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RESEARCH ARTICLE

CEO overconfidence and bank systemic risk: Evidence from U.S. bank holding companies

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Abstract

Following the 2007–2008 financial crisis, the attention of financial regulators and academics has shifted from bank individual risk to bank systemic risk, that is, banks' exposure to future systemic crises. In this paper, we examine whether CEO overconfidence could explain cross-sectional heterogeneity in the systemic risk of U.S. bank holding companies. Using measures of overconfidence based on CEOs' options exercise behaviour and language used in the Managerial Discussion and Analysis of the 10K-filings, we find that banks with overconfident CEOs have higher systemic risk than their counterparts with non-overconfident CEOs. Banks with overconfident CEOs also have higher holding of private mortgage-backed securities and higher leverage. During the 2007–2008 financial crisis, banks with overconfident CEOs experienced higher realized systemic risk. Our work shows that the behaviour of overconfident bank CEOs could impose negative externalities beyond individual bank boundary.

KEYWORDS

banks, CEO overconfidence, MD&A, options, systemic risk, tone analysis

1 | INTRODUCTION

The 2007–2008 financial crisis has prompted intensive discussion about the systemic nature of the financial sector (Acharya, Pedersen, Philippon, & Richardson, 2017; Bisias, Flood, Lo, & Valavanis, 2012; Kashyap, Rajan, & Stein, 2010). While banks could become less risky individually, they could simultaneously impose greater risks to the financial system (Nijskens & Wagner, 2011). Furthermore, banks vary greatly in terms of the systemic risk that they contribute to the financial sector. For example, Acharya et al. (2017) report that the ex post systemic risk of Citigroup and US Bancorp Del., as measured by the stock returns during the crisis period, was −85.86% and −17.56%, respectively. As bank regulators have increasingly been concerned with the stability of the financial sector (Acharya et al., 2017; Peltonen, Rancan, & Sarlin, 2019), a pertinent question is what can explain substantial variations in banks' contribution to a systemic event.

In this paper, we address the above question with the literature of managerial personality traits. Our focus is on overconfidence bias, a personality trait, which, if present, could seriously impair managerial judgement about future outcomes. The psychology literature has provided extensive evidence that individuals over-estimate their own ability and/or are unrealistically optimistic concerning the likely outcome of good future events; and that executives are more prone to this behavioural bias than the general population (see, e.g., Alicke, Klotz, Breitenbecher, Yurak, & Vredenburg, 1995; Moore, 1977; Svenson, 1981;

Weinstein, 1980). Research in corporate finance shows that overconfident CEOs over-estimate the return to investment projects (Malmendier & Tate, 2005), are more likely to make acquisitions (Malmendier & Tate, 2008; Roll, 1986) and are more willing to put their firms at risk by undertaking risky activities (Galasso & Simcoe, 2011; Hirshleifer, Low, & Teoh, 2012). We assert that in the interconnected and systemic financial sector, this personality bias could increase banks' contribution to a systemic crisis and consequently generate negative externalities.[1]

Our attention is on bank CEOs because in a typical bank, the CEO is considered the single most powerful individual and his/her attitude is likely to influence the organization's overall risk preference.[2] Furthermore, CEOs are more prone to overconfidence bias than the general population (Malmendier, Tate, & Yan, 2011) and such bias could be exaggerated by their celebrity/elite status in the media (Hayward, Rindova, & Pollock, 2004). Although most banks have boards of directors, risk committees and other governance mechanisms, these are not always active, independent or effective in reining in CEO behaviours (Ellul & Yerramilli, 2013). Larger boards are even reported to associate with higher bank systemic risk during the 2007–2008 crisis (Battaglia & Gallo, 2017).

Following Acharya et al. (2017), we measure systemic risk as a bank's marginal expected shortfall (*MES*). This is the expected amount the bank is undercapitalized in a systemic event in which the overall financial system is undercapitalized. Compared to other measures such as *CoVaR* (Adrian & Brunnermeier, 2016) or tail betas (De Jonghe, 2010),[3] *MES* is conceptually different and has more predictive power for the ex post losses during the 2007–2008 crisis (Acharya et al., 2017).[4] It is an ex ante measure of systemic risk based on bank capital, which is important for the financial sector stability. For example, Beltratti and Stulz (2012) find that better capitalized banks perform better during the 2007–2008 crisis (see also Laeven, Ratnovski, & Tong, 2015). Battaglia and Gallo (2017) report that banks headquartered in European countries with less restriction on capital have more systemic risk during the crisis. In keeping with the motivation of the paper, we also investigate whether CEO overconfidence is associated with their banks' holding of private mortgage-backed securities (MBSs) which, unlike any other type of loans, exposes banks to the whole financial system (Bernanke et al., 2008; Longstaff, 2010; Purnanandam, 2011; Thakor, 2015a).[5,6]

We use two measures of CEO overconfidence. The first is based on CEO options exercise behaviour as in Malmendier and Tate (2005) and Campbell, Gallmeyer, Johnson, Rutherford, and Stanley (2011). The second is based on the language/tone that CEOs use in the Managerial Discussion and Analysis (MD&A) section of banks' 10K-filings. Unlike the options-based proxy, which considers overconfidence as a permanent personality trait (Galasso & Simcoe, 2011; Malmendier & Tate, 2005), the tone-based proxy is time-variant. This allows us to document changes in the usage of optimistic language and their association with bank systemic risk over time.[7]

Our empirical analysis of U.S. bank holding companies (BHCs) shows that on average, banks with overconfident CEOs have higher systemic risk, both measured as the ex ante average dollar loss in market capitalization during the worst 5% of market return days and as the ex post losses during the 2007–2008 crisis, compared to banks with non-overconfident CEOs. Banks with overconfident CEOs also have higher holding of private MBSs and higher leverage. In the aftermath of the financial crisis, fewer CEOs are classified as being overconfident but we find no evidence of a structural break in the relationship between CEO overconfidence and bank systemic risk.

We recognize a certain caveat to our empirical analysis, concerning the possibility of an endogenous relationship between bank systemic risk and overconfident CEOs. It may be that a bank's risk preference, which is not directly observable, determines both its level of systemic risk and the type of CEOs, overconfident or non-overconfident, that it hires.[8] Endogeneity may also present if there is measurement error in our key variable, CEO overconfidence. We conduct multiple checks to address this potential endogeneity issue using different estimation methods and measurements of CEO overconfidence.

Our work contributes to the growing literature that explains cross-sectional variations in bank systemic risk. Prior research focuses on bank- and sector-specific characteristics and activities to explain bank systemic risk such as size and capital (Laeven et al., 2015), interbank exposures (Drehmann & Tarashev, 2013), non-traditional banking activities (Brunnermeier, Dong, & Palia, 2012; De Jonghe, 2010), cross-border banking networks (Peltonen et al., 2019) and the seniority structure of banking liabilities (Bougheas & Kirkman, 2018). We, on the other hand, use a behavioural approach to provide novel evidence of the effect of CEO-biased beliefs on bank systemic risk.

Our paper also contributes to the debate on whether executive compensation structure encourages excessive risk-taking behaviour in the financial sector. Cheng, Hong, and Scheinkman (2015) show that bank individual risk increases with the incentives embedded in bank executives' compensation contracts. In contrast, Fahlenbrach and Stulz (2011) attribute higher bank risk exposure to CEOs' misjudgement based on the evidence that banks with higher incentives awarded to the CEOs do not necessarily perform worse during the 2007–2008 crisis. Our results are consistent with and complement Fahlenbrach and Stulz's finding.

Finally, our work adds to the existing literature on CEO overconfidence in an important way. Previous studies document that overconfident CEOs pursue risky activities and increase firm individual risk (Campbell et al., 2011; Hirshleifer et al., 2012; Malmendier & Tate, 2005, 2008). The few studies on CEO overconfidence bias in the banking sector such as Ho, Huang, Lin, and Yen (2016) and Black and Gallemore (2013) only address the impact of overconfident CEOs on lending standards and loan loss provisions. To the best of our knowledge, this is the first paper that shows how CEO-biased beliefs can affect well *beyond* firm boundary. While lower lending standards and loan loss provision (as addressed in Ho et al., 2016 and Black & Gallemore, 2013) may associate with higher bank systemic risk, these studies do not directly measure banks' contribution to a systemic event like our measure *MES*. Our results therefore have an important implication: overconfidence bias among banks' top decision makers may impose costly externalities to the financial sector and the rest of the economy.

The paper is structured as follows. Section 2 reviews relevant literature and develops hypotheses about the relationship between CEO overconfidence and bank systemic risk. Section 3 describes data and methodology. We present our empirical results in Section 4 and robustness checks in Section 5. Section 6 concludes the paper.

2 | RELEVANT LITERATURE AND HYPOTHESIS DEVELOPMENT

2.1 | CEO overconfidence

Overconfidence bias is defined as unrealistic beliefs about one's ability and skills and/or about the distribution of an uncertain outcome, such as overstating the mean of possible outcomes, or over/under-estimating the likelihood of positive/negative outcomes (see, e.g., Gilovich, Griffin, & Kahneman, 2002; Hirshleifer et al., 2012; Schrand & Zechman, 2012). The psychology literature has provided compelling evidence that people have biased views about their own competence compared to others such as being better driver (Svenson, 1981), being in the top 30% of the peer group (Alicke et al., 1995) or making more accurate predictions (Fischhoff, Slovic, & Lichtenstein, 1977). Weinstein (1980) describes unrealistic optimism about future as people's tendency to believe that their prospects are better than average, that is, positive outcomes (such as getting a good job with high pay) are more likely to happen, while negative outcomes (such as having serious diseases or family issues) are less likely to happen to them than their peers. This literature also indicates that a common source of biased distribution of an uncertain outcome is self-attribution bias, that is, individuals attribute good outcomes to their ability and bad outcomes to external factors (Gilovich et al., 2002; Langer & Roth, 1975).

Overconfidence bias can explain actions of CEOs such as using less conservative accounting (Ahmed & Duellman, 2013), issuing more optimistic forecast (Hribar & Yang, 2015) and intentionally misreporting financial information (Schrand & Zechman, 2012). Prior research also shows that this bias makes overconfident CEOs more likely to put their firms at risk. Adam, Fernando, and Golubeva (2015) report that overconfident CEOs increase speculative activities even after losses have been realized. Hirshleifer et al. (2012) find that overconfident CEOs attempt to show their vision by investing more heavily in innovative but risky projects. But the consequences of CEO-biased beliefs in non-financial firms are typically restricted to the firms themselves and unlikely to trigger a systemic event. In the following section, we argue that actions of overconfident CEOs in financial firms may impose externalities that seriously affect other firms in the sector and the rest of the economy.

2.2 | CEO overconfidence and bank systemic risk

The banking sector is unique in its interconnected and systemic nature. Any losses, illiquidity or insolvency of an individual financial institution can quickly spread to and seriously impair others in the financial sector (Bisias et al., 2012; Drehmann & Tarashev, 2013). In a formal game-theoretic model, Lagunoff and Schreft (2001) show that a financial crisis can arise as losses spread among financial institutions that have linkages through interrelated portfolios and payment commitments. In their model of the banking system, Bougheas and Kirkman (2018) suggest that the higher connectivity, which the seniority structure of bank liabilities encourages, might exacerbate systemic risk. Innovation such as securitization, while improving liquidity in the mortgage market could lead to 'an opaque web of interconnected obligations' among financial institutions and amplify losses into turmoil in the financial market (Brunnermeier, 2009, p. 98).

Although much has been written on bank and sector characteristics that could explain variations in systemic risk (Brunnermeier et al., 2012; Laeven et al., 2015; Peltonen et al., 2019) no prior study has analysed systemic risk from bank CEOs' behavioural perspective. Yet it is hard to dispute the influence that bank CEOs and their beliefs about future outcomes have on bank policies. Ho et al. (2016) postulate that overconfident CEOs overvalue the prospects of their borrowers, place less weight on downside risk and consequently ease lending

standards. Black and Gallemore (2013) show that overconfident CEOs over-estimate the prospects of loan recovery and thus recognize lower loan loss provisions. We hypothesize that overconfident bank CEOs over-estimate the prospects of future outcomes and/or their ability to deliver good outcomes of risky activities which may subject their banks to higher systemic risk compared to banks with non-overconfident CEOs.

Our argument is related to, but different from, the theoretical model of Thakor (2015b). Thakor shows that a systemic crisis may occur when, following a sufficiently long sequence of good outcomes, investors and financial institutions have unrealistic beliefs in the risk management skills of bankers and consequently underestimate the true risk of risky activities and invest more in high risk products (Thakor, 2015b). The focus of our paper, however, is the biased beliefs that bank CEOs have about their own ability and the probability of the occurrence of good future outcomes.

Investment in MBSs is an innovation unlike any other bank activities. In the years leading to the 2007–2008 financial crisis, the MBSs appeared attractive in terms of earnings and risk: they distributed risk among holders and were often assigned high ratings by securities rating agencies (Longstaff, 2010). Here we conjecture that overconfident bank CEOs are attracted to the innovative MBSs, perhaps in the same way as overconfident CEOs in non-financial firms to high-risk innovations (as in Galasso & Simcoe, 2011; Hirshleifer et al., 2012). However, dramatic growth in the subprime mortgage market and originating banks' deteriorating incentives to screen and monitor mortgage deals led to decrease in quality and increase in the risk of holding of these securities more than previously estimated (Purnanandam, 2011). The MBSs exposed banks to the whole financial system through mortgage holdings of off-balance-sheet vehicles and claims on counterparties that were exposed to subprime and other complex securities (Bernanke et al., 2008; Longstaff, 2010), increasing the likelihood that banks incur losses at the same time (Brunnermeier et al., 2012; Nijskens & Wagner, 2011). This demonstrates what Acharya, Engle, and Richardson (2012) describe as a shock in the financial market due to a change in the fundamental value of the assets traded in the market. As Thakor (2015a) puts it, the MBS holding of 'interconnected and systemically important institutions' creates greater systemic risk (p. 170). The above discussion leads to the following hypotheses:

H1 Banks with overconfident CEOs have higher systemic risk than banks with non-overconfident CEOs.

H2 Banks with overconfident CEOs hold more MBSs investment than banks with non-overconfident CEOs.

3 | DATA AND METHODS

3.1 | Data

Our analysis is based on a sample of CEOs of BHCs which is the intersection of the following datasets: Execucomp (for data on CEO compensation and CEO characteristics), the quarterly FR-Y9C call reports from the Federal Reserve Bank of Chicago (for accounting and financial data) and the EDGAR database on the SEC's website (for the 10K-filings) from 1994 to 2014. As in Fahlenbrach and Stulz (2011), we exclude non-traditional banking firms such as pure brokerage, insurance or investment firms and use Compustat Bank and Bankscope if there are missing accounting observations in the FR-Y9C reports. We obtain stock returns from the Center for Research in Security Prices (CRSP) database. All financial and accounting variables are winsorized at 1 and 99% to eliminate the effects of outliers. This process yields a final sample of 1,236 firm-year observations with 164 banks and 238 CEOs.[9]

3.2 | Identification strategy

To measure the impact of CEO overconfidence on bank systemic risk, we use the following model:

$$y_{i,t} = \alpha_1 + \alpha_2 OC_{i,t-1} + \beta' X_{i,t-1} + \gamma' Z_{i,t-1} + \nu_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

where $y_{i,t}$ represents the dependent variables of interest, which are systemic risk (*MES*) and private mortgage-backed securities (*MBS*) for bank i in year t, $OC_{i,t-1}$ is a dummy variable that takes a value of 1 if bank i has an overconfident CEO in year $t-1$ and 0 otherwise, $X_{i,t-1}$ is a vector of bank characteristics of bank i in year $t-1$, $Z_{i,t-1}$ is a vector of CEO characteristics of the CEO of bank i in year $t-1$, ν_i and μ_t are bank and year fixed effects, respectively, and $\varepsilon_{i,t}$ is the random error. We report the OLS and the WLS estimations. While both provide qualitatively similar results, we prefer the WLS approach, which uses bank size as weights to account for the fact that U.S. banks vary greatly in size. This is also the popular choice among studies of U.S. banks such as Ellul and Yerramilli (2013) and Ho et al. (2016).

We recognize that our estimation process may suffer from an endogeneity problem which, if present, could confound the results and yield biased and inconsistent estimates. Endogeneity may occur in our empirical analysis due to omitted variables that may be correlated with CEO overconfidence and at the same time determine bank systemic risk. One may argue that a bank that pursues an aggressive risk strategy may also hire a CEO who

is more likely to implement this strategy. Such bank may also structure the managerial compensation that encourages risky behaviour and makes it more costly for shareholders to monitor the managers (Bai & Elyasiani, 2013). To address this concern, we include bank- and year-fixed effects to control for unobserved omitted variables. Furthermore, as in Battaglia and Gallo (2017), we control for bank and CEO characteristics that are likely to affect risk-taking decisions, all measured in the preceding year.

To deal with the concern that the nature of endogeneity in our estimation could be dynamic,[10] for example, bank risk strategy may change over time and when it does it may simultaneously change bank systemic risk and the types of CEO that banks hire, we also estimate a dynamic panel GMM model as in Ellul and Yerramilli (2013), using lags of systemic risk and bank and CEO characteristics as instruments to take into account bank past exposure to a systemic event in the estimation.

3.3 | Measures of CEO overconfidence

As CEO overconfidence is not directly observable, extant literature resorts to proxies that use CEOs' options exercising or trading behaviour (Malmendier & Tate, 2005, 2008), CEOs' language/tone (Davis, Piger, & Sedor, 2012) or media portrayal of CEOs (Hirshleifer et al., 2012; Malmendier & Tate, 2008). In this paper, we use a stock options-based proxy and a tone-based proxy for CEO overconfidence.

3.3.1 | Options-based measure of CEO overconfidence

Following Malmendier and Tate (2005), we define CEOs as being overconfident if they delay exercising stock options that are 100% in the money, that is, if the stock price exceeds the exercise price by more than 100%. The decision not to exercise highly in-the-money exercisable options of CEOs indicates their optimistic bias on their ability to keep the firms' stock prices rising (Malmendier & Tate, 2005). We follow Campbell et al. (2011)'s method to calculate the average option moneyness as the realizable value per option divided by the average exercise price using executive compensation data from ExecuComp. The realizable value per option is the total realizable value of the exercisable options *OPT_UNEX_EXER_EST_VAL* divided by the number of exercisable options *OPT_UNEX_EXER_NUM*. The average exercise price is the difference between the realizable value per option and the stock price at the fiscal year end *PRCCF*.

We construct a dummy variable *OC_Options*, which takes a value of 1 from the first year in which a CEO postpones the exercisable options that are 100% in the money and 0 otherwise. We require that a CEO exhibits this behaviour in two consecutive years, rather than twice during the sample period (as in Malmendier & Tate, 2008 and Campbell et al., 2011) to ensure that such behaviour is driven by optimistic bias rather than market timing (Jenter, 2005). This method of classifying a CEO as being overconfident from the first year in which (s)he postpones the exercisable options that are 100% in the money means that the overconfidence bias is revealed only years after the CEO is hired and that the same CEO is classified as being non-overconfident before this event. This is in line with the evidence presented by Billett and Qian (2008) that CEOs develop overconfidence through experience.[11]

3.3.2 | Tone-based measure of CEO overconfidence

Prior research shows that tone and linguistic styles in corporate reports and management discussions provide important non-quantitative information about firm prospects (Davis et al., 2012; Huang, Teoh, & Zhang, 2013; Li, 2010) and executives' personality biases (Davis et al., 2012; Hambrick, 2007). Motivated by the observation that overconfident CEOs use more optimistic language (Hribar & Yang, 2015) we construct *OC_MD&A*, a dummy variable that takes a value of 1 if a CEO uses more optimistic words than pessimistic words in the Managerial Discussion and Analysis (MD&A) section in a 10K-filing and 0 otherwise. To classify words into optimistic and pessimistic, we use the textual analysis software Diction. While Loughran and McDonald (2015, p. 1) caution that 'Diction's optimistic and pessimistic word lists were not specifically created to analyze financial documents', extant literature has not yet reached a consensus on which dictionary is most appropriate to analyse the financial statements. The Diction wordlist is used in numerous contexts to count optimistic and pessimistic words, for example, earnings press release (Davis et al., 2012) and shareholder litigation (Rogers, Van Buskirk, & Zechman, 2011).

Our measure is very close to the measure used in Malmendier and Tate (2005) and Hirshleifer et al. (2012) who record the optimistic/pessimistic words that the press describes CEOs. Our tone-based measure uses the MD&As rather than the press articles for two important reasons: First, the MD&A section of 10K-filings is one of the most read and important components of the financial statements, providing qualitative and forward-looking

information (Kothari, Li, & Short, 2009; Li, 2010).[12] We expect our tone-based proxy to reveal CEO personality traits embedded in the non-quantifiable content of these documents. Second, the MD&As are required by the SEC, in which the CEOs (and banks) use their own language. Our measure therefore is not prone to the extent of media coverage of or the words of the press about individual CEOs (c.f. Hribar & Yang, 2015).

A potential source of endogeneity in our analysis could be the measurement error in CEO overconfidence. To address this concern, we employ several alternative proxies for overconfidence (discussed in the robustness check), all of which yield very similar results.

3.4 | Dependent variables

Following Acharya et al. (2017), we use the marginal expected shortfall *MES* as a measure of ex ante bank systemic risk. *MES* is based on a bank's net equity returns (w_1^i/w_0^i) calculated as the equally weighted average daily equity return of the bank (R^i) during the 5% worst days for the market returns in any given year $(I_{5\%})$.[13] Acharya et al. (2017) show that the information contained in these 'moderately bad days' (p. 13), that is, 5% worst days of the market, can be used to estimate what would happen in the extreme event of a crisis.

$$\mathrm{MES}^i_{5\%} \equiv -E\left[\frac{w_1^i}{w_0^i}-1|I_{5\%}\right] \equiv -\frac{1}{\#\mathrm{days}}\sum_{t:\text{system is in its 5\%tail}} R_t^i \tag{2}$$

We use the realized systemic expected shortfall *SES* for the ex post systemic risk where *SES* is calculated as the return of a bank during the period July 2007–December 2008 as in Acharya et al. (2017). We measure investment in private mortgage-backed securities *MBS* as the total value of private MBSs held in both trading and investment portfolios (excluding MBSs that are either issued or guaranteed by government-sponsored enterprises) divided by total assets as in Acharya, Litov, and Sepe (2013).

3.5 | Control variables

We control for bank-specific characteristics in examining the relationship between systemic risk and CEO overconfidence. We include *Log(TA)*, the natural logarithm of the value of total assets, to proxy for bank size. Prior research shows that systemic risk increases with bank size because large banks tend to pursue risky activities and/or suffer from agency problems that make them more exposed to liquidity shocks and market failures (Brunnermeier et al., 2012). Similarly, regulators are reluctant to let larger banks fail (Laeven et al., 2015). We control for *DEBT*, the ratio of long-term debt to total assets, because high leverage could cause liquidity shock and exacerbate financial risk across the financial system (Fahlenbrach & Stulz, 2011). We include *ROA*, the ratio of net income over total assets, because better performance could shield banks from the risk of defaulting and from contributing to the systemic risk of the financial sector. However, higher profitability might also indicate that banks engage in risky but more profitable non-lending activities, contributing more to a systemic event (Brunnermeier et al., 2012). We also control for *LOANS* and *DEPOSITS*, the ratios of loans and deposits over total assets, respectively. While a large loans portfolio could make a bank more vulnerable to increase in creditors' default rates, a small loans portfolio could be complemented by a larger portfolio of corporate or government bonds, which could also expose the bank to spikes in credit spread during a crisis (Beltratti & Stulz, 2012). High deposits, on the other hand, could be considered as a shock-absorbing buffer (Laeven et al., 2015). We include *MTB*, the market-to-book ratio, to control for differences in bank-specific investment opportunities (Brunnermeier et al., 2012).

We control for several CEO-specific characteristics: age, tenure, gender and total compensation. Serfling (2014) finds that older CEOs prefer less risky investment while younger CEOs pursue riskier investment to appear talented. Huang and Kisgen (2013) observe that male CEOs undertake more acquisitions, issue more debt and place narrower bound on earnings estimates. Definitions for all variables are in Appendix.

3.6 | Summary statistics

Table 1 presents the summary statistics of the variables of interest and bank- and CEO-specific characteristics. Nearly 40% CEO-years in our sample are classified as options-based overconfident. Fewer CEO-years are classified as tone-based overconfident (only 31.5%). This is comparable to the percentage of overconfident CEOs in industrial firms reported in Campbell et al. (2011) and Hirshleifer et al. (2012).[14]

The average and median values of *MES* are 0.023 and 0.019, indicating that the average and median returns on the 5% worst return days for the banks in our sample is −2.3% and −1.9%, respectively. These are comparable to the figures reported in Acharya et al. (2017).[15] As shown later in the paper, the average and median values of the ex ante measure of systemic risk *MES* are much smaller compared

TABLE 1 Bank characteristics summary statistics

	N	Mean	First quartile	Median	Third quartile	*SD*
OC_Options	1,236	0.398	0	0	1	0.490
OC_MD&A	1,236	0.315	0	0	1	0.465
MES	1,236	0.023	0.013	0.019	0.028	0.016
MBS	1,236	0.014	0.000	0.000	0.013	0.034
LVG	1,236	0.910	0.898	0.912	0.924	0.021
TA ($m)	1,236	79,746	6,025	14,000	45,000	246,997
Log(TA)	1,236	16.705	15.607	16.441	17.628	1.518
DEBT	1,236	0.631	0.572	0.658	0.712	0.107
LOANS	1,236	0.611	0.562	0.648	0.704	0.148
DEPOSITS	1,236	0.710	0.652	0.721	0.784	0.099
MTB	1,236	2.181	1.442	1.954	2.639	1.093
ROA	1,236	0.011	0.009	0.011	0.014	0.005
TOTAL_COMP ($,000)	1,236	4,553	1,405	2,403	5,557	5,319
Log(TOTAL_COMP)	1,236	7.928	7.248	7.785	8.623	0.968
TENURE	1,236	8.558	3	7	12	6.894
AGE	1,236	56.506	53	57	61	6.427
Log(AGE)	1,236	4.028	3.970	4.043	4.111	0.117
MALE	1,236	0.985	1	1	1	0.120

Note: This table shows the summary statistics of the bank and CEO characteristics of the BHCs in our sample.

to the *ex post* systemic risk *SES*, that is, loss in market value of U.S. banks during the 2007–2008 financial crisis. Other notable statistics in Table 1 are those of bank size and CEO total compensation. The average bank size is influenced by the presence of very large banks in our sample and bank size in our sample varies greatly. This is consistent to other studies on U.S. banks such as Ellul and Yerramilli (2013). Similar to bank size, the variation in CEO total compensation is very high, indicating the heterogeneity in total compensation of bank CEOs in our sample. Indeed, while the average CEO total compensation over the sample period is $4.6 million, the maximum total compensation is nearly $33 million. The variations in total compensation are partly due to high compensation awarded to star CEOs and partly because no bonuses are awarded in more than 30% of the CEO-year observations.[16]

4 | CEO OVERCONFIDENCE AND SYSTEMIC RISK

4.1 | CEO overconfidence and systemic risk

To test whether CEO overconfidence bias is related to banks' exposure to a systemic event, we use the marginal expected shortfall *MES* as dependent variable in the regressions of Table 2. We use options-based overconfidence *OC_Options* in Columns (1) to (3) and tone-based overconfidence *OC_MD&A* in Columns (4) to (6). In all regressions, we cluster the standard errors at the bank level to control for the correlation of residuals within CEO-bank pairs (Petersen, 2009). We also include bank and year fixed effects to control for unobserved heterogeneity across banks and over time.

We start with the OLS estimation in Column (1). The positive coefficient of *OC_Options* indicates that banks with overconfident CEOs have higher systemic risk. In Column (2), we report the WLS estimation, which uses bank size as weights. This approach is more appropriate in our analysis due to the size heterogeneity of banks in our sample. In Column (3), we repeat the regression in Column (2) after adding CEO-specific variables. The WLS coefficients of *OC_Options* increase substantially compared to the OLS coefficient whilst remaining significant at the 1% level once bank size is used to purge heteroscedasticity. Our results reveal that the economic impact of CEO overconfidence on systemic risk is considerable. Using the coefficient of *OC_Options* in Column (3), which is 0.003, and the mean level of *MES* of banks with non-overconfident CEOs of 0.022, on average an overconfident CEO increases bank systemic risk by a

TABLE 2 CEO overconfidence and bank systemic risk

	(1)	(2)	(3)	(4)	(5)	(6)
$OC\_Options_{t-1}$	0.0024**	0.0038***	0.0030**			
	(0.0011)	(0.0013)	(0.0015)			
$OC\_MD\&A_{t-1}$				0.0008	0.0020**	0.0018**
				(0.0007)	(0.0009)	(0.0010)
$Log(TA)_{t-1}$	0.0027**	0.0029**	0.0020	0.0029**	0.0034**	0.0021
	(0.0011)	(0.0013)	(0.0016)	(0.0012)	(0.0014)	(0.0016)
$DEBT_{t-1}$	−0.0327	−0.0501	−0.0370	−0.0359	−0.0617	−0.0451
	(0.0343)	(0.0471)	(0.0456)	(0.0347)	(0.0496)	(0.0475)
$LOANS_{t-1}$	0.0014	0.0068	0.0051	0.0007	0.0054	0.0031
	(0.0066)	(0.0058)	(0.0057)	(0.0064)	(0.0056)	(0.0054)
$DEPOSITS_{t-1}$	−0.0090	−0.0193*	−0.0212**	−0.0108	−0.0217**	−0.0228**
	(0.0092)	(0.0102)	(0.0102)	(0.0092)	(0.0101)	(0.0101)
MTB_{t-1}	0.0016**	0.0019**	0.0018**	0.0019***	0.0023**	0.0021**
	(0.0007)	(0.0008)	(0.0008)	(0.0007)	(0.0009)	(0.0009)
ROA_{t-1}	−0.3813***	−0.4200*	−0.4848**	−0.3686**	−0.3886*	−0.4687**
	(0.1435)	(0.2213)	(0.2339)	(0.1427)	(0.2224)	(0.2333)
$Log(TOTAL\_COMP)_{t-1}$			0.0014			0.0013
			(0.0010)			(0.0009)
$Log(AGE)_{t-1}$			0.0000			0.0000
			(0.0001)			(0.0001)
$TENURE_{t-1}$			0.0002			0.0003**
			(0.0001)			(0.0001)
$MALE_{t-1}$			−0.0052**			−0.0064***
			(0.0025)			(0.0024)
Constant	0.0046	0.0222	0.0204	0.0054	0.0267	0.0286
	(0.0354)	(0.0547)	(0.0539)	(0.0356)	(0.0559)	(0.0551)
N	1,001	1,001	1,001	1,001	1,001	1,001
R^2	.8504	.8607	.8627	.8490	.8586	.8620

Note: This table reports the results of the OLS (Columns 1 and 4) and the WLS (Columns 2, 3, 5 and 6) regressions examining the relationship between CEO overconfidence and BHCs' systemic risk. The dependent variable is *MES*, the average stock return of a BHC on the days in which the market return is in the bottom 5% for the year. All other variables are defined in Appendix. Bank and year fixed effects are included. Clustered by bank robust standard errors are in parentheses. ***, **, * Stand for statistical significance at the 1%, 5% and 10% level, respectively.

substantial 13.6%. This provides strong supports for Hypothesis H1 that banks with overconfident CEOs have higher systemic risk than their counterparts with non-overconfident CEOs.

In all estimations *MTB* have positive coefficients, indicating that banks with higher market-to-book values have higher systemic risk. This is consistent with previous research (Brunnermeier et al., 2012; Laeven et al., 2015). The negative coefficients of *ROA* indicate that more profitable banks are systemically less risky. This is in line with the argument that high profitability reduces banks' default risk and their contribution to a systemic event (Brunnermeier et al., 2012). In the WLS estimations, the negative coefficients of *DEPOSITS* become statistically significant, indicating that banks with more deposits are systemically less risky. In Columns (4) to (6), we use the tone-based overconfidence measure *OC_MD&A*. Overall, the results are qualitatively similar to those using *OC_Options*. We continue to find strong evidence supporting Hypothesis H1 that banks with overconfident CEOs have higher systemic risk. The coefficients of *OC_MD&A* are also larger in the WLS estimations compared to that in the OLS estimation.

4.2 | CEO overconfidence and mortgage-backed securities

Table 3 reports the results where we examine the impact of CEO overconfidence bias on bank investment in mortgage-backed assets, using *MBS* as the dependent variable. As in Table 2, we report both OLS and WLS estimations using options-based overconfidence in Columns (1) to (3) and tone-based overconfidence in Columns (4) to (6). We find that the coefficients for *OC_Options* are positive and statistically significant in all the three specifications. The WLS coefficient in Column (3) shows that having an overconfident CEO increases the ratio of private mortgaged-backed securities over total assets by 0.0073. Using the mean level of *MBS* of non-overconfident CEOs of 0.011, on average an overconfident CEO increases their bank's investment in MBSs by a substantial 66%. The statistical and economic significance of these coefficients provide strong support for Hypothesis H2 that overconfident CEOs increase their banks' exposure to systemic risk through increasing their banks' investment in MBSs. The coefficients of *Log(TA)*, *LOANS* and *MTB* indicate that smaller banks, banks with lower loans over asset ratio and lower market-to-book

TABLE 3 CEO overconfidence and private mortgage-backed securities

	(1)	(2)	(3)	(4)	(5)	(6)
$OC\_Options_{t-1}$	0.0069***	0.0079**	0.0073**			
	(0.0024)	(0.0036)	(0.0039)			
$OC\_MD\&A_{t-1}$				0.0012	0.0043	0.0039
				(0.0021)	(0.0038)	(0.0037)
$Log(TA)_{t-1}$	−0.0106***	−0.0086*	−0.0126**	−0.0098***	−0.0076	−0.0122**
	(0.0029)	(0.0053)	(0.0058)	(0.0029)	(0.0053)	(0.0058)
$DEBT_{t-1}$	0.0828	0.2205	0.2801*	0.0748	0.1959	0.2607*
	(0.0693)	(0.1503)	(0.1545)	(0.0696)	(0.1470)	(0.1511)
$LOANS_{t-1}$	−0.0875***	−0.1012***	−0.1058***	−0.0892***	−0.1041***	−0.1104***
	(0.0125)	(0.0248)	(0.0250)	(0.0126)	(0.0255)	(0.0253)
$DEPOSITS_{t-1}$	0.0194	0.0520	0.0429	0.0152	0.0471	0.0392
	(0.0172)	(0.0415)	(0.0406)	(0.0174)	(0.0407)	(0.0398)
MTB_{t-1}	−0.0030*	−0.0051**	−0.0065***	−0.0020	−0.0042*	−0.0056**
	(0.0016)	(0.0022)	(0.0023)	(0.0015)	(0.0022)	(0.0022)
ROA_{t-1}	0.2124	0.6901	0.5026	0.2511	0.7564	0.5397
	(0.2616)	(0.4681)	(0.4735)	(0.2626)	(0.4655)	(0.4713)
$Log(TOTAL\_COMP)_{t-1}$			0.0084***			0.0081***
			(0.0027)			(0.0028)
$Log(AGE)_{t-1}$			−0.0004*			−0.0004**
			(0.0002)			(0.0002)
$TENURE_{t-1}$			0.0005			0.0007**
			(0.0003)			(0.0003)
$MALE_{t-1}$			0.0031			0.0001
			(0.0078)			(0.0079)
Constant	0.1257	−0.0458	−0.0708	0.1245	−0.0358	−0.0520
	(0.0816)	(0.1819)	(0.1832)	(0.0823)	(0.1795)	(0.1789)
N	1,001	1,001	1,001	1,001	1,001	1,001
R^2	.7205	.7429	.7515	.7184	.7421	.7513

Note: This table reports the results of the OLS (Columns 1 and 4) and the WLS (Columns 2, 3, 5 and 6) regressions examining the relationship between CEO overconfidence and BHCs' systemic risk. The dependent variable is *MBS*—total private mortgage-backed securities divided by total assets. All other variables are defined in Appendix. Bank and year fixed effects are included. Clustered by bank robust standard errors are in parentheses. ***, **, * Stand for statistical significance at the 1%, 5% and 10% level, respectively.

value are more likely to invest in *MBS*. When CEO characteristics are controlled for in Column (3), we also find that the holding of MBSs increases with bank debt and CEO compensation.

In Columns (4) to (6), we report the regressions using *OC_MD&A*. While all other results remain similar, the coefficients of *OC_MD&A* are still positive but no longer statistically significant. This could be because in the later period of the sample, that is, during and after the 2007–2008 financial crisis many banks remove MBSs holdings from their balance sheets and the language that CEOs use appears to be less optimistic (more details in the next section). The estimation results (not reported here for brevity) using a subsample that excludes all observations during 2008–2014 yield positive and statistically significant coefficients of *OC_MD&A*.

4.3 | CEO overconfidence and systemic risk during and after the 2007–2008 financial crisis

We now examine the link between CEO overconfidence and bank systemic risk during and after the 2007–2008 financial crisis. For this purpose, we do three things: First, we document changes in CEO overconfidence in three periods: before, during and after the crisis. Second, we compare the ex post systemic risk *SES*, that is, bank returns during the crisis period of banks with overconfident CEOs and banks with non-overconfident CEOs. Third, we examine if the crisis results in a structural break in the link between CEO overconfidence and bank systemic risk.

Table 4 compares the averages of the annual percentages of overconfident CEOs during and after the crisis with the average in the pre-crisis period. Before the 2007–2008 crisis, on average every year 43.71% of CEOs are classified as options-based overconfident. During the 2 years of the crisis, only 37.2% of CEOs are overconfident. In the post-crisis period, this figure declines to 22.94%, that is, about half of the pre-crisis figure. All the differences are significant at the 1% level. The declines in the percentages of tone-based overconfident CEOs are even more evident. A total of 40.35% CEOs are tone-based overconfident before the crisis and this figure drop to 26.42% during the crisis and 13.43% in the post-crisis period, which is about a third of the pre-crisis figure. This indicates that CEOs notably use less optimistic language during and after the crisis. The reported larger changes in the percentages of tone-based overconfident CEOs, compared to options-based, lend support to our conjecture that the tone-based proxy incorporates more time-variant variations. All the results remain the same when we compare the medians instead of the means.

We also compare the average of numbers and percentages of optimistic and pessimistic words over the total number of words in the MD&A sections.[17] The average numbers of both optimistic and pessimistic words in the MD&As increase steadily over the sample period. The average percentage of optimistic words during the crisis period increases to 1.61% from 1.18% in the pre-crisis. Similarly, the percentage of pessimistic words increases to 1.46% from 1.10%. The post-crisis average percentage of optimistic words increases slightly compared to that in the crisis period while the post-crisis average percentage of pessimistic words declines slightly. All the differences are statistically significant at the 1% level. Interestingly, the length of the MD&As increases considerably over the three periods, which could indicate concerns over economic uncertainty. For example, the average length of the MD&As in 1994 is 9,541 words, compared to 16,154 words in 2008 and 28,806 words in 2014. We find a similar trend in the length of the 10K-filings.

Next, we examine whether CEO overconfidence is associated with ex post systemic risk during the financial crisis. In the previous section, we find that banks with overconfident CEOs have higher marginal expected

TABLE 4 CEO overconfidence before and after the financial crisis

	% Of overconfident CEOs		Optimistic words		Pessimistic words	
	OC_Options	*OC_MD&A*	Number	%	Number	%
Pre-crisis years (1994–2006)	43.71%	40.35%	205	1.18%	192	1.12%
Crisis years (2007–2008)	37.20%***	26.42%***	264	1.61%***	239	1.46%***
Post-crisis years (2009–2014)	22.94%***	13.43%***	412	1.74%***	326	1.38%***

Note: This table shows the average annual percentages of overconfident CEOs during the pre-crisis, crisis and post-crisis periods using the options-based and tone-based proxies of overconfidence. The table also reports the annual average number and percentages of optimistic and pessimistic words over total number of words used in the MD&A section of the BHCs' 10K-filings over three periods: pre-crisis, crisis and post-crisis. *t*-Statistics test the hypothesis of no difference between the percentages of overconfident CEOs and of optimistic/pessimistic words, in the crisis and post-crisis periods compared to the pre-crisis period. ***, **, * Stand for statistical significance at the 1%, 5% and 10% level, respectively.

TABLE 5 CEO overconfidence and realized systemic risk during the crisis

Panel A: (*OC_Options*)				
	Banks with non-overconfident CEOs (*N* = 68)		**Banks with overconfident CEOs (*N* = 40)**	
	Mean	**Median**	**Mean**	**Median**
SES	−34.91%	−26.67%	−37.69%*	−28.26%*
Panel B: (*OC_MD&A*)				
	Banks with non-overconfident CEOs (*N* = 82)		**Banks with overconfident CEOs (*N* = 26)**	
	Mean	**Median**	**Mean**	**Median**
SES	−34.44%	−29.79%	−41.91%**	−16.59%**

Note: This table compares the average *SES*, the ex post stock return during the period July 2007–December 2008, of BHCs with overconfident CEOs with BHCs with non-overconfident CEOs. Panel A partitions the sample into option-based non-overconfident CEO and overconfident CEOs subsamples. Panel B partitions the sample into tone-based non-overconfident CEO and overconfident CEOs subsamples. *t*-Statistics test the hypothesis of no difference between the means (medians) of the non-overconfident and overconfident subsamples. ***, **, * Stand for statistical significance at the 1%, 5% and 10% level, respectively.

shortfall *MES* than banks with non-overconfident CEOs. Unlike *MES*, which is an ex ante measure of each bank's tail dependence with the market during the more frequent 'moderately bad days', *SES* is the measure of systemic risk in an infrequent 'extreme' tail event (Acharya et al., 2017, p. 13). We use the stock returns during July 2007 and December 2008 as the ex post bank systemic risk *SES* as in Acharya et al. (2017). We partition 108 banks that have stock returns during this period into two subsamples: banks with overconfident CEOs and banks with non-overconfident CEOs, using the classification in 2006. This is to make sure that our results are not affected by changes in CEO behaviour or indeed CEO turnover during the crisis.[18] Panel A of Table 5 reports the means and medians of stock returns of both groups using the option-based overconfidence measure. On average banks with overconfident CEOs lost 37.69% of their market value during the crisis while banks with non-overconfident CEOs only lost 34.91%. The result is similar when we compare the median returns. In Panel B, we repeat the above exercise using tone-based overconfidence. There are fewer tone-based overconfident CEOs than options-based overconfident CEOs (26 and 40, respectively), which is consistent with our previous results in Table 2. We continue to find that the mean return of banks with overconfident CEOs is lower than that of banks with non-overconfident CEOs. The median return of the former, however, is higher than that of the latter group. Overall, our results indicate that banks with overconfident CEOs have higher ex post systemic risk compared to banks with non-overconfident CEOs during the crisis.

Finally, we investigate the extent to which the link between CEO overconfidence and bank systemic risk changes in the post-crisis period. In Table 6, we introduce a dummy variable *PostCrisis* that takes a value of 1 for all the years after the crisis, that is, 2009–2014, and 0 otherwise. In Column (1), we report the WLS estimation of the impact of options-based overconfidence on *MES*, controlling for bank characteristics. We interact *PostCrisis* with *OC_Options* and all other bank characteristics. We continue to find that bank systemic risk increases with CEO overconfidence. The coefficient of the interaction of *OC_Options* and *PostCrisis* is insignificant, indicating that the link between CEO overconfidence and bank systemic risk does not change after the crisis. The negative coefficient of the interaction of *Log(TA)* indicates that the effect of bank size on systemic risk is smaller in the post-crisis period compared to the pre-crisis period. The statistically significant coefficients of the interactions of *LOANS* and *DEPOSITS* suggest that loans and deposits become more important in explaining variations in bank systemic risk after the crisis. We obtain very similar results in Column (2) where we use tone-based overconfidence.[19]

5 | ROBUSTNESS CHECK

5.1 | Alternative measures of CEO overconfidence

As overconfidence is a psychological cognitive trait that is not directly observable (Galasso & Simcoe, 2011; Hambrick, 2007; Hirshleifer et al., 2012), in this section, we check if our reported results remain unchanged when we use alternative measures of overconfidence.

TABLE 6 CEO overconfidence and systemic risk: Structural breaks

	(1)	(2)
$OC\_Options_{t-1}$	0.0020**	
	(0.0010)	
$OC\_MD\&A_{t-1}$		0.0024***
		(0.0009)
$Log(TA)_{t-1}$	0.0040***	0.0039***
	(0.0013)	(0.0012)
$DEBT_{t-1}$	−0.0225	−0.0454
	(0.0315)	(0.0406)
$LOANS_{t-1}$	−0.0051	−0.0012
	(0.0070)	(0.0047)
$DEPOSITS_{t-1}$	−0.0010	−0.0088
	(0.0095)	(0.0092)
MTB_{t-1}	0.0013**	0.0018***
	(0.0006)	(0.0007)
ROA_{t-1}	−0.2229*	−0.2672*
	(0.1313)	(0.1392)
$PostCrisis*OC\_Options_{t-1}$	0.0014	
	(0.0031)	
$PostCrisis*OC\_MD\&A_{t-1}$		−0.0016
		(0.0028)
$PostCrisis*Log(TA)_{t-1}$	−0.0023**	−0.0029**
	(0.0009)	(0.0012)
$PostCrisis*DEBT_{t-1}$	0.0506	0.0646
	(0.0674)	(0.0759)
$PostCrisis*LOANS_{t-1}$	0.0197***	0.0172***
	(0.0064)	(0.0053)
$PostCrisis*DEPOSITS_{t-1}$	−0.0267*	−0.0425**
	(0.0158)	(0.0214)
$PostCrisis*MTB_{t-1}$	−0.0023	−0.0027
	(0.0021)	(0.0035)
$PostCrisis*ROA_{t-1}$	−0.2754	−0.1088
	(0.2835)	(0.3854)
Constant	−0.0327	−0.0100
	(0.0381)	(0.0457)
N	1,001	1,001
R^2	.8577	.8657

Note: This table reports the results of the WLS regressions examining the relationship between CEO overconfidence and BHCs' systemic risk. The dependent variable is *MES*, the average stock return of a BHC on the days in which the market return is in the bottom 5% for the year. *PostCrisis* is the dummy that takes a value of 1 for the years after the financial crisis, that is, 2009–2014, and 0 otherwise. All other variables are defined in Appendix. Bank and year fixed effects are included. Clustered by bank robust standard errors are in parentheses. ***, **, * Stand for statistical significance at the 1%, 5% and 10% level, respectively.

One might argue that our options-based overconfidence proxy *OC_Options* depends on whether a bank achieves exceptional stock performance, that is, whether the stock price exceeds the option exercise price by more than 100%. To address these concerns, we check whether our results change after we include 'moderately overconfident' CEOs as in Campbell et al. (2011). It is possible that these CEOs are overconfident but the stock price of their banks does not exceed the exercise price by more than 100%. In the first three columns of Table 7, we repeat the OLS and WLS regressions in Table 2 using *OC_Options67* which classifies a CEO as being overconfident if s/he delays exercising the options that are 67% in the money (as in Malmendier & Tate, 2005; Hirshleifer et al., 2012).[20] The positive and significant coefficients of *OC_Options67* indicate that bank systemic risk increases with CEO overconfidence even after we lower the moneyness cutoff. The magnitudes of the coefficients are smaller than those reported in Table 2, suggesting that the link between overconfidence bias and bank systemic risk is stronger among highly overconfident CEOs. All other results regarding bank-specific characteristics are consistent with that in Table 2, indicating that our previous results are not affected by how we construct the overconfidence proxy.

In the last three columns of Table 7, we report the OLS and WLS estimations using *OC_OptionsAll* which classifies a CEO as being overconfident if *OC_Options* takes a value of 1 in any year during the period of study and 0 otherwise. This means if a CEO delays exercising in-the-money options for any two consecutive years, the CEO is classified as being overconfident for the whole period. This is different from *OC_Options*, which classifies a CEO as being overconfident only in the years after s/he delays exercising in-the-money options. Therefore, *OC_OptionsAll* is more in line with the argument that overconfidence bias could be a permanent trait (Galasso & Simcoe, 2011). The results using *OC_OptionsAll* are quantitatively and qualitatively similar to that reported in Columns (1) to (3) of Table 2.

To check the robustness of the tone-based overconfidence proxy, we repeat our estimation with several other proxies using the language in the MD&As. We construct a ratio of the difference between optimistic words and pessimistic words scaled by the total number of optimistic and pessimistic words in a MD&A. We also create several dummy variables that classify a CEO as being overconfident if the value of this ratio is in the top 10, 20 and 50% of the sample. The results of the estimations using both the continuous and binary tone-based overconfidence proxies (not reported here for brevity) show that bank systemic risk

TABLE 7 CEO overconfidence and bank systemic risk: Alternative measures of CEO overconfidence

	(1)	(2)	(3)	(4)	(5)	(6)
$OC\_Options67_{t-1}$	0.0007*	0.0018**	0.0019**			
	(0.0010)	(0.0014)	(0.0014)			
$OC\_OptionsAll_{t-1}$				0.0024**	0.0035***	0.0026**
				(0.0010)	(0.0012)	(0.0014)
$Log(TA)_{t-1}$	0.0029**	0.0036***	0.0021	0.0028**	0.0032**	0.0022
	(0.0011)	(0.0013)	(0.0016)	(0.0011)	(0.0014)	(0.0016)
$DEBT_{t-1}$	−0.0317	−0.0521	−0.0354	−0.0321	−0.0527	−0.0397
	(0.0351)	(0.0494)	(0.0469)	(0.0335)	(0.0472)	(0.0456)
$LOANS_{t-1}$	0.0013	0.0067	0.0041	0.0006	0.0053	0.0040
	(0.0065)	(0.0057)	(0.0055)	(0.0065)	(0.0057)	(0.0056)
$DEPOSITS_{t-1}$	−0.0107	−0.0217**	−0.0230**	−0.0091	−0.0192*	−0.0212**
	(0.0094)	(0.0106)	(0.0107)	(0.0091)	(0.0103)	(0.0103)
MTB_{t-1}	0.0018**	0.0020**	0.0017*	0.0016**	0.0019**	0.0019**
	(0.0008)	(0.0009)	(0.0009)	(0.0007)	(0.0008)	(0.0008)
ROA_{t-1}	−0.3701**	−0.3994*	−0.4819**	−0.3759***	−0.4072*	−0.4762**
	(0.1420)	(0.2220)	(0.2320)	(0.1426)	(0.2197)	(0.2327)
$Log(TOTAL\_COMP)_{t-1}$			0.0013			0.0013
			(0.0010)			(0.0010)
$Log(AGE)_{t-1}$			0.0000			0.0001
			(0.0001)			(0.0001)
$TENURE_{t-1}$			0.0003**			0.0002
			(0.0001)			(0.0001)
$MALE_{t-1}$			−0.0057**			−0.0053**
			(0.0024)			(0.0024)
Constant	0.0012	0.0163	0.0192	0.0033	0.0218	0.0201
	(0.0359)	(0.0560)	(0.0547)	(0.0353)	(0.0554)	(0.0542)
N	1,001	1,001	1,001	1,001	1,001	1,001
R^2	.8489	.8585	.8621	.8502	.8601	.8622

Note: This table reports the results of the OLS (Columns 1 and 4) and the WLS (Columns 2, 3, 5 and 6) regressions examining the relationship between CEO overconfidence and BHCs' systemic risk. The dependent variable is *MES*, average stock return of a BHC on the days in which the market return is in the bottom 5% for the year. All other variables are defined in Appendix. Bank and year fixed effects are included. Clustered by bank robust standard errors are in parentheses. ***, **, * Stand for statistical significance at the 1%, 5% and 10% level, respectively.

statistically and significantly increases with CEO overconfidence.

5.2 | CEO overconfidence and bank leverage

In the framework in Acharya et al. (2017), leverage is an important predictor for ex post bank systemic risk because it plays a crucial role in determining bank capital and the financial distress cost of highly leveraged firms is high in a crisis. High leverage incentivizes banks to take on tail risks (Ellul & Yerramilli, 2013) and increases the financial system fragility (Thakor, 2015a). Indeed, Reinhart and Rogoff (2009) uncover that financial intermediaries are highly leveraged in advance of most financial crises (see also Ho et al., 2016). Here we explore if CEO overconfidence is associated with bank leverage using Acharya et al. (2017)'s approximation of leverage *LVG* which is the ratio of quasi-market value of assets to market value of equity. In Table 8, we repeat the OLS and WLS estimations of Table 2 using *LVG* as the

TABLE 8 CEO overconfidence and bank leverage

	(1)	(2)	(3)	(4)	(5)	(6)
$OC\_Options_{t-1}$	0.1619	0.2124*	0.3817*			
	(0.3549)	(0.3110)	(0.3664)			
$OC\_MD\&A_{t-1}$				0.1269	0.3170	0.3441*
				(0.1710)	(0.1986)	(0.1935)
$Log(TA)_{t-1}$	0.4230	0.2728	0.2113	0.4283	0.2756	0.2215
	(0.3391)	(0.3368)	(0.2977)	(0.3116)	(0.3092)	(0.2818)
$LOANS_{t-1}$	0.9958	1.0044	1.3813	0.9107	0.8566	1.1030
	(1.1239)	(1.0806)	(1.0781)	(1.1015)	(1.0579)	(1.0016)
$DEPOSITS_{t-1}$	−0.1575	−1.6716	−2.0712	−0.3345	−1.8803	−2.3216
	(2.2247)	(2.1576)	(2.0711)	(2.1031)	(2.0942)	(2.0066)
MTB_{t-1}	−0.7651***	−0.7258***	−0.7466***	−0.7465***	−0.7092***	−0.7109***
	(0.2740)	(0.2329)	(0.2266)	(0.2351)	(0.2093)	(0.2002)
ROA_{t-1}	−64.0518*	−64.4757**	−72.0933**	−63.1558*	−61.1067**	−68.6369**
	(33.8489)	(30.0842)	(30.5538)	(35.1665)	(30.7748)	(30.6980)
$Log(TOTAL\_COMP)_{t-1}$			0.2250			0.2148
			(0.1882)			(0.1887)
$Log(AGE)_{t-1}$			0.0320			0.0310
			(0.0204)			(0.0204)
$TENURE_{t-1}$			−0.0572*			−0.0451*
			(0.0314)			(0.0244)
$MALE_{t-1}$			−0.1655			−0.3535
			(0.4284)			(0.3835)
Constant	2.4287	5.7981	4.2951	2.4496	5.7990	4.5147
	(4.0035)	(4.6336)	(4.1110)	(3.8586)	(4.4899)	(4.1198)
N	1,001	1,001	1,001	1,001	1,001	1,001
R^2	.7890	.8075	.8108	.7890	.8084	.8111

Note: This table reports the results of the OLS (Columns 1 and 4) and the WLS (Columns 2, 3, 5 and 6) regressions examining the relationship between CEO overconfidence and BHCs' systemic risk. The dependent variable is *LVG*—Quasi-market value of assets divided by market value of equity. All other variables are defined in Appendix. Bank and year fixed effects are included. Clustered by bank robust standard errors are in parentheses. ***, **, * Stand for statistical significance at the 1%, 5% and 10% level, respectively.

dependent variable.[21] The positive and significant coefficients of *OC_Options* in the WLS estimations indicate that banks with overconfident CEOs have higher leverage than banks with non-overconfident CEOs. The coefficients of the tone-based overconfidence *OC_MD&A* remain positive but only statistically significant in the last regression. Overall, our results suggest that CEO overconfidence is associated with bank leverage, which is consistent with the finding that overconfident CEOs in non-financial firms issue more debt compared to non-overconfident CEOs (Malmendier et al., 2011) and that overconfident CEOs in financial firms increase leverage more than non-overconfident CEOs prior to the 2007–2008 crisis, making these firms more vulnerable to the shock of the crisis (Ho et al., 2016).

5.3 | Dynamic panel GMM estimator

To address the concern that the relationship between CEO overconfidence and systemic risk could be dynamically endogenous such that a bank risk strategy determines both its exposure to a systemic event and the type of CEO that it hires, we use a dynamic panel GMM estimator as in Arellano and Bond (1991). Following Ellul and Yerramilli (2013), we explicitly control for lagged values of *MES* and bank characteristics to provide instruments for identifying the relationship between bank systemic risk and CEO overconfidence.

Table 9 presents results of the dynamic GMM regressions in which we use *MES* as the dependent variable, its three lags as regressor variables and bank characteristics

TABLE 9 CEO overconfidence and bank systemic risk: Dynamic GMM estimator

	(1)	(2)	(3)	(4)
$OC\_Options_{t-1}$	0.0042**	0.0040**		
	(0.0020)	(0.0017)		
$OC\_MD\&A_{t-1}$			0.0020**	0.0008**
			(0.0009)	(0.0012)
MES_{t-1}	0.1471***	0.1142***	0.1474***	0.2634***
	(0.0383)	(0.0271)	(0.0237)	(0.0362)
MES_{t-2}	−0.1095***	−0.1355***	−0.0879***	−0.0694**
	(0.0232)	(0.0316)	(0.0233)	(0.0331)
MES_{t-3}	−0.1272***	−0.1463***	−0.1177***	−0.1365***
	(0.0207)	(0.0211)	(0.0178)	(0.0230)
$Log(TA)_{t-1}$	0.0038***	0.0043***	0.0023**	0.0157***
	(0.0012)	(0.0016)	(0.0011)	(0.0014)
$DEBT_{t-1}$	0.0123	0.0259	−0.0376	−0.1417*
	(0.0346)	(0.0360)	(0.0418)	(0.0531)
$LOANS_{t-1}$	0.0027	0.0080	0.0010	0.0050
	(0.0060)	(0.0103)	(0.0110)	(0.0067)
$DEPOSITS_{t-1}$	0.0059	−0.0084	−0.0088	0.0036
	(0.0063)	(0.0082)	(0.0065)	(0.0053)
MTB_{t-1}	0.0015**	0.0010	0.0016*	0.0008
	(0.0007)	(0.0008)	(0.0008)	(0.0012)
ROA_{t-1}	−0.2488**	−0.2525***	−0.2091**	−0.1153*
	(0.1089)	(0.0854)	(0.0962)	(0.1181)
$Log(TOTAL\_COMP)_{t-1}$		−0.0020***		0.0018*
		(0.0005)		(0.0010)
$Log(AGE)_{t-1}$		0.0002***		0.0003***
		(0.0001)		(0.0001)
$TENURE_{t-1}$		0.0000		0.0005***
		(0.0002)		(0.0002)
Constant	0.0598	0.0178	0.0230	0.0991*
	(0.0511)	(0.0570)	(0.0569)	(0.0594)
N	650	650	650	650
Sargan χ^2	73.48	67.85	75.12	74.15
Sargan P-value	1.000	1.000	1.000	1.000

Note: This table reports the results of the dynamic GMM regressions examining the relationship between CEO overconfidence and BHCs' systemic risk. The dependent variable is *MES*, average stock return of a BHC on the days in which the market return is in the bottom 5% for the year. *OC_Options* is an indicator variable that takes the value of 1 if the CEO holds in-the-money options at 100% or greater in two successive years, and 0 otherwise. *OC_MD&A* is an indicator variable that takes the value of 1 if there are more optimistic words than pessimistic words in the MD&A section in the BHC's 10K-filing, and 0 otherwise, where optimistic and pessimistic words are based on *Diction*. All other variables are defined in Appendix. Bank and year fixed effects are included. Clustered by bank robust standard errors are in parentheses. ***, **, * Stand for statistical significance at the 1%, 5% and 10% level, respectively.

lagged four periods or more as exogenous instruments. We employ the same set of bank and CEO characteristics as control variables as before. The coefficients of CEO overconfidence, either measured with the options-based or tone-based proxy, continue to be positive and significant. Results of the Sargan test for the validity of instruments

indicate that we cannot reject the null hypothesis that our instruments are valid. Our results remain unchanged when we employ two lags of *MES* and bank characteristics lagged three periods or more as instruments as in Ellul and Yerramilli (2013). Overall, the results suggest that banks with overconfident CEOs have higher systemic risk, even after controlling for the possible dynamic endogeneity between overconfidence and systemic risk.

5.4 | Other tests

We conduct some further robustness tests (results are not reported for brevity) to check whether results are sensitive to our selected empirical method. We apply the propensity score matching method, which uses bank-specific factors to match, without replacement, a bank with an overconfident CEO with a bank of similar characteristics with a non-overconfident CEO. We then repeat the regressions in Tables 2 and 3 for the matched sample. We continue to find that bank systemic risk increases with both options-based and tone-based CEO overconfidence and that banks with overconfident CEOs hold more mortgaged-backed securities investment. We also use the language in the 10K-filings, rather than just the MD&A sections to construct various tone-based proxies of overconfidence. We use several methods to construct overconfidence measures, both discrete and continuous, using optimistic and pessimistic language in the MD&As and 10K-filings. The results are qualitatively similar to that using the MD&As but with reduced economic and statistical significance.

6 | CONCLUSION

We present empirical evidence that banks with overconfident CEOs have higher systemic risk, invest more in mortgaged-backed securities and have higher leverage. During the 2007–2008 financial crisis, U.S. banks with overconfident CEOs also experienced higher realized systemic risk. We use two proxies for CEO overconfidence using options exercise behaviour and language in the Managerial Discussion and Analysis of the 10K-filings. While the former is more in line with the suggestion that overconfidence could be a permanent personality trait, the latter reveals time-variant patterns in CEO overconfidence bias. We also document that fewer CEOs are classified as being overconfident during and after the 2007–2008 financial crisis. Our findings point to the role of biased beliefs, rather than agency problems, in explaining bank excessive risk-taking behaviour. Overconfident managers' interests and those of shareholders can be aligned when the former take risk on behalf of the latter. While this risk-taking behaviour could be desirable for CEOs and current shareholders ex ante, it could harm banks and the financial system as a whole ex post. Our results seem at odds with that of Bhagat and Bolton (2014), who argue that bank CEOs engage in value-decreasing projects that increase short-term returns to exercise their options at a higher price. Rather, our results are more in line with the findings of Fahlenbrach and Stulz (2011) that bank CEOs do not reduce or hedge their holdings of shares in anticipation of poor outcomes due to their misjudgement.

Our findings point to the potential consequences of CEO overconfidence bias beyond individual banks/firms. Overconfidence bias could encourage CEOs to take desirably sufficient risk, resulting in greater innovative success (Hirshleifer et al., 2012). Alternatively, it could lead to value-destroying acquisitions (Malmendier & Tate, 2008) or weakened lending standards (Ho et al., 2016). We show that overconfidence can impose external costs when bank CEOs take risks that are borne by other financial institutions and the rest of the economy. This has important implication in the light of the 2007–2008 financial crisis and its effects on the real economy. While our paper focuses on CEO-biased beliefs, future research could explore whether and to what extent CEO overconfidence might affect biased beliefs among investors, and how the two types of biases are related to bank risk (as in the model of Thakor, 2015b).[22]

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from [WRDS, EDGAR]. Restrictions apply to the availability of these data, which were used under license for this study. Data are available [from the authors] with the permission of [WRDS, EDGAR].

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ENDNOTES

[1] There is anecdotal evidence of this biased belief among bank CEOs prior to the 2007–2008 financial crisis. For example, regarding the acquisition of the mortgage specialist Golden West Financial Corp in July 2007, *Wachovia*'s CEO, Ken Thompson, said

'Don't underestimate the advantage of all of a sudden now being able to offer the Golden West product line through 3,500 Wachovia branches, through Wachovia securities... and through Wachovia's direct bank.... It's (the slumping mortgage market) not a big impact to our company' (Reuters July 18, 2007, *Wachovia CEO optimistic despite mortgage slump*). *Wachovia*'s income fell 98% in the fourth-quarter of 2007 following the meltdown in the housing market and the bank was acquired by *Wells Fargo* in December 2008.

[2] In their model, Hermalin and Weisbach (1998) show that the CEO has control over the firm when the board of director is ineffective in its monitoring role. Research on bank CEO power provides evidence that a CEO's ability to compel board decisions is associated with bank risk-taking (Pathan, 2009, see also Ellul & Yerramilli, 2013) and other policies such as dividend payout (Onali, Galiakhmetova, Molyneux, & Torluccio, 2016).

[3] *CoVaR*, for example, measures the contagion risk, or the financial system performance conditional on a realization in the left tail of the distribution of bank returns (Adrian & Brunnermeier, 2016).

[4] For a comprehensive review of different measures of systemic risk see Bisias et al. (2012).

[5] Our data show that banks that experienced heavy losses during the crisis such as *National City Corp*., *Wachovia* and *Citigroup*, were all heavily exposed to the mortgage-backed securities in the pre-crisis period.

[6] Thakor (2015a) points out the role of financial innovation that 'spurred the growth of the subprime mortgage market' and other marketable securities that make banks more connected with each other (as they all were holding similar securities) and more 'intertwined with markets' (p 2). Of these innovative securities, the MBS, or more precisely the developments in the subprime mortgages, was considered the trigger of the crisis and the interconnectedness of financial institutions via the MBS amplified the initial shocks (as described in Bernanke et al., 2008 and Brunnermeier, 2009).

[7] For example, neither Chuck Prince of *Citigroup* nor Ken Thompson of *Wachovia* are classified as being overconfident based on their options-exercise behavior during the period of study. Yet both are often remembered as the overly optimistic bank CEOs amid the height of the 2007–2008 crisis. In his interview with the *Financial Times* on July 9, 2007, Chuck Prince said 'we are still dancing', denying that the problems in the subprime mortgage market and other concerns could lead to a more systemic impact on the financial sector. Similarly, Wachovia's MD&A section of the 10K-filing on February 28, 2008 stated: 'we remain confident about our growth prospects'. Both CEOs are classified as being overconfident by our tone-based measure.

[8] However, Malmendier and Tate (2005) argue that it is not always easy to identify an overconfident CEO ex ante.

[9] There are 71 CEO turnover events involving 49 banks in our sample period. A CEO turnover is defined as a change in the identity of the CEO in a bank (Campbell et al., 2011). In five events where the new CEO is considered as overconfident but the outgoing CEO is not, there is a slight increase in the average bank systemic risk under the new CEO (measurement of overconfidence and systemic risk is described in Sections 3.3 and 3.4). In the other events (41 events where there is no difference between the new and outgoing CEOs in terms of the overconfidence measurement and 25 events where the outgoing CEO is considered as overconfident but the new CEO is not), the average change in bank systemic risk (between the two regimes) is not statistically and significantly different from zero. We thank an anonymous referee for directing us to investigate this issue.

[10] See Wintoki, Linck, and Netter (2012) for a discussion of dynamic endogeneity.

[11] Based on the notion that individuals 'learn' to be overconfident through self-attribution bias, that is, they attribute events that confirm the validity of their actions to their ability and suppress information that conflicts with their actions (see Gilovich et al., 2002 for more details), Billett and Qian (2008) interpret their finding that overconfident CEOs who make successful M&As are more likely to acquire again (although subsequent deals, driven by overconfidence, have poor wealth effects) and become more optimistic about their firm prospects (as evidenced by their bullish insider trading activity) as being consistent with their hypothesis that CEOs develop overconfidence through successful acquisition experience.

[12] One can argue that managers have incentives to provide optimistic disclosures because the market on average reacts positively to optimistic disclosures (see, e.g., Yang, 2012). However, litigation risk (Rogers et al., 2011) and investor skepticism (Kothari et al., 2009) may deter such actions.

[13] As in Acharya et al. (2017), we use average daily data of equity returns to calculate *MES*. More details can be found at the Volatility Institute at the NYU Stern School of Business which provides details of how systemic risk is calculated and publishes Systemic Risk Rankings (see https://vlab.stern.nyu.edu).

[14] Campbell et al. (2011) classify 35% CEO-year observations as high optimism using the measure that we adopt in our work, that is, CEOs holding options at 100% or greater moneyness. In Hirshleifer et al. (2012), the percentage is 61% but their moneyness cut-off is 67%.

[15] It should be noted that Acharya et al. (2017) report *MES* for both BHCs and other financial institutions from June 2006 to June 2007. We compare our statistics with the mean and median *MES* of the BHCs in Acharya et al.'s sample.

[16] In our sample, there are small differences between banks led by female CEOs and male CEOs. Female CEOs are also less overconfident than male CEOs. Nonetheless, as Wolfers points out, differences between organizations led by female CEOs and those led by male CEOs 'should not be exaggerated given the very small sample of female CEOs' (Wolfers, 2006, p. 533). The percentage of female CEO-years in our sample is 1.5%, which is similar to the percentage reported in Wolfers (2006) for industrial firms (1.3%). Our regression results remain unchanged when the dummy variable for CEO gender is excluded.

[17] The results are similar when we use the ratio of optimistic (pessimistic) words over total words in the 10K-filings.

[18] The results are qualitatively similar when we use the 2005 classification.

[19] We obtain very similar results when we include CEO characteristics and their interactions with *PostCrisis*. The results are not reported here for the sake of brevity.

[20] Campbell et al. (2011) discuss a sensitivity analysis for different moneyness cutoffs.

[21] We exclude *DEBT* from the set of control variables.

[22] We thank an anonymous referee for pointing out this direction for future research.

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APPENDIX: VARIABLE DEFINITION

Name	Definition
OC_Options	Dummy variable that takes a value of 1 for all CEO-years after the CEO postpones the exercise of vested options that are at least 100% in the money in two successive years and 0 otherwise
OC_Options67	Dummy variable that takes a value of 1 if a CEO postpones the exercise of vested options that are at least 67% in the money in two successive years and 0 otherwise
OC_OptionsAll	Dummy variable that takes a value of 1 for all CEO-years if the CEO postpones the exercise of vested options that are at least 100% in the money in two successive years and 0 otherwise
OC_MD&A	Dummy variable that takes a value of 1 if the number of optimistic words that a CEO uses in the management discussion and analysis (MD&A) section of the 10K-filing is greater than the number of pessimistic words, where optimistic and pessimistic words are based on the *Diction* word list. There are in total 686 *Diction* optimistic words (such as 'praise', 'satisfaction' and 'inspiration') and 920 *Diction* pessimistic words (such as 'blame', 'hardship' and 'denial')
MES	Average return of a BHC on days when the market as a whole is in the tail of its return distribution (the lowest 5% days of market return) in a given year
MBS	Private mortgage-backed securities (*BHCK1709* + *BHCK1733* + *BHCK1713* + *BHCK1736* + *BHCK3536*) divided by total assets (*BHCK2170*)
LVG	Quasi-market value of assets divided by market value of equity, where quasi-market value of assets is book value of assets (*BHCK2170*) minus book value of equity (*BHCK3210*) plus market value of equity. Market value of equity is the value of stock price at year end multiplied by number of shares outstanding
Realised SES	The ex post stock return during the period July 2007–December 2008
Log(TA)	Natural logarithm of the book value of total assets (*BHCK2170*)
DEBT	Long-term debt (*BHCK3298*) divided by total assets (*BHCK2170*)
LOANS	Total loans (*BHCK2122*) divided by total assets (*BHCK2170*)
DEPOSITS	Total deposits (*BHDM6631* + *BHDM6636* + *BHFN6631* + *BHFN6636*) divided by the total assets (*BHCK2170*)
MTB	Market value of equity divided by total equity capital where market value of equity is the value of stock price at year end multiplied by number of shares outstanding
ROA	Net income (*BHCK4300*) divided by total assets (*BHCK2170*)
Log(TOTAL_COMP)	Natural logarithm of a CEO's annual total compensation, which comprises salary, bonus, total value of restricted stock granted, total value of stock option-granted (using Black-Scholes), long-term incentive payouts and all other bonuses
TENURE	Number of years a CEO has held position as CEO in a BHC
Log(AGE)	Natural logarithm of the age of a BHC's CEO
MALE	Dummy variable that takes the value of 1 if a CEO is male and 0 otherwise