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Board diversity: Moderating effects of CEO overconfidence on firm financing decisions

Constantin Gurdgiev [a,*], Qiuxin Ni [b]

[a] *University of Northern Colorado, Monfort College of Business, United States*
[b] *Trinity College, Dublin, Ireland*

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ABSTRACT

The importance of CEO overconfidence in capital structure decision-making has drawn attention of many scholars in the past. Despite this, literature on the subject to-date does not offer consensus on how CEO overconfidence biases interact with corporate governance in determining company strategies for financing its capital investments. Our paper aims to address a specific gap in the literature concerning the potentially moderating role of board diversification on the CEO overconfidence and its impact on corporate capital structure decision-making. In a major innovation to the literature, we look at board diversity from five perspectives: gender and age diversity, board independence, board size, and the duality of the roles of CEO and chairperson. To make our findings methodologically robust, we consider two measures of the CEOs' overconfidence: media-based measure (implied measure of overconfidence) and CEO stock purchases (revealed measure of overconfidence). We extend our analysis to the top 100 US listed companies over 2011–2019 — the period between two systemic crises, the Great Recession and the Covid19 pandemic. We show that general effect of board diversity on CEO overconfidence is highly sensitive to different measures of overconfidence. CEOs' implied overconfidence has a negative correlation with debt financing of the company, which is consistent with the findings of Heaton (2002). These results do not hold for the revealed measure of CEO overconfidence. Board diversity plays an important role in moderating the impact of CEO overconfidence on capital structure decisions. This holds for gender diversity, and for the board size and the number of independent directors, confirming prior literature on the subject. However, age diversity of the board and the duality of the CEO and chairperson are insignificant in moderating CEO overconfidence, which adds new insights to the literature to-date.

1. Introduction

Academic research focuses extensively on identifying factors that affect the financial decisions of CEOs and other senior executives. Such factors range broadly from external (e.g. Rajan and Zingales, 1995), to internal (including the company's existing capital structure, per Vasiliou and Daskalakis, 2009).

Outside exogenous and firm-specific factors, firm financing decisions are shaped by behavioral characteristics of the managers. Senior managers' decisions are commonly influenced by a range of cognitive biases (as consistent with the definition in Korteling and Toet, 2022[1]). According to empirical research, one such bias

is a major determinant of managerial decisions when it comes to the financial position of the firms: over-confidence (Russo and Schoemaker, 1992; Ishikawa and Takahashi, 2010; Hilary and Hsu, 2011; Hatoum, 2021; Killins et al., 2021; Chen et al., 2019; Zheng et al., 2022; Qiao et al., 2022; Hatoum et al., 2022).

On the other hand, academic research is increasingly paying more attention to the influence of board diversity and other aspects of corporate governance on the nature and quality of decision-making process in companies. One important strand of literature here focuses on the view that the information asymmetry between shareholders and the management can be mitigated by the board of directors (e.g. Khajavi and Dehghani, 2016; Yildiz, 2021; Kasbar et al., 2022). Similarly, empirical research shows that board independence alongside board diversity can

* Correspondence to: Montfort College of Business, University of Northern Colorado, 800 17th St, Greeley, CO 80639, United States.

E-mail addresses: constantin.gurdgiev@unco.edu (C. Gurdgiev), niqi@tcd.ie (Q. Ni).

[1] Korteling and Toet (2022, page 610) define cognitive biases as "...systematic cognitive dispositions or inclinations in human thinking and

reasoning that often do not comply with the tenets of logic, probability reasoning, and plausibility. These intuitive and subconscious tendencies are at the basis of human judgment, decision making, and the resulting behavior". This definition is similar to that provided by Wilkie and Mata (2012) and others.

improve decision-making and ameliorate systemic errors that may arise from CEOs' and other executives' overconfidence biases (e.g. Banerjee et al., 2015; Ullah et al., 2020; Masulis, 2020; Ongsakul et al., 2022). Despite this, as noted in our literature review section below, there are relatively few studies that directly explore, simultaneously, the relationship between CEO overconfidence, board diversity, and decision-making involving corporate financial management.

With this in mind, our paper aims to study the moderating role of board diversity on the effect that CEO overconfidence may have on corporate capital structure decision-making. To provide deeper insights into behavioral aspects of decision-making interactions with governance, we examine the impact of diversity of the board from five perspectives: gender and age diversity, board independence, board size, and the duality roles of CEO and chairperson. This the first study in the empirical literature that covers this wide range of board governance metrics. We use the characteristics of enterprise as control variables to reduce the risk of omitted variables bias so common in the case of corporate finance decisions analysis and to partially address the potential criticism of non-replicability and non-robustness of results, so common to the modern behavioral finance literature.

We posit an intuitively and theoretically derived hypothesis that CEO overconfidence can be ameliorated by high governance standards of the board, captured by greater degree of board independence and diversity. We further stipulate an additional hypothesis that lower CEO overconfidence induced by greater board diversity and higher quality governance leads to more stable corporate strategy for structuring company capital decisions.

The significance of these hypotheses is two-fold. On the one hand, this paper discusses the role of the board of directors in moderating the overconfidence of CEOs in capital structure decision-making. Existent research on the role of the board diversity in regulating CEO overconfidence in financial decision-making is rare and hard to reconcile with the theory of managerial cognitive biases. Previous research mostly studied factors that lead to CEO overconfidence (Gervais et al., 2011; Schrand and Zechman, 2012; Lee et al., 2017), or the influence of CEO overconfidence on corporate performance or operations (Hayward and Hambrick, 1997; Heaton, 2002; Malmendier and Tate, 2005a). In contributing to the past literature, our paper explores whether board diversity will have a regulating effect on the influence of CEO overconfidence in strategic financing decision-making.

We cover data for the top 100 US-listed companies according to Fortune 100 (2019) over the time period of 2011–2019. Our panel data sample, therefore, covers companies that find themselves under constant public and analysts' scrutiny, reducing the likelihood of self-attribution bias emerging in our findings (Burkhard et al., 2022). We increase robustness of our model estimation by focusing on the period between two major systemic crises, the Global Financial Crisis and the Great Recession of 2007–2010 and the Covid19 pandemic of 2020–2022. We show that CEO overconfidence significantly affects the capital structure decisions of the company. CEO overconfidence is negatively correlated with the debt financing of the company, which also supports earlier literature on the subject. However, CEO overconfidence based on stock-purchase measurement (revealed measurement) generates statistically insignificant results. We also show that board diversity plays an important role in moderating the impact of CEO overconfidence on capital structure decisions. We find positive gender diversity effects (in line with broader literature, e.g. Chen et al., 2019), as well as board size and independent directors effects (in line with some literature, such as, for example Omran et al., 2008; Adams and Mehran, 2012). At the same time, age diversity and duality of the CEO and chairperson are both found to have no statistically significant effects on moderating the adverse effects of CEO overconfidence.

To achieve the key objectives of our research, in Section 2 below, we first survey existent literature on behavioral overconfidence, CEO decision-making and board governance. This leads us to posit four key research questions that are anchored to existent literature and advance our current knowledge on the links between CEO overconfidence, board quality and corporate capital structures. *Are differences between CEOs overconfidence contributing to the observed differences across firms capital structures? Are the effects of CEO overconfidence on firm capital structure sensitive to the choice of overconfidence metrics? Does CEO overconfidence lead to higher degree of risk taking in company M&A activities and investments? Do board governance quality indicators, as captured by either gender and age diversity, independent directors presence, or separation of the CEO role contribute to the overall impact of CEO overconfidence on firm capital structure and investment decisions?*

On foot of these questions, Section 3 develops a set of testable hypotheses and Section 4 introduces our empirical models and provides description of data. Section 5 develops analysis of key empirical results, while Section 6 concludes.

2. Literature review

2.1. Traditional theories of financing decision

The earliest structured theory of financing decisions of the firm is the well-known Modigliani–Miller (MM) theorem (Modigliani and Miller, 1963) which points out that absent transaction costs and market frictions, companies should optimally opt for debt financing. On the other hand, Kraus and Litzenberger (1973) trade-off theory suggests that after taking account of taxes, financial and bankruptcy risks, the optimal capital structure can be tailored by companies to their specific circumstances and environments. Amongst others, both the MM theory and trade-off theory share one key assumption that there are no asymmetries in information. In contrast, the signaling theory (Ross, 1977) suggests that managers get access to more information about the company than investors. Hence, in the market with asymmetric information managers know the true value of the company. Actions and policies adopted by the enterprise imperfectly transmit this information to the market. In this respect, the company's dividend policy, financing plans, and investment projects, amongst other metrics, signal to investors information previously held privately by the managers (Ross, 1977). The pecking order theory believes that the ideal order of financing for an enterprise should prioritize first internal financing, followed by debt financing and, finally, equity financing, as companies should choose the financing methods with lower financing costs first (Myers and Majluf, 1984).

Overall, the four traditional theories of corporate capital structure mainly focus on the factors referring to the risks arising within the operations of the firm, as well as information asymmetries that exist within the firm and between the firm and its shareholders. As such, none of these mainstream theories allow for the influence of managers' psychology and behavioral biases on the decision-making process.

2.2. CEO overconfidence

Overconfidence is a cognitive bias (per Kinari, 2016, page 32 definition) with extensive coverage in finance (see, for example, Goel and Thakor, 2008; Hackbarth, 2008; Hambrick, 2010; Burkhard et al., 2022). Literature on behavioral biases relating to expectations formation (Moore and Healy, 2008) identifies three types of overconfidence biases. The first one is that of overestimation, a bias that leads a decision maker to believe that their own ability or performance are of better quality than they

Table 2.1
Main definitions of overconfidence.

Representative scholars	Definitions of overconfidence
Langer (1975)	Psychological bias that overestimates the probability of success and underestimates the probability of failure
Russo and Schoemaker (1992)	Overestimation of the certainty of the expected result
Griffin and Tversky (1992)	Cognitive bias to overestimate own knowledge and accuracy of judgment
Heaton (2002)	Overestimating the accuracy of own information
Simon and Houghton (2003)	Overestimating the accuracy of own predictions
Moore and Healy (2008)	Three definitions of overconfidence and a distinguishing definition of optimism
Hill et al. (2012)	Overestimating one's own abilities
Kinari (2016)	Overestimating the accuracy of own predictions

actually are. The second one is that of over-placement, which is a bias relating to over-estimation of one's own ability relative to the peer group or a reference group ability. Finally, the third type of overconfidence is that of over-precision, which is a bias linked to over-estimation of one's knowledge concerning general performance and/or abilities. Most of the studies surveyed here and the analysis we pursue below relate to the first two phenomena.

Generally, studies covering CEO overconfidence are based on the Upper Echelons Theory (UET) which postulates that overconfidence bias of a CEO will affect her/his perceptions of themselves and their awareness of internal and external environment of the organization (Hambrick and Mason, 1984). In the context of Moore and Healy (2008) taxonomy of overconfidence biases, this implies that studies of CEO's behavioral biases target types one and two of overconfidence (Burkhard et al., 2022). CEO's behavioral biases, such as overconfidence, in turn, are hypothesized to influence their decision-making abilities and translate into changes in organizational performance. Even if the concept of overconfidence has been relatively clearly and well-defined for some time, the causes and influence of CEO overconfidence are still debatable. There are still non-trivial problems present in the ways CEO overconfidence is measured and defined (Hatoum et al., 2022; Burkhard et al., 2022). The main definitions of overconfidence used across the major literature of relevance here are shown in Table 2.1.

In line with the literature summarized in Table 2.1, we define "CEO overconfidence" as a psychological bias reflected in the tendency of the CEOs to overestimate their own ability (revealed bias) and the accuracy of their prediction or judgment (implied bias). These are broadly consistent with Moore and Healy (2008) types one and two biases for our revealed bias, and type three bias for our implied bias that are also in line with Hill et al. (2012) and Kinari (2016) separate definitions.

According to previous papers, the factors that contribute to CEO overconfidence can be grouped into the following three main categories: self-attribution, personal characteristics and external factors (Moore and Healy, 2008).

Gervais et al. (2011), Lee et al. (2017) and Choi et al. (2018), amongst others, argue that CEO overconfidence is mainly caused by self-attribution. CEOs usually attribute their success to their own (higher than average) abilities while assigning causes of failures to external factors. Additionally, a number of studies show that past successful experiences would intensify CEO's over-optimism (Hirshleifer, 2001; Hilary et al., 2016; Edelson et al., 2019). Thus, past literature suggests that self-attribution bias can lead CEOs to believe in and signal to the markets their own capabilities as being superior to others in their ability to cope with the upcoming uncertain events exposing the company to financial risks (as reflected in our implied bias channel). At the same time, self-attribution bias can manifest itself through CEOs own choices relating to trading in the company stock (as consistent with our revealed bias channel).

Personal characteristics of the CEO, including education (Malmendier and Tate, 2005a; Schrand and Zechman, 2012; Wang and Yin, 2018), past employment experience and skills (Camerer and Lovallo, 1999; Billett and Qian, 2008; Hwang et al., 2020), gender (Byrnes et al., 1999; Doan and Iskandar-Datta, 2021 and Hatoum et al., 2022), etc., are the major causes or correlates of overconfidence. Furthermore, past literature shows that company managers are more likely to show overconfidence due to their higher positions in power hierarchy and their ability to control resources (Kruger and Dunning, 1999; Vilanova and Vilanova, 2021; Enslin, 2022; Zhang et al., 2022).

The external factors that affect CEO overconfidence can be subdivided into company-specific factors and more exogenous, or company-external events. The firm internal factors mainly include CEO relative compensation being positively linked to CEO self-esteem and overconfidence (Hayward and Hambrick, 1997; Kaplan et al., 2022, among others). Similarly, such factors include the CEO selection mechanism (Goel and Thakor, 2008; Vilanova and Vilanova, 2021) with more competitive CEO selection processes leading to higher likelihood of CEO over-confidence. On the other hand, company-external events mainly refer to the positive evaluation of CEOs by the media and analysts. In this context, the portrayal of the CEO by the media as optimistic, positive, future-oriented and confident promote these CEO traits as desirable to a wider markets, thereby strengthening the authority of the CEO in the organization and increasing their overconfidence (Cameron and Whetten, 1983; Hayward and Hambrick, 1997; Gao et al., 2021; Ji et al., 2021; Gong, 2022 among others).

2.3. Overconfidence measurement

Measuring overconfidence has always been a major challenge in empirical research, especially in the context of recent controversies involving non-replication problems in experimental and behavioral research. According to the existent literature, the main indicators used to measure CEO overconfidence can be summarized as implied indicators (e.g. media references and evaluations) and revealed indicators (CEO own investment decisions revealed in CEO purchases or sales of company stock).

The evaluation of CEOs by the media is frequently used to measure CEO overconfidence. Malmendier and Tate (2005b) used media reporting as a variable to examine the degree of overconfidence that can be attributed to individual CEOs. The authors collected counts of two sets of key words describing CEOs performance from business news flow. The first set of words included "confident", "confidence", "optimistic" and "optimism", signifying potential overconfidence. The second set included "not confident", "not optimistic", "reliable", "cautious", "conservative", "stable" and other implying or signaling lack of confidence. If the count of words in the first category was greater than the count of words in the second category when describing a particular CEO, the CEO is considered to be overconfident. Brown and Sarma (2007) expressed these counts as the ratio of the number of words

in the first category to the second category. Hribar and Yang (2016) further modified the continuous variable to define the overconfidence variable as the ratio of the difference between the number of words in the first category minus the number of words in the second category to the sum of the two types of words. In this way, the sign of the overconfidence variable can indicate whether the CEO is overconfident and scale of the variable can indicate the degree of overconfidence. As an important aside, Tang et al. (2015) suggested that CEO overconfidence might not be a continuous variable. Instead, the authors suggest a threshold level of the Brown and Sarma (2007) indicator for identifying overconfidence.

Malmendier and Tate (2005a) first used stock options data to measure CEO overconfidence with three independent proxy variables: "Holder67", "Longholder", and "Net Buyer". If the CEO more than once holds options with a premium greater than 67% in the fifth year of the sample period, the CEO is considered to be overconfident, and the value of the variable "Holder67" is recorded as 1. If the CEO holds options until the last year of the sample period, the CEO is also considered to be overconfident and the value of "Longholder" is recorded as 1. Lastly, if the CEO is a net buyer of stocks of the company in most years over the first 5 years of the sample period, the CEO then is considered to be overconfident. Moreover, the creation of above three indicators is based on the research of Hall and Murphy (2002), in which they found that risk-averse CEOs usually exercise options earlier to reduce risk and guarantee returns when the stock price is higher, while overconfident CEOs will firmly believe that the market usually underestimates the value of their company, thereby delaying the exercise of options and even increasing their holdings of stocks. Hatoum et al. (2022) confirm these findings across more recent literature.

Based on the "Holder67" indicator proposed by Malmendier and Tate (2005a), Campbell et al. (2011) classified CEO overconfidence into three levels: highly optimistic, moderately optimistic, and less or lowly optimistic. The classification criterion is: if the CEO at least twice holds stock options with a premium greater than 100% in the 5th year of the sample period, the CEO will be classified as highly optimistic. If the CEO exercises options with a premium of less than 30% during the sample period and does not hold other exercisable options with a premium of more than 30%, the CEO will be considered to be lowly optimistic. Finally, if the CEO holds or exercises an option with a premium of 30% to 100% during the period, the CEO is classified as moderate optimistic CEO.[2]

In addition to own investment decisions by CEOs, Malmendier and Tate (2005a) and Doukas and Petmezas (2007) used merger and acquisition frequency as an indicator to measure CEO overconfidence. On the other hand, Lin et al. (2005) proposed that CEO overconfidence can be measured by forecasts of earnings or profit released by the company. Lin et al. (2005) defined "high forecast" as "the difference between the predicted pre-tax profit and the actual pre-tax profit is greater than 0", and "low forecast" as "the difference between the predicted pre-tax profit and the actual pre-tax profit is less than 0". If the number of "high forecasts" was greater than that of "low forecast", the company's CEO

was considered overconfident. Subsequent literature expanded on these, with Otto (2014) using earnings forecasts and Li and Tang (2010) using CEO's subjective forecasts of company profit as the signals of CEO overconfidence. Burkhard et al. (2022) and Hatoum et al. (2022) provide most recent comprehensive coverage of the financial/investment risk-taking metrics used in detecting CEO overconfidence.

Overall, per above, prior literature established a wide range of methods for measuring overconfidence. Despite the lack of general consensus on the best metric, no studies to date have used several metrics to improve robustness of the empirical tests for the relationship between CEO overconfidence, quality of corporate governance and financial structure of the firm. Similarly, no study to date provides an empirical insight into how sensitive the effect of the CEO overconfidence bias on firm performance can be to the application of different metrics of overconfidence. Our study attempts to close both of these gaps and to measure the overconfidence of CEOs based on two dimensions to ensure the robustness of our empirical findings.

First, drawing on Malmendier and Tate (2005b) and subsequent literature surveyed above, we estimate CEO overconfidence using media coverage data that refers to the CEO. We classify the specific words and phrases used to describe CEOs into 2 categories:

- Category I words that indicate confidence among CEOs includes keywords of 'Confident', 'Optimistic', 'Positive', 'Exuberant', 'Enthusiastic', and their derivatives, e.g. 'Confidence' 'Enthusiasm' and 'Conviction';
- Category II words that indicate that these CEOs might be not confident enough, including 'Not Confident', 'Not Optimistic', 'Pessimistic', 'Frugal', 'Steady', 'practical', 'Reliable', 'Conservative', 'Stable', 'Predictable', 'Certain' and 'Cautious', and their derivatives.

All publications and web news in the FACTIVA database are included as the initial data source. We then record the number of articles that refers to the CEO using each keyword, and denote the total number of articles using category I and II as ΣI and ΣII respectively. Thus, the value of the variable is determined by the following criteria:

$$Overcon - Media = \begin{cases} 1, & if \ \Sigma\text{I} > \Sigma\text{II} \\ 0, & if \ \Sigma\text{I} \leq \Sigma\text{II} \end{cases}$$

This provides us with the measure of overconfidence that is implied by the media reports and coverage.

Additionally, we identify whether CEO purchase their companies' shares on their own initiative as another measurement of CEO's revealed overconfidence. Excluding stock awards, stock dividends, rights offering, and stock option incentives, etc., CEOs whose own purchase of their companies' shares was greater than 0 during the year are considered overconfident, and the values of the variable are recorded as 1 accordingly. If there is no information referring to the CEOs' stock purchase, we do not consider those CEOs as overconfident. This method of measuring CEO overconfidence is consistent with the method 'Netbuy' proposed by Malmendier and Tate (2005a) as well as with the range of metrics covered in meta-analytical survey of the literature on CEO overconfidence in Burkhard et al. (2022).[3]

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[2] General Google Scholar search shows 31 studies of investors and executive officers' overconfidence published in peer-reviewed journals and volumes since 2018 that used directly (as a metric) or indirectly (as a derivative metric) "Holder 67" indicator. Burkhard et al. (2022, page 11) use six different measures of CEO overconfidence, including those relating to options, stock purchases, firm investments, media coverage and composite in their selection of studies to be included in meta-analysis. Their criteria for stock ownership-based metric of overconfidence is that the CEO is considered to be overconfident "if they purchase additional company stock despite already high exposure to company risk (e.g., net buyer)" Burkhard et al. (2022, page 13).

[3] We extend this measure to consider overconfidence when signaled by the CEO purchases of company stock in excess of the historical annual average. The results of our robustness tests are qualitatively similar to those obtained using the original data.

2.4. Importance of CEO overconfidence

There is still debate on the implications of CEO overconfidence for capital structure decisions. Empirical research indicates that overconfident managers believe that their company's securities are always undervalued by the capital market, so they tend to issue risky securities and rely more on external funding (Heaton, 2002). Overconfident managers also engage more aggressively in stock repurchases, and respond more to stock-price declines (Banerjee et al., 2018). Other studies show that overconfident managers will refer to the theory of time marketing when making financing decisions, that is, overconfident managers might underestimate the company's risk when making financing decisions, believing that the value of their corporate bonds is undervalued while the value of stocks is overvalued. Therefore, the potential financing methods adopted by the management will be equity financing, followed by bond financing, which is inconsistent with the pecking order theory (Hackbarth, 2008). However, other studies show that overconfident managers are more inclined to choose internal funds than managers who are not overconfident, and when using external financing, they are more inclined to use debt financing (Malmendier and Tate, 2005b; Hatoum, 2021; Mundi and Kaur, 2022). Empirical research also shows that overconfident CEOs are more inclined to overestimate the operating performance of their own companies, so they believe that the company's stock price is undervalued, which makes them more cautious in financing decisions and prefer internal financing to external financing (Malmendier et al., 2007; Wrońska-Bukalska, 2018; Mundi and Kaur, 2022; Zaman et al., 2022).

Lacking literature consensus on the relationship between CEO overconfidence and capital structure decision-making at the firm level,[4] we are warranted to postulate our first set of research questions as follows:

Research Question 1. *Do differences between CEOs overconfidence contribute to the observed differences across firms' capital structures?*

Research Question 2. *Are the effects of CEO overconfidence on firm capital structure sensitive to the choice of overconfidence metrics?*

Lastly, there is a substantial literature on the effects of the CEOs' behavioral traits on the outcomes of company M&A activities. Some scholars found that CEO overconfidence can cause the company to pay a relatively high premium in acquisition activities (Hayward and Hambrick, 1997; Malmendier and Tate, 2005a). Brown and Sarma (2007) show that overconfident CEOs are inclined to overestimate their own abilities in choosing profitable investments and also overestimate potential for company absorbing and generating growth in the future, thereby carrying out multiple acquisitions in a short period. Similar evidence is shown in subsequent studies, e.g. Choi et al. (2018), Kumar et al. (2020) and Hatoum (2021). Gao et al. (2021) and Ji et al. (2021) relate the same effects to executives' overconfidence captured from media reports. Furthermore, companies with overconfident CEOs usually keep a relatively high rate of investment activities, since overconfident CEOs tend to overestimate their abilities and underestimate potential risks (Campbell et al., 2011; Schrand and Zechman, 2012; Kumar et al., 2020). Notably, Burkhard et al. (2022, page 29) explicitly identify the area of M&A deals analysis of the firm as an important avenue for future research into the impact of CEO overconfidence on firm financial performance. With this in mind, we postulate our third research question as follows:

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4 Lack of such consensus is discussed and empirically documented in Burkhard et al. (2022).

Research Question 3. *Does CEO overconfidence lead to higher degree of risk taking in company M&A activities and investments?*

2.5. Governance and board diversity

Starting with early literature (e.g. Hambrick and Mason, 1984), empirical research in finance and corporate strategy linked the characteristics of the board to corporate strategies formulation and performance. Walt and Ingley (2003) defined the board diversity as the integration of various skills, characteristics and expertise that individual board members can provide in the decision-making process. They also pointed out that the board usually plays an important role in the decision-making of the company, including company decisions concerning capital structure and investment allocations. A number of studies over the years also proposed that gender and ethnic diversity of board members are key attributes of a well-functioning institutional design and a measure of sound corporate governance, a finding that is broadly confirmed across a range of other studies (e.g. Trillium Asset Management, 2016; Schopohl et al., 2021; Khatib et al., 2021). The majority of this literature focus on the diversity impact on corporate performance, innovation, and social responsibilities (Burkhard et al., 2022). Our study explores the role of board diversity in the relationship between the CEO overconfidence and company financing decisions from five perspectives of diversity, covering gender diversity, age diversity, the duality of CEO and chairperson roles, board independence, and board size.

The concept of "glass ceiling", which refers to the barriers that block or restrict the advancement of female employees, was first proposed in the United States in the 1980s. Since then, the importance of female directors in the boardroom has informed a number of studies of corporate governance and performance. Carter et al. (2003, 2010) explored the relationship between gender diversity of the board and company valuations, showing that the increase in the proportion of female directors in the boardroom increases the value of the firm, while a decrease in the proportion of independent directors reduces the company valuation. Adams and Ferreira (2009) provide evidence that the increase in the proportion of female results in an increased demand for higher quality of external audit, helping to strengthen governance of enterprise, and mitigating the problem of information asymmetry classically found to exist between the management, the board and the shareholders. Similar conclusions were reached by Alfraih (2016). Hafsi and Turgut (2013) proposed that board gender and age diversity have a significant impact on company performance. However, there are also studies that draw contrary conclusions, including those that suggest that gender diversity does not necessarily improve company performance and decision-making (Farrell and Hersch, 2005; Akpan and Amran, 2014; Ullah et al., 2020; Schopohl et al., 2021; Ongsakul et al., 2022).

It is commonly believed that older directors are more experienced and more knowledgeable, while younger directors have a greater interest in taking on risks, pursuing R&D investments and adoption of new technologies (Siciliano, 1996). Therefore, a board with diverse age backgrounds of their members might have a broader and a more comprehensive understanding of the company and industry, which would have a positive impact on making major decisions (Kim and Lim, 2010; Mahadeo et al., 2012). However, some scholars found that age diversity of the board can weaken the profitability of companies (Ali et al., 2014), cause conflict (Williams and O'Reilly, 1998), and hinder the board decision-making and weakening corporate performance (Westphal and Bednar, 2005; Wang and Hsu, 2013). The above lack of consensus on the matter is consistent with the meta-analytical survey of the literature presented in Burkhard et al. (2022).

Independent directors tend to pursue an objective of maintaining their personal reputation for governance allowing them to better supervise CEOs (Fama and Jensen, 1983). Empirical research shows that independent directors improve the company's credit rating and reduce firm-specific and systematic risks (Ashbaugh-Skaife et al., 2006), and may reduce debt financing costs (Anderson et al., 2004). Omran et al. (2008) and Jermias and Gani (2014) found a positive relationship between the percentage of independent directors and company overall performance, although Adams and Kirchmaier (2016) find this relationship to be not significant. Per Andreou et al. (2016), Goodell et al. (2023), internal directors may be more important for companies operating in the environment with high uncertainty, confirming the intuition of Fama and Jensen (1983).

The duality of CEO and chairperson, referring to the leadership arrangement whereby the CEO concurrently serves as the chair of the board, is shown to have negative effects on the control and supervisory capabilities of the board (Jensen, 1993; Lasfer, 2006; Hardwick et al., 2011; Garg, 2013; Wang et al., 2019; Burkhard et al., 2022). However, some scholars believe that the duality could help to clarify the direction for the company, reduce the possibility of conflict between the management and the board, create stability for the company, and thus improve company performance (Desai et al., 2003). Dey et al. (2011) linked the above viewpoints through "consolidation theory" that asserts that the duality of CEO and the chairperson roles leads to an increase in organizational costs due to the board's reduced ability to monitor the CEO and "efficiency theory" which postulates that the duality of CEO and the chairperson reflects the efforts made by companies to meet the leadership structure requirements resulted from the economic environment. The authors then looked at the data for 282 companies that had changed their leadership structure during 2001–2009, confirming the efficiency theory: there was a generally positive impact of CEO duality on the company performance.

Lipton and Lorsch (1992) proposed that the impact of the size of the board of directors on company performance can be either positive (by improving supervisory capabilities) or negative (by increasing coordination and communication costs). Per Jensen (1993), individual directors on large boards have lower motivation to supervise CEOs. Most empirical studies since (e.g. Yermack, 1996) found a negative correlation between board size and corporate performance. Empirical studies also show that the board size is negatively correlated with company value (De Andres et al., 2005; Bhagat and Bolton, 2008; Drakos and Bekiris, 2010; O'Connell and Cramer, 2010). Yet, some scholars found that board size is positively correlated with corporate performance (Kiel and Nicholson, 2003; Adams and Mehran, 2012; Koerniadi et al., 2014). Rashid (2020) shows that board size and board independence have a positive mitigating effect on ownership structure when it comes to determining firm performance. In international setting, Pucheta-Martínez and Gallego-Álvarez (2020) find that board size, board independence and gender diversity, as well as CEO duality, are all positively associated with firm performance. Meanwhile Arora (2022) found that the board size has a negative impact on firm return on assets, while gender diversity of the board has a strong positive impact on firm's financial performance. In simple terms, there is currently no consistency in the literature on the governance effectiveness of the size of the board.

The above review of the literature suggests that we are warranted in asking our final research question, postulated as follows:

Research Question 4. *Do board governance quality indicators, as captured by either gender and age diversity, independent directors presence, or separation of the CEO role contribute to the overall impact of CEO overconfidence on firm capital structure and investment decisions?*

3. Hypotheses development

To sum up, existing literature regarding the negative or positive impact of board diversity on company operating activities, decision-making and performance offers at best partial consensus on the overall potential effects of CEOs overconfidence on financial and investment performance of companies. Even less agreement can be found when it comes to considering the effects of board diversity on companies' performance in the presence of the effects of CEO overconfidence. Additionally, the impact of CEO overconfidence on capital structure decisions is debatable and potentially sensitive to the choice of methods used to measure the CEOs' overconfidence. As evidenced by our four Research Questions in Sections 2.4 and 2.5 above, our study attempts to fill a range of gaps in the surveyed literature, exploring the effect of board diversity on the relationship between CEO overconfidence and firm level financial decisions. To achieve this objective, we set out six testable Hypotheses that are linked (through our Research Questions 1 through 4) to the surveyed literature.

First, based on the assumption that overconfident CEOs tend to rely more on equity financing (Heaton, 2002; Hackbarth, 2008; Burkhard et al., 2022; Hatoum et al., 2022)), we propose the first hypothesis (H1):

H1. CEO overconfidence is positively correlated with equity financing, and negatively correlated with debt financing.

To analyze the role of diverse boards, this paper tries to examine influence of the board diversity on the relationship between CEO overconfidence and firm-level financial decisions from five perspectives: the effect of the duality of CEOs and chairpersons, female participation in the board room, independent directors proportion, age diversity of the board, and board size respectively. These aspects of our research are formalized in Hypotheses 2 through 5 below.

Since powerful CEOs are more likely to highlight potential success and self-attribute such success, they are more likely to be overconfident. Such overconfidence would have a greater influence on firm financing decisions (Adams et al., 2005; Burkhard et al., 2022) absent moderating effects on the CEO powers from board quality (diversity, independence, etc.). We expect that gender and age diversity, independence level and board size will help to constrain the behavior of CEOs, including CEOs' overconfidence. Therefore, we propose the following hypotheses:

H2. The duality of CEO and chairperson will strengthen the influence of CEO overconfidence on financing decisions, and the company thus will be more inclined to rely on equity financing. Thus, the duality of CEO and chairperson is expected to positively influence the relationship between CEO overconfidence and financing decisions.

H3. An increase in the share of female directors on the Board will reduce the impact of CEO overconfidence on financing decisions, and the company will be more inclined to rely on debt financing. Thus, gender diversity is expected to have a negative moderating effect on the relationship between CEO overconfidence and financing decisions.

H4. An increase in the share of independent directors on the Board will reduce the influence of CEO overconfidence on financing decisions. Thus, the independence of the board of directors is expected to play a negative role in regulating the relationship between CEO overconfidence and financing decisions.

Table 6.1
Tested variables and definitions.

	Variables selected	Symbols used	Definitions
Dependent variable	Debt Ratio	*Debt*	Total debt divided by total assets
Independent variable	CEO Overconfidence	*Overcon_Media*	The value is 1 if the CEO is considered overconfident using the media-based measurement; otherwise, the value is 0
		Overcon_Buy	The value is 1 if the CEO is overconfident using the stock-purchase-based measurement; otherwise, the value is 0
Moderating variables	Duality of CEO and chairperson of the board	*Dual*	The value is 1 if CEO and chairperson of the board are occupied by the same person; otherwise, the value is 0
	Gender diversity of the board	*Gender*	The percentage of female directors in the boardroom
	Independent level of the board	*Independ*	The proportion of independent directors in the Board
	Age diversity of the board	*Age*	Coefficient of Variation (the standard deviation of directors ages divided by the average age of directors)
	Board size	*Boardsize*	The total number of directors in the board
Control variables	Company size	*Comsize*	The natural logarithm of total assets
	Profitability	*Profit*	Return on Assets (Net income divided by total assets)
	Growth	*Grow*	The growth rate of total revenues over prior year
	Liquidity	*Liq*	Current ratio (current assets divided by current liabilities)
	Financial flexibility	*Flex*	Cash holdings divided by total assets
	Industry Year		The fixed effects of industry and year

H5. Higher dispersion of the age of directors will mitigate the influence of CEO overconfidence on capital structure decisions, namely age diversity will moderate the relationship between CEO overconfidence and financing decisions.

H6. An increase of the Board size will mitigate the influence of CEO overconfidence on capital.

4. Models and data

For the dependent we use the debt-to-assets ratio as the proxy for the financing decisions (capital structure choices) made by the company (Rajan and Zingales, 1995; Chen, 2004; Malmendier and Tate, 2005a,b; Banerjee et al., 2020; Ismail and Mavis, 2022). As discussed above, we use CEO overconfidence as the independent variable. In addition, in line with Hypotheses 2–6, we examine the moderating effects of board diversity across five dimensions: gender diversity, the board size, independence of the board, age diversity, and the duality of CEO and chairperson. These form our moderating variables. Our control variables cover company-specific characteristics that also might have an impact on financing decisions of companies. The detailed description of all variables selected is summarized in the following Table 6.1, with all moderating variables covered in the Literature Review Section 2 above, and all control variables selected to be consistent with literature surveyed in Banerjee et al. (2020) and Ismail and Mavis (2022).

To test hypotheses proposed in Section 4 above, we set up the following six theoretical models. Before regressing these models, we performed analysis of correlations and tested each model for multicollinearity. In addition, model selection test (the F test and Hausman test) were conducted. The results of these preliminary tests are available upon a request. According to the above tests, Fixed Effect (FE) model was found to be appropriate.

The influence of CEO overconfidence on corporate decision-making, as well as firm financing decisions, are continuous factors. Overall, it is therefore important to consider the effects of lagged moderating variables. We do so in the context of our robustness testing.

Regression model (1) was designed to assess the impact of CEO overconfidence on financing decisions:

$$
\begin{aligned}
Debt_{i,t} = {} & \beta_0 + \beta_1 Overcon\_Media_{i,t} + \beta_2 Comsize_{i,t} + \beta_3 Profit_{i,t} \\
& + \beta_4 Grow_{i,t} + \beta_5 Liq_{i,t} + \beta_6 Flex_{i,t} + \Sigma Ind \\
& + \Sigma Year + \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

Regression model (2) was established to examine the effect of the duality of CEO and chairperson on the relationship between CEO overconfidence and capital structure decisions:

$$
\begin{aligned}
Debt_{i,t} = {} & \beta_0 + \beta_1 Overcon\_Media_{i,t} + \beta_2 Overcon\_Media_{i,t} * Dual_{i,t} \\
& + \beta_3 Comsize_{i,t} + \beta_4 Profit_{i,t} + \beta_5 Grow_{i,t} + \beta_6 Liq_{i,t} \\
& + \beta_7 Flex_{i,t} + \Sigma Industry + \Sigma Year + \varepsilon_{i,t}
\end{aligned}
\tag{2}
$$

Regression model (3) was established to check the effect of gender diversity of the board on the relationship between CEO overconfidence and capital structure decisions:

$$
\begin{aligned}
Debt_{i,t} = {} & \beta_0 + \beta_1 Overcon\_Media_{i,t} \\
& + \beta_2 Overcon\_Media_{i,t} * Gender_{i,t} \\
& + \beta_3 Comsize_{i,t} + \beta_4 Profit_{i,t} + \beta_5 Grow_{i,t} + \beta_6 Liq_{i,t} \\
& + \beta_7 Flex_{i,t} + \Sigma Industry + \Sigma Year + \varepsilon_{i,t}
\end{aligned}
\tag{3}
$$

Regression model (4) was established to check the impact of board independence on the relationship between CEO overconfidence and capital structure decisions:

$$
\begin{aligned}
Debt_{i,t} = {} & \beta_0 + \beta_1 Overcon\_Media_{i,t} \\
& + \beta_2 Overcon\_Media_{i,t} * Independ_{i,t} \\
& + \beta_3 Comsize_{i,t} + \beta_4 Profit_{i,t} + \beta_5 Grow_{i,t} \\
& + \beta_6 Liq_{i,t} + \beta_7 Flex_{i,t} \\
& + \Sigma Industry + \Sigma Year + \varepsilon_{i,t}
\end{aligned}
\tag{4}
$$

Regression model (5) was established to check the impact of age diversity of the board on the relationship between CEO overconfidence and financing decisions:

$$Debt_{i,t} = \beta_0 + \beta_1 Overcon\_Media_{i,t} + \beta_2 Overcon\_Media_{i,t} * Age_{i,t}$$
$$+ \beta_3 Comsize_{i,t} + \beta_4 Profit_{i,t} + \beta_5 Grow_{i,t} + \beta_6 Liq_{i,t}$$
$$+ \beta_7 Flex_{i,t} + \Sigma Industry + \Sigma Year + \varepsilon_{i,t} \quad (5)$$

Regression model (6) was built to check the effect of board size on the relationship between CEO overconfidence and financing decisions:

$$Debt_{i,t} = \beta_0 + \beta_1 Overcon\_Media_{i,t}$$
$$+ \beta_2 Overcon\_Media_{i,t} * Boardsize_{i,t}$$
$$+ \beta_3 Comsize_{i,t} + \beta_4 Profit_{i,t} + \beta_5 Grow_{i,t}$$
$$+ \beta_6 Liq_{i,t} + \beta_7 Flex_{i,t}$$
$$+ \Sigma Industry + \Sigma Year + \varepsilon_{i,t} \quad (6)$$

Fortune 100 companies represent a selective sample of successful companies with relatively more comprehensive and higher quality information regarding their financial performance, board features, as well as indicators of the CEOs' overconfidence (Hirshleifer, 2001; Hilary et al., 2016). We use 2011–2019 data for the Fortune 100 companies screened to meet the following criteria. Firstly, we exclude listed companies in the banking and insurance industries, as is common with literature covering corporate finance. Secondly, we exclude companies without complete board information as well as companies listed after 2010. Our final sample consists of 82 companies. To maintain the comparability of data, we capture each set of data from the same source, and we use annual data for each firm and each CEO.

S&P Capital IQ database was used as a source for operational and financial data of individual companies. Data for our measure of CEO overconfidence based on press statements and articles was captured from the FACTIVA database by first scraping the database for key words and then manually checking and recording the number of articles that meet our pre-set criteria discussed in Section 2.4. This allowed us to check instances of error messages generated in some individual FACTIVA results. For example, due to searchability issues, some of the reports covering annual and quarterly filings for several companies-years have been omitted from our automated searches and some of the reports were entered multiple times in the search results. By identifying gaps and overlaps in reports compiled through the automated search we were able to check these reports manually. Stock purchasing information for each CEO was automatically scraped from the EDGAR database using Python-based program. EDGAR database contains all material company filings referring to insider trading as these are disclosed to the SEC (*Form 4*). Historical board and senior executives' diversity data was collected from THOMSON ONE database using Structured Query Language programming. This allowed us to compute the total number of directors, the number of female directors, and the number of independent directors of each firm on a yearly basis, as well as the descriptive statistics on the age of directors.

Table 6.2 demonstrates the descriptive statistics of all variables in our sample. Fortune 100 companies use debt 27 percent of the time on average to finance their operating and investing activities. Additionally, relatively small variation is shown in the capital structure decisions among these companies with the standard deviation of 0.208, and the maximum value of 1.201 means that certain companies almost completely rely on debt financing.

85 percent of CEOs are considered overconfident according to media-based measurement, which is consistent with previous literature (Goel and Thakor, 2008; Hackbarth, 2008; Ji et al.,

Table 6.2
Statistical Description of All Variables.

Variables	N	Mean	Std.Dev	Min	Max
Debt	739	0.27	0.208	0	1.201
Overcon_Media	738	0.85	0.355	0	1
Dual	738	0.65	0.477	0	1
Gender	738	0.21	0.096	0	0.556
Independ	738	0.84	0.113	0	1
Age	738	0.10	0.035	0	0.295
Boardsize	738	11.50	2.258	5	17
Comsize	738	11.18	1.369	6.992	15.045
Profit	738	0.06	0.042	−0.032	0.236
Grow	738	0.09	0.263	−0.758	3.629
Liq	738	2.25	5.652	0.175	81.524
Flex	736	0.07	0.062	0	0.597

2021). Manifestations of overconfidence vary slightly in different companies with the standard deviation of 0.355.

As for the duality of CEO and Chairperson, on average 65 percent of CEOs also hold the role the chairperson of the board. On average, only 21 percent of directors are female in the sample, and the maximum value of 0.556 and the minimum value of 0 indicate that the female participation in the boardroom is still at a relatively lower level. Next, the mean value of the proportion of independent directors is 84 percent, which means the majority of boards in the sample have a high proportion of independent directors. The age coefficient of variation mean value of 0.10 and the standard deviation of 0.035 indicate that the age dispersion of directors of the companies in the sample is quite low level, and the difference in the degree of director age dispersion between companies is also small. The size of the board of directors of the companies in the sample is between 5–17, with an average of around 11–12, and the standard deviation of 2.258. The latter statistic highlights the large difference in board sizes across sample companies.

The mean value of company size is 11.18 which reflects the fact that our sample is focused on the FORTUNE 100 companies which are all well-established multinational companies. In addition, the statistics for revenues growth reveal the wide range of revenues dynamics among companies. Meanwhile, mean profitability is at around 6 percent, and our sample is relatively closely clustered around the mean (the standard deviation of 0.042). The results for the liquidity of companies observed indicate a large variation among the companies with the maximum current ratio of 81.524 and the minimum current ratio of 0.175. Finally, Table 6.2 shows that the majority of companies maintain relatively low cash holdings with the mean value of 0.07, maximum value of 0.597 and the standard deviation of only 0.062.

Lastly, we consider two overconfidence metrics, defined earlier. Inconsistent nature of the results for CEO overconfidence from media-based (implied) and stock purchase-based (revealed) measurements are highlighted in Table 6.3. As the table shows, only 21 percent of all observations have overconfidence results for individual CEOs consistent across the two measurements. In terms of media-based measurement, the majority of observations are considered overconfident, while only 9 percent of observations are identified as overconfident according to stock purchase-based measurement. Results driven by these two methods are often completely opposite, which validates our interest (expressed in the Research Question 2) in how the differences in overconfidence measurement methodologies may influence our analysis of the effects of overconfidence on managerial decisions and the moderating influence that board governance systems can have on CEOs overconfidence.

The differences in overconfidence identification results revealed by the stock-purchase-based data might be caused by the following factors. Firstly, the time horizon of 2011 to 2019 might

Table 6.3
Comparison between Overcon_Media and Overcon_Buy.

	Overcon_Media=0	Overcon_Media=1	
Overcon_Buy=0	99(13%)	570(77%)	669(91%)
Overcon_Buy=1	10(1%)	59(8%)	69(9%)
	109(14%)	629(85%)	738(100%)

Table 7.1
Model (1) correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Debt	1						
(2) Overcon_Media	−0.517***	1					
(3) Comsize	0.340***	−0.171***	1				
(4) Profit	−0.185***	0.104***	−0.378***	1			
(5) Grow	0.095***	−0.096***	0.016	0.047	1		
(6) Liq	0.375***	−0.271***	0.306***	−0.108***	0.113***	1	
(7) Flex	−0.253***	0.176***	−0.317***	0.320***	0.091**	−0.047	1

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

be not enough for covering the full extent of CEOs' securities trading. Additionally, even though a purchase of shares of their own companies my reflect CEO's willingness to take risks and overconfidence, other signs of CEO overconfidence related to securities holding or trading such as "Holder67" or "Longholder" (Malmendier and Tate, 2005a; Kaplan et al., 2022) might need to be taken into consideration simultaneously. Under this circumstance, we will not use Overcon_Buy as the instrument for Overcon_Media to test the robustness of models, while instead considering the endogeneity of media-based measurement. We estimate the model for Overcon_Buy in a separate model setting, while we use the lagged value of Overcon_Media to test the robustness of our models.

5. Empirical results

We start our empirical analysis with correlation matrices and, based on the results of F test and Hausman test, proceed with the Fixed Effects model to test the Hypotheses 1–6 proposed earlier. Additionally, to ensure the robustness of our results, values of the explanatory variable are replaced by lagged values of CEO overconfidence.

5.1. Correlations analysis

Tables 7.1 to 7.6 demonstrate the results of Pearson correlation analysis of all variables in each model. Overall, it can be seen that the absolute value of the correlation coefficient of each variable is below 0.517, with majority of correlation coefficients concentrated around 0.1 in absolute value. Based on that, we form a preliminarily conclusion that there is no multicollinearity problem among the variables of each model.

Model (1): As Table 7.1 shows, the correlation coefficient between Overcon_Media and Debt is −0.517 which is significant at 1% level which is in line with our prior expectation. In addition, the correlation coefficients between all control variables and the dependent variable are significant, which suggests that our selection of control variables is appropriate.

Model (2): According to Table 7.2, the negative correlation between Overcon_Media* Dual and the dependent variable Debt, with the negative coefficient of the independent variable, is consistent with the expectation that the duality of CEO and chairperson roles can amplify the impact of overconfidence. Also notably, control variables show significant correlations with our dependent variable.

Model (3): From Table 7.3, the correlation coefficient between Overcon_Media* Gender and Debt is −0.356 (*p*-value < 0.01),

which is inconsistent with the expectation of Hypothesis 3. However, we cannot draw conclusions based on the Pearson correlation analysis alone and shall rely on regression results instead.

Model (4): In terms of the correlation matrix of Model (4), the negative correlation coefficient between the cross term Overcon_Media* Independ and the Debt implies a rejection of Hypothesis 4.

Model (5): Table 7.5 results indicate the potentially important role for Debt and other variables, excluding Age in our analysis. The correlation coefficient between Overcon_Media* Age and the dependent variable Debt is −0.400 (*p*-value < 0.01).

Model (6): As Table 7.6 shows, the dependent variable is significantly correlated with other variables (P < .01), and the correlation coefficient between Overcon_Media* Boardsize and Debt is −0.354 (P < .01), which is not in line with the expectation of Hypothesis 6. To further analyze the effect of board diversity on the relationship between the overconfidence of CEOs and capital structure decisions, we then run the FE model for testing each estimated model.

5.2. Regression results

5.2.1. Regression based on Overcon_Media
To test Hypotheses 1 to 6, we estimated six regression models. The results of all regressions are shown in Table 7.7.

First, the results in Model 1 confirm Hypothesis 1: the coefficient of Overcon_Media is −0.030 (*p*-value < 0.01), indicating that implied CEO overconfidence is negatively correlated with the debt financing level of the company. On the other hand, in terms of the results of control variables, the coefficient of Comsize is 0.018 (*p*-value < 0.05), signifying that the larger the company, the higher the level of debt financing in the sample. The difference in absolute magnitude between the two estimated coefficients indicates that overconfidence of CEO is economically significant: media-based (implied) CEO overconfidence is, indeed, a major factor co-determining debt financing levels carried by a company.

For Model 2, the coefficient of Overcon_Media is −0.026 (*p*-value < 0.05) while the coefficient of Overcon_Media* Dual is negative in estimated magnitude, but not statistically significant. Therefore, the duality of CEO and chairperson has no statistically significant moderating effect on the relationship between CEO overconfidence and capital structure decisions.

The results of Model 3 indicate a significant positive correlation between Overcon_Media* Gender and Debt (0.096, *p*-value <

Table 7.2
Model (2) correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Debt	1								
(2) Overcon_Media	−0.517***	1							
(3) Dual	0.085**	−0.049	1						
(4) Overcon_Media * Dual	−0.153***	0.457***	0.804***	1					
(5) Comsize	0.340***	−0.171***	0.149***	0.120***	1				
(6) Profit	−0.185***	0.104***	−0.138***	−0.109***	−0.378***	1			
(7) Grow	0.095***	−0.096***	−0.028	−0.016	0.016	0.047	1		
(8) Liq	0.375***	−0.271***	−0.117***	−0.128***	0.306***	−0.108***	0.113***	1	
(9) Flex	−0.253***	0.176***	−0.005	0.082**	−0.317***	0.320***	0.091**	−0.047	1

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

Table 7.3
Model (3) correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Debt	1								
(2) Overcon_Media	−0.517***	1							
(3) Gender	−0.137***	0.143***	1						
(4) Overcon_Media * Gender	−0.356***	0.663***	0.772***	1					
(5) Comsize	0.340***	−0.171***	0.117***	−0.059*	1				
(6) Profit	−0.185***	0.104***	0.071*	0.115***	−0.378***	1			
(7) Grow	0.095***	−0.096***	−0.130***	−0.165***	0.016	0.047	1		
(8) Liq	0.375***	−0.271***	0.064*	−0.181***	0.306***	−0.108***	0.113***	1	
(9) Flex	−0.253***	0.176***	0.036	0.095***	−0.317***	0.320***	0.091**	−0.047	1

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

Table 7.4
Model (4) correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Debt	1								
(2) Overcon_Media	−0.517***	1							
(3) Independ	−0.085**	0.078**	1						
(4) Overcon_Media * Independ	−0.504***	0.962***	0.280***	1					
(5) Comsize	0.340***	−0.171***	0.066*	−0.158***	1				
(6) Profit	−0.185***	0.104***	−0.032	0.091**	−0.378***	1			
(7) Grow	0.095***	−0.096***	−0.103***	−0.116***	0.016	0.047	1		
(8) Liq	0.375***	−0.271***	0.02	−0.273***	0.306***	−0.108***	0.113***	1	
(9) Flex	−0.253***	0.176***	−0.017	0.147***	−0.317***	0.320***	0.091**	−0.047	1

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

Table 7.5
Model (5) correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Debt	1								
(2) Overcon_Media	−0.517***	1							
(3) Age	0.028	−0.023	1						
(4) Overcon_Media * Age	−0.400***	0.744***	0.608***	1					
(5) Comsize	0.340***	−0.171***	−0.090**	−0.138***	1				
(6) Profit	−0.185***	0.104***	0.141***	0.153***	−0.378***	1			
(7) Grow	0.095***	−0.096***	0.141***	0.047	0.016	0.047	1		
(8) Liq	0.375***	−0.271***	−0.02	−0.142***	0.306***	−0.108***	0.113***	1	
(9) Flex	−0.253***	0.176***	0.180***	0.278***	−0.317***	0.320***	0.091**	−0.047	1

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

0.05), with the negative correlation between CEO overconfidence and debt financing (−0.051, p-value < 0.01), in line with Hypothesis 3. Thus, the gender diversity of the board has a moderating effect on the influence of CEO overconfidence on financing decisions, namely the higher proportion of female directors in the boardroom, the lesser the impact of CEO overconfidence.

In Model 4, the higher the board independence, the lower the influence of CEO overconfidence on financing decisions, with a significant negative coefficient of Overcon_Media (−0.116, p-value < 0.01) and significant positive coefficient of Overcon_Media* Independ (0.104, p-value < 0.05). We therefore confirm a statistically negative moderating effect of the independence of the boards.

Based on the results for Model 5, the impact of CEO overconfidence on capital structure decisions is still statistically significant (−0.048, p-value < 0.01). However, the moderating effect of age

Table 7.6
Model (6) correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Debt	1								
(2) Overcon_Media	−0.517***	1							
(3) Boardsize	0.188***	−0.061*	1						
(4) Overcon_Media * Boardsize	−0.354***	0.891***	0.361***	1					
(5) Comsize	0.340***	−0.171***	0.371***	0.012	1				
(6) Profit	−0.185***	0.104***	−0.190***	−0.002	−0.378***	1			
(7) Grow	0.095***	−0.096***	−0.192***	−0.147***	0.016	0.047	1		
(8) Liq	0.375***	−0.271***	−0.037	−0.255***	0.306***	−0.108***	0.113***	1	
(9) Flex	−0.253***	0.176***	−0.077**	0.109***	−0.317***	0.320***	0.091**	−0.047	1

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

Table 7.7
Regression results of each model based on Overcon_Media.

Variables	(1) Debt	(2) Debt	(3) Debt	(4) Debt	(5) Debt	(6) Debt
Overcon_Media	−0.030*** (0.009)	−0.026** (0.012)	−0.051*** (0.013)	−0.116*** (0.039)	−0.048*** (0.016)	−0.096*** (0.025)
Overcon_Media* Dual		−0.005 (0.011)				
Overcon_Media* Gender			0.096** (0.047)			
Overcon_Media* Independ				0.104** (0.045)		
Overcon_Media* Age					0.178 (0.134)	
Overcon_Media* Boardsize						0.006*** (0.002)
Comsize	0.018** (0.008)	0.019** (0.008)	0.019** (0.008)	0.018** (0.008)	0.019** (0.008)	0.012 (0.009)
Profit	−0.236* (0.135)	−0.234* (0.136)	−0.246* (0.136)	−0.246* (0.135)	−0.224* (0.136)	−0.255* (0.135)
Grow	−0.019* (0.011)	−0.019* (0.011)	−0.017 (0.011)	−0.019* (0.011)	−0.020* (0.011)	−0.018* (0.011)
Liq	0.0001 (0.001)	0.00009 (0.001)	0.0001 (0.001)	0.00008 (0.001)	0.00009 (0.001)	0.0001 (0.001)
Flex	0.079 (0.076)	0.079 (0.076)	0.079 (0.076)	0.077 (0.075)	0.066 (0.076)	0.066 (0.076)
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.108 (0.097)	0.105 (0.098)	0.098 (0.096)	0.111 (0.097)	0.103 (0.098)	0.172* (0.100)
Observations	736	736	736	736	736	736
Number of Firm	82	82	82	82	82	82

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

diversity of the board cannot be confirmed since coefficient for Overcon_Media* Age is not statistically significant. Thus, we find no support to the proposition that the age diversity of the board could moderate the influence of CEO overconfidence on capital structure decisions.

The results of Model 6 consistently indicate a negative relationship between Overcon_Media and Debt (−0.096, *p*-value < 0.01), and the coefficient of the cross term for the Boardsize is 0.006 (*p*-value < 0.01), which is in line with the hypothesis regarding the effect of board size. The larger the size of the board, the lesser the impact of CEO overconfidence on financing decisions. This result stands in contrast to some of the literature showing that larger boards generate governance inefficiencies, as reviewed in Section 2 above, although no literature has directly tested the links between board size, CEO overconfidence and the share of debt financing amongst the largest US-based companies.

To sum up, the basic hypothesis regarding the impact of CEO overconfidence on financing decisions is confirmed in all models tested: the more overconfident the CEO is, the less debt financing the company relies on. In addition, the moderating effects of gender diversity, board size, and the independence of the board on the relationship between CEO overconfidence and financing decisions is also confirmed. Put differently, Hypotheses 3, 4 and

6 are confirmed. In contrast, the results of the duality of CEO and chairperson and age diversity of the board show statistical insignificance. Moreover, in most cases, the coefficients on company size, profitability and growth are statistically significant, while the coefficients of the liquidity and cash holdings are mostly insignificant.

5.2.2. Results with Overcon_Buy

Regression results (Table 7.8) based on values of CEO overconfidence measured by stock purchases (revealed overconfidence) show statistical insignificance, which is in line with the prediction discussed earlier in our analysis in Section 4 (Table 6.3). As Table 7.8 shows, Overcon_Buy is not statistically significantly related to capital structure decisions of companies across all 6 models, which is distinct from the regression results with Overcon_Media which showed a significant negative correlation between Overcon_Media and debt financing for all 6 model specifications.

This finding is of significance. Firstly, it reflects problems embedded in the CEO overconfidence measurements and relevant to those prior studies that did not consider differences in overconfidence metrics in deriving their results. Secondly, these results also indicate the importance of more careful consideration of

Table 7.8
Insignificant results with Overcon_Buy.

Variables	(1) Debt	(2) Debt	(3) Debt	(4) Debt	(5) Debt	(6) Debt
Overcon_Buy	−0.005	−0.001	−0.01	−0.064	0.011	−0.054
	(0.008)	(0.014)	(0.023)	(0.086)	(0.026)	(0.051)
Overcon_Buy* Dual		−0.005				
		(0.018)				
Overcon_Buy* Gender			0.024			
			(0.098)			
Overcon_Buy* Independ				0.07		
				(0.100)		
Overcon_Buy* Age					−0.15	
					(0.236)	
Overcon_Buy* Boardsize						0.004
						(0.004)
Comsize	0.009	0.009	0.01	0.009	0.009	0.011
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Profit	−0.240*	−0.240*	−0.241*	−0.238*	−0.240*	−0.233*
	(0.130)	(0.130)	(0.131)	(0.130)	(0.130)	(0.131)
Grow	−0.023**	−0.023**	−0.023**	−0.023**	−0.023**	−0.021**
	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.011)
Liq	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Flex	0.102	0.102	0.1	0.099	0.102	0.098
	(0.072)	(0.073)	(0.073)	(0.073)	(0.072)	(0.073)
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.173	0.173	0.161	0.17	0.173	0.151
	(0.106)	(0.106)	(0.105)	(0.106)	(0.106)	(0.104)
Observations	736	736	736	736	736	736
Number of Firm	82	82	82	82	82	82

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

behavioral incentives imbedded in different CEO compensation structures. Since the equity- and options-based compensation structures are complex, options timing issues might distort the signals of overconfidence contained in CEOs own trading. For instance, if a CEO holds in-the-money call options, he or she can simply choose to exercise the option instead of directly buying shares at the market price.

5.3. Robustness tests

As discussed earlier, one period lagged values of the independent variable are used in the robustness tests, as the influence of CEO overconfidence on corporate decision-making is considered not a one-off single period variable, but a continuous one, and since, commonly, firm financing decisions are made before the beginning of the current period. (See Table 7.9)

Overall, the regression results using lagged one period values of independent variable Overcon_Media are broadly consistent with those attained in the original models. The lagged Overcon_Media is still significantly negatively correlated with Debt (−0.026, p-value < 0.01), indicating that the CEO overconfidence in the last year also has an influence on the current year debt financing, and the influence is less compared with the influence of CEO overconfidence in the current year (−0.030, p-value < 0.01), which is in line with our expectation. Coefficients for Overcon_Media* Dual and Overcon_Media* Age are still insignificant in robustness tests, which is also consistent with the results of our original models. The results of Models 3, 4 and 6 show similar findings to those discussed before, confirming the negative moderating effects of board independence, gender diversity, and board size. Notably, the results for gender diversity show a more significantly positive correlation between Overcon_Media* Gender and Debt with a substantial increase from 0.096, p-value < 0.05 to 0.142, p-value < 0.01. The results regarding control variables remain broadly unchanged.

5.4. Summary of the results

Overall, the following conclusions can be drawn based on the consistent results from regression analysis and robustness tests. Firstly, Hypothesis 1 is confirmed: the CEO overconfidence is negatively correlated with debt ratio. Secondly, based on the results of Model 1, the moderating effects of gender diversity, board independence and board size can be confirmed in Models 3, 4 and 6. Notably, the duality of CEO and chairperson and age diversity of the board show statistically insignificant results, suggesting that the duality and age diversity do not ameliorate or exacerbate the influence of CEO overconfidence on capital structure decisions. Table 7.10 provides a summary of the main empirical results.

6. Conclusions

The importance of cognitive biases of the senior management, particularly CEO overconfidence, has drawn the attention of many scholars. Yet, historically, majority of the researchers studying the relationship between CEO overconfidence do not pay much attention to the potentially moderating effect of board diversity on the impact of CEO overconfidence on capital structure decisions. This paper attempted to fill this gap.

To achieve this, we firstly summarized previous literature on the definitions, mechanisms, measurement and significances of CEO overconfidence. We show that there is no universally accepted method for measuring CEO overconfidence. Hence, to improve robustness and replicability of our empirical findings, our study maps out considerable differences in the measurements of CEO overconfidence based on two specific definitions of overconfidence biases (Moore and Healy, 2008): CEOs' own revealed biases (their own trading activities) and CEOs' externally signaled biased as reflected in the media reporting. In this, our study links with the more robust current literature on CEO overconfidence in

Table 7.9
Robustness tests of each model.

Variables	(1) Debt	(2) Debt	(3) Debt	(4) Debt	(5) Debt	(6) Debt
L. Overcon_Media	−0.026***	−0.019	−0.056***	−0.093**	−0.040**	−0.068**
	(0.010)	(0.013)	(0.014)	(0.041)	(0.017)	(0.027)
L. Overcon_Media* Dual		−0.009				
		(0.012)				
L. Overcon_Media* Gender			0.142***			
			(0.051)			
L. Overcon_Media* Independ				0.080*		
				(0.047)		
L. Overcon_Media* Age					0.135	
					(0.138)	
L. Overcon_Media* Boardsize						0.003*
						(0.002)
Comsize	0.017*	0.017*	0.017**	0.017*	0.017*	0.013
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Profit	−0.283**	−0.279**	−0.302**	−0.288**	−0.277**	−0.292**
	(0.140)	(0.140)	(0.140)	(0.139)	(0.140)	(0.140)
Grow	−0.022**	−0.022*	−0.020*	−0.019*	−0.023**	−0.021*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Liq	0	0	0	0	0	0
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Flex	−0.018	−0.021	−0.02	−0.019	−0.018	−0.013
	(0.087)	(0.087)	(0.087)	(0.087)	(0.087)	(0.087)
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.127	0.12	0.121	0.129	0.121	0.163
	(0.102)	(0.103)	(0.101)	(0.102)	(0.103)	(0.104)
Observations	655	655	655	655	655	655
Number of Firm	82	82	82	82	82	82

Note: ***, ** and * denote the significance at 1%, 5%, 10% level respectively.

Table 7.10
Summary of empirical results.

Main variables	Expected correlation with debt	Empirical results
Overcon_Media	−	−
Overcon_Media* Dual	+	0
Overcon_Media* Gender	+	+
Overcon_Media* Independ	+	+
Overcon_Media* Age	+	0
Overcon_Media* Boardsize	+	+

"−" denotes significantly negative correlation.
"+" denotes significantly positive correlation.
"0" denotes lack of statistical significance.

theoretical context (Moore and Healy, 2008; Hatoum, 2021) and empirical context (Hatoum et al., 2022; Kaplan et al., 2022).

Secondly, this paper used five governance variables including the proportion of female directors, the coefficient of variation of age, the percentage of independent directors, the duality of the CEO and the chairperson roles, and the total number of directors in the boardroom. This allows us to more robustly relate our findings to the broader literature on board-level governance (Goel and Thakor, 2008; Banerjee et al., 2020). We then examined whether the diversity of the board plays a moderating role in the impact of CEO overconfidence on capital structure decisions from these five perspectives.

Python programming and Structured Query Language were used in the stage of data acquisition and processing, which also helped to improve the accuracy, replicability and reliability of the data, as well as expand the statistical power of our analysis.

We cover data for the top 100 US-listed companies according to Fortune 100 (2019) over the time period of 2011–2019. Thus, our empirical analysis on the panel data contains 738 observations and covers a period between two structural crises, the Global Financial Crisis and The Great Recession and the Covid19 pandemic. This period selection also enhances robustness of our findings.

We show that within FORTUNE 100 companies, over 80 percent of CEOs have been confirmed as overconfident according to media-based (implied) overconfidence measurement. CEO overconfidence significantly affects the capital structure decisions of the company. Specifically, CEO overconfidence is negatively correlated with the debt financing of the company, which is also consistent with the findings of Heaton (2002) and subsequent literature on the subject. On the other hand, what is noteworthy is that regression results based on data sets processed with stock-purchase-based measurement of CEO overconfidence (revealed measurement) are statistically insignificant. This might be due to complex compensation structures and conflicting signals that CEOs aim to send through the media versus their own stock trading as consistent with Kaplan et al. (2022).

Board diversity plays an important role in moderating the impact of CEO overconfidence on capital structure decisions. The increase in the proportion of female directors can weaken the influence of CEO overconfidence on financing decisions, which is in line with findings that a relatively high proportion of female directors in the boardroom, could moderate overconfident actions of male CEOs (Chen et al., 2019). Similarly, the expansion of the board size and the increase of independent directors can also weaken the influence of CEO overconfidence on financing decisions, which might be due to the fact that the increase of independent directors and also board members could strengthen the control and supervisory capabilities of the board of directors (Omran et al., 2008; Adams and Mehran, 2012). However, the

regression results of the age diversity of the board and the duality of the CEO and chairperson are statistically insignificant. There is no evidence that the duality and age diversity have a moderating effect on the influence of CEO overconfidence on capital structure decisions, which is inconsistent with the broader findings of Adams et al. (2005).

Finally, the scale of the company is positively correlated with debt financing, while the profitability and growth are negatively correlated with the level of debt financing. This is also consistent with traditional theory: the expansion of the scale of the company would cause higher capital requirements, and the increase in revenues and relative returns reflect the ability of the enterprise to generate cash flows, and thus the demand for external financing might be accordingly reduced. In addition, this research also shows that liquidity and relative cash holdings are not statistically significantly related to capital structure decisions.

Our study has limitations in terms of the sample: Fortune 100 companies are well-established, large and multinational companies so our findings may or may not be applicable to small and medium-sized companies or younger and faster growing companies. It is, therefore, natural to suggest that future research should be extended to include a larger number of companies with greater variation in company sizes. Our chosen time horizon over 2011 to 2019 offers us an insight into the phenomena we are interested in studying during the only period in the last 15 years when the global economy and the US markets experienced a relatively 'normal' environment (environment not characterized by major systemic crises). Unfortunately, such a short period of time might be not enough to capture CEO overconfidence as revealed through stock purchases and holdings (Malmendier and Tate, 2005a). A longer time horizon should thus be used to check the robustness of our findings over a range of macroeconomic and strategic environments. However, such an extension should carefully address the periods of two major systemic crises that flank our period of choice. Lastly, future research can focus on a highly important area of research that we have omitted here due to the scale of data collection and analysis involved: the importance other features of board diversity such as racial, ethnic, religious and background diversity.

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