies, analyst forecast error and analyst forecast dispersion, to measure information asymmetry following prior studies.[12] The low level of information asymmetry indicates a transparent information environment. The $LowError_{i,t-1}$ ($LowDispersion_{i,t-1}$) is an indicator variable that equals one if analyst forecast error (analyst forecast dispersion) is lower than the mean value of the same industry in the same year, and zero otherwise. The moderating effect of information asymmetry on the relationship between CFO overconfidence and stock price crash risk is shown in columns (4) to (9) of Table 10. The coefficient on $Holder67CFO_{i,t-1} \times LowError_{i,t-1}$ is significantly negative in columns (4) to (6). In columns (7) to (9), $Holder67CFO_{i,t-1} \times LowDispersion_{i,t-1}$ has a negative and significant coefficient. These findings suggest that a transparent information environment mitigates the effect of overconfident CFOs on stock price crash risk.

6. Conclusion

In this study, we shed light on the association between CFO overconfidence and firm-specific stock price crash risk. Using a large sample of US-listed firms from 1993 to 2019, we find that overconfident CFOs increase future stock price crash risk. To mitigate the adverse causality

[12] Detailed variable information is shown in the Appendix.

Table 10
Governance and information asymmetry.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$	$SCR\_Crash_{i,t}$	$SCR\_Ncskew_{i,t}$	$SCR\_Duvol_{i,t}$
$Holder67CFO_{i,t-1}$	0.060*	0.000	0.020	0.034***	0.064***	0.040***	0.036***	0.070***	0.042***
	(0.034)	(0.061)	(0.040)	(0.012)	(0.021)	(0.014)	(0.012)	(0.022)	(0.015)
$LowEindex_{i,t-1}$	0.056	0.180**	0.069						
	(0.050)	(0.081)	(0.051)						
$Holder67CFO_{i,t-1} \times LowEindex_{i,t-1}$	**−0.103****	**−0.076**	**−0.072**						
	(0.049)	**(0.082)**	**(0.054)**						
$LowError_{i,t-1}$				0.029***	0.067***	0.036***			
				(0.011)	(0.019)	(0.013)			
$Holder67CFO_{i,t-1} \times LowError_{i,t-1}$				**−0.028****	**−0.059****	**−0.029***			
				(0.014)	**(0.024)**	**(0.016)**			
$LowDispersion_{i,t-1}$							0.029**	0.057***	0.039***
							(0.012)	(0.021)	(0.013)
$Holder67CFO_{i,t-1} \times LowDispersion_{i,t-1}$							**−0.026***	**−0.063****	**−0.032***
							(0.015)	**(0.026)**	**(0.017)**
Constant	0.251	−0.217	−0.105	0.048	−0.593***	−0.366**	0.013	−0.639***	−0.376**
	(0.389)	(0.449)	(0.295)	(0.139)	(0.194)	(0.144)	(0.146)	(0.195)	(0.148)
Observations	2602	2602	2602	17,245	17,245	17,245	16,448	16,448	16,448
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.015	0.044	0.072	0.041	0.027	0.041	0.041	0.027	0.042

Notes: The tables show the moderating effect of strong governance on the relationship between CFO overconfidence and stock price crash risk. The standard errors clustering at the firm level are displayed in parentheses. Controls include control variables in eq. (7) and CEO characteristics ($Holder67CEO_{i,t-1}$, $CEO\_equityincentive_{i,t-1}$, and $CEO\_male_{i,t-1}$). The Appendix contains detailed information on the variables. *, **, and *** denote 0.10, 0.05, and 0.01, respectively. The variables highlighted in bold are the ones we are interested in.

concern, we conduct the PSM-DID test. Compared to firms where former and new CFOs are non-overconfident, firms that change their CFOs from non-overconfidence to overconfidence increase the possibility of crash risk, which supports our main finding. Besides, our finding is robust under three stock price crash risks and two overconfidence measures. Moreover, the influence of CFO overconfidence on stock price risk is not driven by insider trading incentives.

In the cross-sectional tests, we prove that overconfident CFOs affect stock price crash risk through two channels, taking more risky activities and hoarding bad news. We further show that CFO overconfidence exceeds CEO overconfidence in affecting stock return tail risks. Firms with both overconfident CEOs and CFOs raise stock price crash risk. In addition, we document that the positive effect of overconfident CFOs on stock price crash risk is lessened when CFOs are strongly monitored or their firms have low information asymmetry.

Our findings contribute to the literature and theory and have substantial practical implications. In terms of the contributions to the literature, we complement and extend the study of Kim, Wang, and Zhang (2016) on the influence of CEO overconfidence on stock price crash risk by testing the effect of CFO overconfidence and jointly considering the CEO and CFO overconfidence. Our study also extends the research on CFO overconfidence and answers the calls made by Black and Gallemore (2013) and Malmendier et al. (2019). Theoretically, our findings reveal that CFOs' psychological characteristics significantly affect their decisions, providing more empirical evidence to support overconfidence and upper echelon theories. The dominating effect of CFO overconfidence in the stock price crash contributes to the power circulation theory. Our findings on the joint effect of CFO overconfidence and CEO overconfidence on crash risk contributes to the false consensus effect theory. In terms of contributions to practice and policy, given that a sharp drop in stock prices may result in severe losses for investors' portfolios (Hong and Stein, 2003), our findings should serve as a warning to financial statement users to keep an eye on the information disclosure of overconfident CFOs.

Compared with the research on CEO overconfidence, the research on CFO overconfidence is very limited. As an increasing number of CFOs are involved in corporate strategy decision-making, we suggest that future studies should investigate the effect of CFO overconfidence and how it interacts with CEO overconfidence in a series of strategic decisions.

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Declaration of Competing Interest

None.

Data availability

Data will be made available on request.

Appendix A. Variable information

Variables	Definition	Database
Dependent variables		
$SCR\_Crash_{i,t}$	The chance of a crash (Kim et al., 2011a, 2011b)	CCM; CRSP
$SCR\_Ncskew_{i,t}$	Negative conditional return skewness (Chen et al., 2001).	CCM; CRSP

(continued on next page)

(*continued*)

Variables	Definition	Database
$SCR\_Duvol_{i,t}$	Down-to-up volatility (Kim et al., 2011a).	CCM; CRSP
Independent variables		
$Holder67CFO_{i,t-1}$	CFO overconfidence: $Holder67CFO_{i,t-1}$, an indicator variable, equals one when CFOs hold vested options that are at least 67% in the money for the first time until the end of their tenure, and zero otherwise (Chen et al., 2022).	ExecuComp
$CFO\_equityincentive_{i,t-1}$	CFOs' equity-based incentives: ONEPCT/(ONEPCT+Salary+Bonus). The variable ONEPCT represents the dollar change in the value of the CFOs' stock and option holdings as a result of a 1% increase in the firm stock price. (Bergstresser and Philippon, 2006).	ExecuComp
$CFO\_male_{i,t-1}$	Male CFO: an indicator variable equals one if the CFO is a male, and zero otherwise.	ExecuComp
$Dturn_{i,t-1}$	Stock trading volume: *Average monthly share turnover in year t − Average monthly share turnover in year t-1* (Note: $Monthly\ share\ turnover = \frac{Monthly\ trading\ volume}{The\ total\ number\ of\ shares\ outstanding\ during\ the\ month}$) (Kim et al., 2011a)	CCM; CRSP
$SCR\_Ncskew_{i,t-1}$	Negative conditional return skewness in year t-1. (Kim et al., 2011a)	CCM; CRSP
$Sigma_{i,t-1}$	Return volatility: the standard deviation of firm-specific weekly returns over the fiscal year period (Kim et al., 2011a).	CCM; CRSP
$Ret_{i,t-1}$	Average firm-specific weekly return: the mean of firm-specific weekly returns over the fiscal year period, times 100. (Kim et al., 2011a)	CCM; CRSP
$MTB_{i,t-1}$	Market to book ratio: equity market value (PRCC_F × CSHO) divided by equity book value (SEQ) (Demerjian, Lewis-Western, and McVay, 2020)	CCM
$ROA_{i,t-1}$	Return on asset: divide income before extraordinary items (IB) by the total asset (AT) (Hsieh, Bedard, and Johnstone, 2014).	CCM
$FirmSize_{i,t-1}$	Firm size: the natural logarithm of total assets (AT) (Jiang et al., 2010).	CCM
$Leverage_{i,t-1}$	Leverage: sum of long-term debt (DLTT) and short-term debt (DLC) over total assets (AT) (Hsieh et al., 2014).	CCM
$AbsAEM_{i,t-1}$	The absolute value of earnings management: we use the measurement proposed by Banker, Byzalov, Fang, and Jin (2019) for the construct earnings management. $\frac{TA_{it}}{A_{it-1}} = \beta_0 + \beta_1\frac{1}{A_{it-1}} + \beta_2\frac{\Delta REV_{it} - \Delta REC_{it}}{A_{it-1}} + \beta_3\frac{PPE_{it}}{A_{it-1}} + \gamma_1 spSGR_{1it} + \gamma_2 spSGR_{2it} + \gamma_3 spSGR_{3it} + \gamma_4 spSGR_{4it} + \gamma_5 spSGR_{5it} + \varepsilon_{it},$ where, TA_{it} refers to the total asset calculated by the balance sheet ((ACT - CHE) - (LCT - DLC) - (DP)). $spSGR_{kit}$ is the spline variable which is calculated as follows: $\mathrm{spSGR_{kit}} = \begin{cases} 0 & \text{if } \mathrm{SGR_{it}} \text{ is below quintile k} \\ \mathrm{SGR_{it}} - \mathrm{spSGR_k^{low}} & \text{if } \mathrm{SGR_{it}} \text{ is in quintile k} \\ \mathrm{spSGR_k^{high}} - \mathrm{spSGR_k^{low}} & \text{if } \mathrm{SGR_{it}} \text{ is above quintile k} \end{cases},$ where, SGR_{it} is the sale growth rate ((SALE − L. SALE) / L. SALE). The lower limit of sales growth rate quintile k is $spSGR_k^{low}$. The upper limit of sales growth rate quintile k is $spSGR_k^{high}$. The discretionary accrual (AEM_{it}) is residual. We use the lagged absolute value of AEM ($AbsAEM_{i,t-1}$) to capture the magnitude of AEM.	CCM
Variables in the robustness tests		
$Holder100CFO_{i,t-1}$	CFO overconfidence: $Holder100CFO_{i,t-1}$, an indicator variable, equals one when CFOs hold vested options that are at least 100% in the money (the lagged value of the *average percent moneyness of the option*$_{i,t}$) for the first time until the end of their tenure, and zero otherwise.	ExecuComp
$AbEarnings_{i,t-1}$	The difference between this year's and last year's earnings per share is divided by the fiscal year-end stock price. (Huang et al., 2016)	CCM
Variables in the cross-sectional tests		
$PositiveAEM_{i,t-1}$	Income increasing earnings management: $\frac{TA_{it}}{A_{it-1}} = \beta_0 + \beta_1\frac{1}{A_{it-1}} + \beta_2\frac{\Delta REV_{it} - \Delta REC_{it}}{A_{it-1}} + \beta_3\frac{PPE_{it}}{A_{it-1}} + \varepsilon_{it},$ where, TA_{it} is the total accrual calculated from the cash flow statement (CCM variable: IBC - (OANCF − XIDOC)). β_0 is the unscaled intercept. ΔREV_{it} is the change of revenue (REVT − L. REVT). ΔREC_{it} is the change of accounts receivable (RECT − L. RECT). PPE_{it} is the property, plant, and equipment (PPEGT). A_{it-1} is the lagged total asset (L. AT). The discretionary accrual (AEM_{it}) is the estimated residual from the equation. We use lagged discretionary accrual (AEM_{it-1}). We define income-increasing accrual-based earnings management, $Positive\_AEM_{it-1}$, as an indicator variable that equals one if AEM_{it-1} is positive and zero otherwise.	CCM
$LowCETR_{i,t-1}$	The low level of firms' cash effective tax rate: Cash effective tax rate ($CETR_{i,t}$) is calculated by cash taxes paid (TXPD) divided by pre-tax book income (PI) less special items (SPI). $Low\_CETR_{i,t-1}$ equals one if $CETR_{i,t-1}$ is lower than the mean tax avoidance level of industry in the same year, and zero otherwise.	CCM
$LowETR_{i,t-1}$	The low level of firms' effective tax rate: Effective tax rate ($ETR_{i,t}$) is calculated by the total tax expense (TXT) divided by pre-tax book income (PI) less special items (SPI) (Dyreng, Hanlon, and Maydew, 2008). $Low\_ETR_{i,t-1}$ equals one if $ETR_{i,t-1}$ is lower than the mean tax avoidance level of industry in the same year, and zero otherwise.	CCM
$Holder67CEO_{i,t-1}$	CEO overconfidence: $Holder67CEO_{i,t-1}$, an indicator variable, equals one when CEOs hold vested options that are at least 67% in the money (the lagged value of the *average percent moneyness of the option*$_{i,t}$) for the first time until the end of their tenure, and zero otherwise.	ExecuComp
$CEO\_equityincentive_{i,t-1}$	CEOs' equity-based incentives: ONEPCT/(ONEPCT+Salary+Bonus). The variable ONEPCT represents the dollar change in the value of the CEOs' stock and option holdings as a result of a 1% increase in the firm stock price. (Bergstresser and Philippon, 2006).	ExecuComp
$CEO\_male_{i,t-1}$	Male CEO: an indicator variable equals one if the CEO is a male, and zero otherwise.	CCM
$LowEindex_{i,t-1}$	The low value of the E index: an indicator variable that equals one if E index is less than three, and zero otherwise (Hsu et al., 2017).	Bebchuk et al. (2009)
$LowError_{i,t-1}$	The low level of analyst forecast error: analyst forecast error is calculated by the absolute value of the difference between the mean value of the analyst forecast and actual earnings in year t-1 divided by the absolute value of actual earnings in year t-1 (Li and Zhao, 2008). $LowError_{i,t-1}$ is an indicator variable that equals one if analyst forecast error is lower than the mean value of the same industry in the same year, and zero otherwise.	I/B/E/S
$LowDispersion_{i,t-1}$	The low level of analyst forecast dispersion: Analyst forecast dispersion is measured using the standard deviation of analyst forecasts in year t-1 divided by the absolute value of the median value of analyst forecasts in year t-1 (Richardson, 2000). $LowDispersion_{i,t-1}$ is an indicator variable that equals one analyst forecast dispersion is lower than the mean value of the same industry in the same year, and zero otherwise.	I/B/E/S

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