The effect of CEO overconfidence on firm leverage during Covid-19

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Abstract

This empirical study aims to analyze the impact of CEO overconfidence on firm leverage and further investigates how the Covid-19 pandemic affects the latter relationship. CEO overconfidence is measured by a proxy, reflecting the CEO's option holder behavior; first introduced by Malmendier and Tate (2005). A comprehensive dataset of firms included in the U.S. Standard and Poor's 1,500 index (U.S. S&P 1,500), covering the period from 2012 until 2022, is employed and a separate sample is utilized to analyze the Covid-19 period. The study employs Ordinary Least Squares (OLS) and multivariate regressions with fixed effects to explore the relationship while controlling for various factors. The study finds that there is no statistically significant relationship between CEO overconfidence and leverage. However, further analysis shows that during periods of low interest rates, such as Covid-19, overconfident CEOs will increase or decrease firms' leverage. The results also demonstrate that the relationship between CEO overconfidence is positive and significant for financial firms specifically. The study controls for firm-specific characteristics to mitigate potential endogeneity concerns and employs a propensity score matching (PSM) model, indicating that firm-specific characteristics and CEO overconfidence strongly correlate. The findings highlight that high levels of leverage in firms can have significant financial- and social consequences, which may be further exacerbated during unanticipated market shocks. CEO overconfidence can amplify these problems, emphasizing the importance of selecting management and capital structure policies carefully.

Keywords: CEO overconfidence, leverage, Covid-19, CEO characteristics, macroeconomic indicators, firm-specific characteristics, panel study

Acknowledgements

This section aims to provide a brief overview of the final projected I completed for my MSc. Financial Economics at the Erasmus School of Economics. Over the course of the last several months, I encountered various challenges while progressing through my thesis writing. Notwithstanding these difficulties, I have found the writing process to be engaging and it sparked my curiosity in the subject of CEO overconfidence and its potential impacts and consequences.

Taking advantage of this opportunity, I would like to express my sincere appreciation to those who have provided support and guidance during the thesis writing process. First and foremost, I want to acknowledge the invaluable guidance and support offered by Professor Ruben Cox, whose PhD in finance and extensive financial expertise provided me with useful insights and challenged me to produce a solid academic research paper. Secondly, I am grateful to Joris Kil, the co-reader of my thesis, who has a wealth of knowledge in my thesis topic and initially inspired me to write on this topic. I would also like to thank him for sparing his time to serve as the second reader and evaluate my master's thesis.

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Introduction

Prior to the outbreak of the global pandemic on March 11, 2020, the debt levels of nonfinancial firms were already at a significant high (Buckley et al., 2021). This can be attributed, in part, to the steady decline of interest rates since the Global Financial Crisis (GFC), which resulted in debt outstanding of United States (U.S.) nonfinancial firms reaching 75% of gross domestic product (GDP) in Q3 of 2019, a record high at the time (Buckley et al., 2021). With the Covid-19 pandemic causing major disruptions for businesses, firms have resorted to increasing debt financing to meet strategic needs during this period of heightened uncertainty. The Covid-19 pandemic therefore acted as a catalysator of surging debt to even higher levels. Moreover, the pandemic caused a prompt and unprecedented slowdown of the worldwide economy, culminating to a historic drop in the U.S. GDP during Q2 of 2020 (Hotchkiss et al., 2020). To mitigate the economic consequences, the U.S. government implemented support programs to facilitate additional lending for companies. As of Q2 2020, firm credit of nonfinancial businesses outstanding summed up to $17.6 trillion, reflecting a year-on-year increase of 10.5% (*The Fed*, n.d.). Particularly, firms with higher leverage are at a higher risk of default, as highlighted by Baxter (1967). Therefore, the substantial increase of U.S. company leverage, observed in 2020, has resulted in firms being more susceptible to heightened risk of bankruptcy.

In addition to the challenges posed by volatile market conditions, a firm's leverage may also be impacted by the characteristics of the CEO managing the firm. Personal characteristics impact the firm's strategic decision-making, with the impact being more pronounced for highly complex decisions and for managers characterized by bounded rationality (Hambrick & Mason, 1984). Therefore, irrational behavior, such as overconfidence, can exacerbate the substantial increase of firm leverage during Covid-19, which gives rise to the following research question:

How do overconfident CEOs, managing U.S. firms included in the S&P 1,500 index, affect the firms' leverage and what is the impact of the Covid-19 pandemic on this relationship?

Previous research has extensively studied capital structure decisions, with most studies supporting traditional economic theories that assume CEOs will make rational decisions. However, a limited number of studies considered the impact of irrational behavior on capital structure decisions,

suggesting that managerial characteristics and biases also play a role. Despite prior literature, the relationship between CEO overconfidence and capital structure remains ambiguous. Considering the conclusions that can be drawn during volatile market circumstances, only one research demonstrates a significant positive relationship between CEO overconfidence and leverage during the GFC (Ho et al., 2016). Despite the GFC primarily affecting financial institutions, the impact of Covid-19 needs to be acknowledged differently, as it constituted an exogenous market shock driven by public health concerns, rather than economic conditions, and was thus unanticipated (Albuquerque et al., 2020). Besides previous research not having considered the potential effect of the Covid-19 pandemic on the relationship, it has not focused on nonfinancial firms, different industries, firm-specific measures and other CEO characteristics. This study aims to control for the described factors and focuses on U.S. firms, in order to reduce variations in corporate governance systems across countries, included in the S&P 1,500 index. The paper will contribute to existing literature by highlighting the consequences of high levels of leverage, especially during unforeseen economic downturns such as the Covid-19 pandemic. Additionally, the research contributes to existing literature by raising questions about the selection of management by the board of directors and addresses the importance of decisions on the firm's capital structure policy measures.

1.2 Impact of the Covid-19 pandemic

The outbreak of the pandemic in early 2020, triggered an acute economic crisis with a considerable aftermath, reflecting different macroeconomic periods. The crisis, in 2020, was characterized by a negative supply and demand shock, whereby Covid-19 related restrictions led to a contraction of labor, disrupted supply chains, and ultimately reduced output (Brinca et al., 2020). Further exacerbating the economic situation, the pandemic also led to a decline in consumer spending due to government lockdowns, shift in consumer preferences, and reduced purchasing power (*The Fed,* n.d.). While supply disruptions remain persistent, the successful vaccine rollout in the U.S. during Q1 of 2021 resulted in increased consumer confidence and high saving accounts. However, 2021 is characterized as a period of slow recovery of demand due to the opposing demand and supply shocks (Brinca et al., 2020). The start of the Russian-Ukraine war, in February 2022, had a

significant impact on global supply chains, further worsening the negative supply shock caused by Covid-19. This conflict led to significant increases in energy and food prices, resulting in inflationary pressures that forced monetary policy to increase interest rates significantly (Caldara et al., 2022). Although it is important to consider the effects of the two economic periods following 2020, potentially worsening the liabilities' accounts of firms, this study will predominantly focus on the unprecedented market crash in 2020.

The economic crisis initiated by the pandemic, along with other recessionary periods, poses a threat to the financial flexibility of firms due to their elevated debt obligations, which in turn, increases the risk of bankruptcy (Baxter, 1967). In addition to the observed increase in business closures, limited financial flexibility can impede the restructuring capacity of companies, leading to potential reductions in wage expenses (*The Fed*, n.d.). The latter social burden of elevated firm leverage is reflected in the rise of unemployment rates, as highlighted by Smith et al. (2021), where the U.S. unemployment rate tripled from 3.6% in Q4 2019 to 13.0 % in Q2 2020. The increase in unemployment rates jeopardizes consumer purchasing power and subsequently reduces consumer spending, comprising a significant factor of economic activity (*The Fed*, n.d.). Consequently, the raised levels of leverage observed during Covid-19 have far-reaching financial and social consequences.

The main findings of the study indicate that there is no significant relationship between CEO overconfidence and a firm's leverage. Although recent research by Gurdgiev and Ni (2023) found insignificant results as well, this study contradicts prior literature suggesting that overconfident CEOs exhibit a preference for either debt or equity financing (Heaton, 2002; Hackbarth, 2008). Further analysis finds a significant difference between CEO overconfidence and firm leverage for varying interest rates, such as the remarkably low interest rates observed during Covid-19. Given the lack of prior literature exploring this relationship during Covid-19, no existing evidence can support the result found. Additionally, a sensitivity analysis illustrates that the relationship between CEO overconfidence and firm leverage is significantly positive for financial firms specifically, which is confirmed by Ho et al. (2016). Besides CEO characteristics and macroeconomic indicators affecting leverage, firm-specific characteristics have remarkable influence on the relationship studied. To mitigate potential endogeneity issues, an additional

analysis is conducted that shows overconfident CEOs tend to manage firms with similar characteristics.

Hereafter, the study is structured in several chapters that collectively answer the research question. The first pillar needed to answer the research question is the discussion of previous literature. The literature review incorporates theories on capital structure and behavioral economics, with a particular focus on CEO overconfidence. Moreover, literature expands on the plausible impact of CEO overconfidence on capital structure. Furthermore, the literature section summarizes how Covid-19 could have a potential effect on the correlation between CEO overconfidence and leverage by examining the relation of both variables to economic downturns. The literature overview will result in several hypotheses that are tested to answer the research question. Subsequently, the third chapter describes the data included in the sample. In relation to that, the methodology of the empirical tests employed is outlined. Both latter chapters provide a detailed overview of the variables included, key model assumptions, and the regression models utilized in this study. Chapter 5 presents the results, including interpretation and hypothesis acceptance or rejection, supported by previous literature. Additionally, robustness checks and complementary statistical tests are detailed to control for possible mediating factors. Lastly, Chapter 6 comprises the conclusion, presenting an answer to the research question and providing suggestions for further research.

Literature review

The literature review will first elaborate on capital structure theories and other factors that potentially affect financial decisions of a firm. Furthermore, the economic fields of traditional- and behavioral finance are analyzed, subsequently focusing in particular on the behavioral finance field, investigating literature on the overconfidence bias. Also, literature that studies the relationship between CEO overconfidence and capital structure will be detailed. Finally, this section presents a comprehensive review of the relevant literature on the characteristics of economic crises, including their potential relationship with CEO overconfidence and its implications for capital structure decisions in firms.

2.1 Capital structure

Several theories on the optimal capital structure of a firm have been established. Modigliani and Miller (1958) were the first to present a theory, known as the Modigliani-Miller (M&M) Theorem, in which the authors assumed perfect- and frictionless markets. Following the latter assumption, the authors argue that the preference for debt- or equity financing has no effect on either firm value, or on the cost of capital. Hence, capital structure is considered to be irrelevant (Myers, 2001). In contrast, the groundwork of the M&M Theorem induced other researchers to test new assumptions that can explain why the choice of capital structure should be considered relevant for firms (Rajan & Zingales, 1995).

The traditional capital structure theories that are widely adopted in economic literature include the trade-off theory, which highlights taxes; the pecking order theory, which emphasizes information asymmetry; and free cash flow theory (i.e., agency cost theory), which stresses agency costs (Myers, 2001). According to the trade-off theory, companies pursue debt levels that balance between the tax benefits (i.e., the marginal value of the tax shields) of increasing debt levels, and the rise in the present value of potential costs generated by financial distress (Kraus & Litzenberger, 1973; Myers, 2001). Therefore, profitable firms tend to prefer debt financing as they have more taxable income to shield. Additionally, firms with safe and tangible assets are likely to incur higher levels of borrowing compared to firms with risky and intangible assets, since high-risk firms are more vulnerable to financial distress and intangible assets can exacerbate the

liquidity problems in case of financial distress (Myers, 2001). The pecking order theory, presented by Myers and Majluf (1984), argues that firms are more likely to issue debt, relative to equity, when their internal cash flow is insufficient to fund capital expenditures. Accordingly, a firm's debt level is considered an indicator of its cumulative external funding needs, as it follows the pecking order hierarchy of progressively issuing riskier debt before issuing equity as last resort. In comparison to the previous two capital structure theories, Jensen's (1986) free cash flow theory explains the consequences of high debt ratios rather than a clarification on how managers will make choices on the capital structure. The free cash flow theory assumes that firm value will increase with higher debt levels, irrespective of the risk of financial distress, as long as the firm's operating cash flow surpasses its viable investment opportunities. The theory is most relevant to mature companies that generally have a tendency towards excessive investments (Jensen, 1986).

Alongside the advantages of attracting additional debt, elevated leverage also present disadvantages that must be acknowledged. A number of benefits to leverage are presented by Klein et al. (2002), providing reasons why firms prefer debt over equity in their capital structure decisions. These include the interest paid over debt to be tax-deductible, the amortization being regularly fixed according to a predetermined schedule, debt holders being prioritized in repayments in case of bankruptcy, and the cost of capital to be lower compared to the cost of equity. In contrast, highly levered firms are subject to strong disadvantages, particularly during macroeconomic events. One of the most pronounced drawbacks follows from the increased future debt obligation, inducing increased bankruptcy risks (Baxter, 1967). Accordingly, a debt-to-equity trade-off is appropriate to apply when making decisions on the optimal capital structure of a firm (Myers, 2001).

Harris and Raviv (1991) conducted a thorough analysis of the determinants of a firm's capital structure, drawing on prior literature. The authors highlight that firm size, tangibility of assets, growth opportunities, and non-debt tax shields are positively related with debt levels, whereas volatility, research and development (R&D) expenditures, probability of default, profitability and the uniqueness of the product are negatively related. Rajan and Zingales' (1995) study, focusing on major industrialized countries, found similar effects of firm size, tangibility of assets, growth opportunities (i.e., market-to-book ratio), and profitability, on firm leverage. These relationships can be explained through economic reasoning and theories. First, larger firms will have reduced

bankruptcy costs and have more diversified portfolios, which allows them to take on additional debt. Second, firms with a higher number of fixed assets will have a higher debt capacity. Third, Modigliani and Miller (1958) explain that firms with growth opportunities will initially finance the project with debt because the market stock price will be relatively low. Subsequently, if the project proves to be profitable, the debt will be repaid by issuing equity with higher returns. The contrary is acknowledged by Myers' (1977) study, which asserts that firms with growth opportunities will issue less risky debt, ceteris paribus, compared to firms supported by assets already in place. In contrast to the positive relationship that the latter three variables exhibit with firm's leverage, the profitability of a firm is negatively associated. This implies that profitable firms prefer internal financing over external financing, which is consistent with the pecking order theory (Rajan & Zingales, 1995; Harris & Raviv, 1991).

2.2 Overconfidence

The field of economics includes theories, such as the Efficient Market Hypothesis (EMH) and the Capital Asset Pricing Model (CAPM), that help us understand financial markets and estimate a security's- and firm's fundamental value (Fama 1963,1965; Sharpe, 1964; Lintner, 1965). These traditional theories assume efficient markets and agents to act completely rational. According to these assumptions, an expected risk and return trade-off can be established. However, in practice, we observe mispricings and other limits in the market, which cannot be explained by these traditional theories (Baker et al., 2004). Examples of such mispricings include, amongst others, the effect of trading hours on price volatility, post-earnings announcement drift, momentum, negative "stub" values, and bubbles and crashes in growth stocks (Barberis & Thaler, 2003). To solve these financial puzzles, resulting from irrational behavior of market agents, behavioral corporate finance, a new branch of economics, emerged to study the effects of psychology on investors and financial markets.

Behavioral finance can be defined as a mix between traditional economic theories and behavioral and cognitive psychological theories (Tversky & Kahneman, 1974; Barberis & Thaler, 2003). The theoretical foundation of behavioral finance is established based on two observations. First, investors have different tastes and preferences, such as their level of risk aversion, and second,

assets differ in multiple characteristics, not only related to risk and expected return (Baker & Wurgler, 2002). These personal preferences and asset characteristics can unconsciously trigger market agents to exhibit psychological biases. According to Kahneman (2011), a prominent author in the field of behavioral finance, overconfidence is "the most significant of the cognitive biases" (p.58). Overconfidence can be defined as the overestimation of one's own capabilities, such as knowledge and skills, and underestimating the accuracy of their future prediction of returns (Malmendier & Tate, 2005). Individuals in positions of power, particularly CEOs, exhibit a greater propensity of overconfidence (Larwood and Whittaker, 1977). Therefore, CEOs are prone to estimating the success of their corporate and investment decisions incorrectly, underestimating the fluctuations in stock market returns, and other financial indicators, and attributing too much of their firms' accomplishments to their own abilities rather than external factors (Malmendier & Tate, 2005; Ben-David et al., 2013). Hence, the overconfidence bias can explain CEO's decision-making and the subsequent consequences of such actions.

Empirical studies have demonstrated that overconfident CEOs can exert a negative influence on investment decision-making. Following Malmendier and Tate (2005), overconfident CEOs will overinvest in new projects when the firm has abundant internal funds, resulting in accepting a negative net present value project. Additionally, overconfident CEOs will forgo projects, which would generate positive net present values, when external funding is required. The first decision can be explained by the fact that CEOs overvalue the returns to their investment and the second decision is made because the CEO believes that capital markets undervalue their firm's risky securities (Heaton, 2002). The study of Heaton (2002) argues that the CEO's misvaluation can be attributed to optimistic managers systematically attaching higher probabilities to good outcomes compared to the capital market. Based on a comprehensive review of the latter literature, the conclusion can be drawn that investment decisions made by an overconfident CEO can turn out to be value destructive.

In contrast, Hirshleifer et al. (2012) indicate a positive relationship between CEO overconfidence and firm value, based on a sample of 1,771 firms between 1993 and 2003. The authors attribute the nature of this relationship to overconfident CEOs systematically underestimating the likelihood of failure, inducing the executives to take additional risk, which, in turn, results in high R&D

investments that create strong growth opportunity (Ben-David et al., 2013). Consistently, Galasso and Simcoe (2010) and Englmaier (2004) argue that overconfident CEOs are more likely to innovate, compared to their non-overconfident peers. In general, innovative firms rely more on external finance, with debt financing being preferred over equity financing, in order to fund their projects (Barker & Mueller, 2002, Myers & Majluf, 1984). However, the use of debt decreases with the size of the R&D investment and therefore the most R&D-intensive firms tend to issue equity rather than debt (Aghion et al., 2004). This preference can be attributed to the higher risks and relatively higher costs that innovative firms face in relation to their investment opportunities. The risky nature of R&D investments can cause financial institutions to be more cautious in lending to highly innovative firms, requiring additional compensation in terms of higher interest rates, which increases the cost of debt for innovative companies. Moreover, financial institutions often require stable cash flows, making equity financing a more attractive option for highly R&D-intensive firms (Titman & Wessels, 1988). While previous research is significantly scarce, the positive correlation between overconfidence and innovation and the non-linear relationship between innovation and debt financing, suggests that the potential relationship between overconfidence and leverage will be stronger for innovative firms.

2.3 Overconfidence and leverage

According to the Upper Echelons Theory (UET), personal characteristics of CEOs have a substantial effect on their strategic choices, including the decisions on financial leverage of a firm (Hambrick & Mason, 1984). The theory also stresses that managers who employ behavioral biases, such as the overconfidence bias, will make decisions based on their cognitive and physiological characteristics. Correspondingly, previous literature has shown that personal characteristics drive CEO overconfidence (Malmendier & Tate, 2005; Hackbarth, 2008). Therefore, the effect of personal characteristics can potentially strengthen the relationship between CEO overconfidence and firm leverage. However, the majority of literature does not consider personal characteristics in studying financial leverage. In combination with the limited available literature on the relationship between CEO characteristics, of which one is overconfidence, and financial leverage, the UET provides plausible explanations, contributing to the behavioral finance literature.

Gender and age are one of the main demographic variables that should be incorporated as CEO characteristics, to study its relation to the manager's risk aversion and financial decision-making. Firms that are headed by female CEOs exhibit significantly lower levels of firm risk and idiosyncratic risk, compared to firms headed by male CEOs (Martin et al., 2009). Additionally, female-led companies tend to issue lower levels of debt and accordingly have lower leverage (Huang & Kisgen, 2013). Furthermore, literature presents ambiguous evidence on the impact of age on leverage. Bertrand and Schoar (2003) and Frank and Goyal (2007) both argue that older CEOs are more likely to take on less leverage compared to younger CEOs. The authors posit that the past experiences of older CEOs are linked with more conservative and risk-averse behavior, while younger CEOs tend to exhibit more radical thinking due to their expectations of the future. However, previous studies have also demonstrated a positive relationship between age and the level of risk-taking. De Bruin et al. (2012) stress that the relation between age and the level of overconfidence depends on how challenging and demanding the job is. Since the tasks of a CEO can be considered cognitively demanding, the authors conclude that older CEOs are generally more overconfident than younger CEOs and subsequently take more risks.

Additionally, it is important to gain a clear understanding of the effect of CEO's tenure on the firm's financial decision-making. Following Cai and Sevilir (2012) and Bergh (2001), CEOs with long tenures possess greater knowledge and understanding of their business and financial markets, which enables them to make more informed decisions and avoid excessive risk-taking, leading to a preference for less debt financing. Hambrick et al. (1993) present evidence that counters the previous argument, suggesting that newly appointed CEOs tend to exhibit lower levels of risk-seeking behavior in the firms' financing decisions due to their greater emphasis on external factors. As CEOs gain more experience in their function, they are likely to become more confident and are inclined towards making more challenging financing decisions, resulting in a preference for higher levels of debt (Hambrick et al. 1993; Malmendier & Tate, 2008).

Besides the aforementioned characteristics grounded to the UET, the effect of two corporate governance measures is important when studying the determinants of the firm's capital structure. The study of Malmendier and Tate (2008) emphasizes the importance of including CEO duality, which is defined as being chairman of the board in addition to having the title of a CEO. CEO

duality can result in the accumulation of greater power within the organization and ineffectiveness within the board (Howton et al., 2001). Therefore, CEO duality has both a positive relation with CEO overconfidence and the level of firm leverage. The board size of a firm is considered the second corporate governance measure. Although this factor is included in the UET, it is considered a firm-specific characteristic rather than a personal characteristic. The effect of board size on a firm's financing decisions has not been studied before, however, research has shown that board size is negatively correlated to the firm value (Gurdgiev & Ni, 2023).

Although previous research investigating the impact of overconfidence on corporate and investment decisions provides clear understanding, the influence of CEO overconfidence on capital structure decision-making remains inconclusive. Malmendier and Tate (2008) conclude that overconfident CEOs are more likely to undertake value-destroying mergers and argue that the effect is more pronounced for firms that have abundant internal financial resources. Similarly, Malmendier and Tate's (2005) earlier research emphasizes that overconfident managers overestimate the returns of their investment and perceive external financing as excessively expensive. As a result, the authors conclude that firms with overconfident CEOs are more likely to rely on internal instead rather than external financing. In case external funding is required for financing acquisitions, overconfident CEOs are more inclined to prefer equity financing over debt financing (Malmendier & Tate, 2008). The latter preference is confirmed by previous studies which suggest that CEO overconfidence is negatively correlated to debt financing of the firm (Heaton, 2002; Gurdgiev & Ni, 2023). The preference of this decision can be explained by the market timing theory, which stresses that overconfident CEOs are likely to underestimate the firms' risk when making financing decisions, assuming that their corporate bonds are undervalued while the value of their stocks are overvalued by the market (Baker & Wurgler, 2002). This belief will result in overconfident CEOs taking advantage of the perceived mispricing and consequently preferring equity financing over debt financing, which is consistent with the reverse pecking order (Hackbarth, 2008). Recent research by Gurdgiev and Ni (2023) examines the impact of board diversity, proxied by individual characteristics and corporate governance measures, on the relationship between CEO overconfidence and capital structure decisions of U.S. firms between 2011 and 2019. The findings suggest that the significant relationship observed is contingent upon the measure of overconfidence employed. Specifically, the use of media coverage data to compute

CEO overconfidence exhibits a negative correlation with debt financing, whereas no significant result is observed when employing the option holder measure of CEO overconfidence. Overall, the multiple studies discussed indicate a negative correlation between overconfident CEOs and the firms' debt levels.

In contrast to the described literature, several studies conclude a positive relationship between CEO overconfidence and a firm's leverage. Huang et al. (2016) find that overconfident CEOs prefer debt over equity and stress that they prefer short-term debt to long-term debt. Hackbarth (2008) shows similar results and underscores that biased managers tend to use more debt financing than non-biased managers, as biased managers identify the firm to be more profitable and less risky. In particular, overconfident CEOs tend to underestimate the costs of financial distress and the market volatility, which highlights their perception of reduced risks (Ben-David et al., 2007). Additionally, empirical evidence shows that overconfident CEOs believe that equity is more undervalued compared to debt, leading to higher leverage under the assumption of ceteris paribus (Heaton, 2002; Malmendier et al., 2011). Although the findings of Graham et al. (2013) confirm the preference of overconfident CEOs' debt financing, the authors highlight that U.S. CEOs are more risk-seeking and optimistic compared to non-U.S. CEOs. However, Mundi (2022) studies S&P BSE 200 companies in India and also highlights that overconfident CEOs prefer debt financing over equity financing. Summarizing the results of these studies, the relationship between overconfidence and leverage is considered positive and significant, with the magnitude of this effect being most pronounced for U.S. firms.

Various factors may influence the relationship between CEO overconfidence and firm leverage, potentially explaining the inverse relationship identified. These factors may range from individual characteristics and macroeconomic indicators, to firm-specific metrics. However, given the lack of consensus on the relationship between CEO overconfidence and firms' capital structure decisions, particularly with regards to debt financing, the first two hypotheses that will be tested are formulated beneath.

$H_{1,0}$ = CEO overconfidence does not affect the level of firm leverage

$H_{2,0}$ = There are no factors that can influence the correlation between CEO overconfidence and firm leverage

2.3 Overconfidence and leverage during Covid-19

Limited literature is available that studies the relationship between CEO overconfidence and firm leverage during crises. Additionally, the latter relationship has not been investigated in literature during the Covid-19 pandemic yet. Ho et al. (2016) research the effect of overconfident CEOs in the banking industry on the lending standards and leverage, reflecting empirical evidence that is most closely related to the research of this study. The authors find that prior to the Russian crisis in 1998 and prior to the GFC, banks with overconfident CEOs are more likely to soften lending standards and raise leverage, compared to banks with non-overconfident CEOs. The latter effect is recognized to have severe consequences, as the banks with overconfident CEOs are found to be more prone to elevated levels of loan defaults, having greater declines in operating- and stock performance, and experience a greater likelihood of bankruptcy. However, as this study employs a sample that includes both financial- and nonfinancial firms, from which nonfinancial firms are inimitable in terms of their asset structure, the results of Ho et al. (2016) cannot be compared directly to the findings in this study. Therefore, it is essential to address the impact of a crisis on both overconfidence and leverage, in a sample of firms operating in all industries in order to accurately assess the potential relationship.

The first question that should be answered reflects whether there is a change in the level of overconfidence in periods of severe market volatility. The latter question has only been studied by applying overconfidence to investors' sentiment. Psychological biases, particularly overconfidence, result in investors mispricing the intrinsic value of stocks and will fuel financial bubbles (De Grauwe & Yi, 2012). Accordingly, Jlassi et al. (2014) conclude that overconfidence is one of the main reasons that globally provoked and lengthened the GFC. Thus, high levels of market volatility can partly be explained by overconfidence. However, Jlassi et al. (2014) also conclude that overconfidence is present in markets during both economic upturn and downturn

periods. Moreover, the authors imply that the level of overconfidence is relatively low during periods of economic downturn compared to economic upturns. Hence, the conclusions drawn on the level of CEO overconfidence during economic downturns are still questionable.

The second question that should be addressed pertains to the potential changes in debt levels of firms during periods of market fluctuations. Narayan et al. (2021) study the relationships of key macroeconomic determinants, specifically interest rates, inflation, and GDP, on corporate leverage among nonfinancial firms in the S&P 500. Their findings highlight that interest rates are positively correlated, inflation is negatively correlated, and GDP is positively correlated, to the leverage of a firm. The first conclusion drawn on interest rates is in line with the trade-off theory (Modigliani & Miller, 1958; Myers, 1984). In contrast, an increase in interest rates also results in higher borrowing costs. Therefore, an increase of interest rates will result in firms reducing the volume of corporate debt issuance (Bernanke et al., 1990). Given that inflation induces interest rates, the findings regarding the impact of inflation on leverage can also be theoretically explained by the trade-off theory. Based on the agency theory, however, firms are more likely to issue equity when inflation increases (Baker & Wurgler, 2002). The authors highlight that there is a positive correlation between S&P 500 returns (i.e., the value of the equity market is up) and U.S. inflation. Furthermore, the trade-off theory also supports the positive correlation between GDP and leverage because the theory emphasizes that higher profitability of a firm, due to high levels of GDP, results in a firm to be more likely to increase debt (Kraus & Litzenberger, 1973; Myers, 2001). Bernanke and Gertler (1989) agree, arguing that during economic downturns, the accessibility of debt is limited due to higher agency costs between lenders and borrowers. By taking into account the aspect of behavioral finance, the market timing theory justifies that firms prefer to raise debt instead of issuing equity during a “bad” market state (Baker & Wurgler, 2002). Based on the latter theory, an overconfident CEO will believe that the market undervalues the stock prices in bear market conditions and therefore clarifies the preference of debt. Lastly, Dermici et al. (2019) and Graham et al. (2013) research the effect of government debt, an indirect proxy of GDP, on leverage of nonfinancial firms, using data from 40 countries and U.S., respectively. Both studies find a statistically significant and negative relation, indicating that poor economic growth corresponds with lower levels of corporate leverage. Based on the majority of theories and literature examining the three interrelated variables, an increase in economic growth, corresponding to lower interest

rates and inflation rates, results in acquiring more leverage. However, some literature present opposing conclusions, leading to ambiguous empirical evidence.

Nevertheless, it can be expected that the impact of an overconfident CEO can have detrimental consequences during periods of high market uncertainty, such as an economic crisis. As described, overconfident CEOs take excessive risks which can result in poor investment decisions, subsequently resulting in lower firm value. Overconfident behavior is only yielding positive outcomes in high-risk environments and industries, such as the innovative industry (Hirshleifer et al., 2012). However, risky decision-making in highly volatile markets is expected to be unfavorable in general. Covid-19 is considered as exogenous shock that was not foreseen, hence, the effect of CEO overconfidence on firm performance will be particularly destructive for firms that have high financial leverage. Following Myers (2001), arguing that the majority of U.S. nonfinancial firms rely on debt financing for investments, it is expected that U.S. firms that increased their investments pre-Covid exhibit relatively high debt-to-asset ratios during Covid-19. This indicates that these firms are subject to a higher bankruptcy risk, which will be magnified by the macroeconomic conditions during the aftermath of Covid-19.

In addition to the fact that no consensus on the relationship between CEO overconfidence and leverage is reached, no research has studied the effect of CEO overconfidence on U.S. firms' leverage during a crisis, specifically during Covid-19, yet. Therefore, the ensuing hypotheses are formulated.

$H_{3,0}$ = CEO overconfidence does not affect the level of firm leverage during Covid-19
$H_{4,0}$ = There are no factors, other than the impact of Covid-19, which can influence the correlation between CEO overconfidence and firm leverage

Data

The data section of this study provides a thorough description of the employed data collection procedure. Specifically, this section details the databases utilized for data collection, presents the variables included in the analysis, and describes the data transformation applied.

3.1 Sample

The study analyzes publicly traded companies that are included in the U.S. S&P 1,500 index in the time period from 2012 until 2022.

The majority of the variables used in this panel study are obtained from Wharton Research Data Services (WRDS), a subscription-based data service provided by the Wharton School of the University of Pennsylvania. WRDS provides a broad range of financial, economic, and business data, including historical data and financial statements from various providers such as Standard & Poor's, Center for Research in Security Prices (CRSP), BoardEx and Compustat (1950s). Amongst others, this study integrates data from the latter three data sources. Compustat is included, as this database provides financial and economic data retrieved directly from companies' income statements, balance sheets, and cash flow statements. Additional data is retrieved from Execucomp, which is a subset of the Compustat database that particularly focuses on executive compensation data. Accordingly, the CEO overconfidence proxy is constructed. Furthermore, corporate governance information is retrieved from BoardEx, which is a database that supplies information on corporate board members and executives, including data on e.g., background, experience, and affiliations. CRSP provides data on U.S. listed securities, trading on amongst others the NYSE, AMEX, and NASDAQ. Correspondingly, annual stock returns of the companies included in the sample are retrieved from CRSP and included as control variable in the analysis. In addition, WRDS focuses on publicly traded companies, primarily from North America, making it an appropriate data source to represent the S&P 1,500 index companies. The S&P 1,500 index comprises stocks from the S&P 500, S&P 400, and S&P 600 indices, encompassing a wide range of companies in terms of diverse industries and market capitalizations. Hence, the S&P 1,500 provides a comprehensive representation of the U.S. stock market.

Additional data is extracted from the Federal Reserve Economic Data (FRED) in order to control for macroeconomic conditions. Lastly, Refinitiv Eikon is employed to retrieve the set of unique identifiers, including the CUSIPs, for all companies included in the S&P 1,500 from 2012 until 2022. Inclusion of the CUSIPs allowed for merging all separate datasets.

3.2 CEO overconfidence

Hall and Murphy's (2002) model shows that risk-averse CEOs typically hold undiversified portfolios and aim to divest themselves from idiosyncratic risk. In order to minimize this risk, risk-averse CEOs will exercise options early, as if they are rational expected utility maximizers. However, overconfident CEOs are likely to overestimate the future returns of their investment projects and believe their company's stock prices will continue to rise, leading them to delay exercising options or buying more company stock for personal gain. According to the latter reasoning, Malmendier and Tate (2005) propose to define a CEO as overconfident if the CEO holds in-the-money stock options. Accordingly, this study utilizes that definition to measure CEO overconfidence.

There are three different CEO overconfidence proxies, based on the personal portfolio decisions of a CEO: Holder 67, LongHolder, and Net Buyer. The first two proxies are a measure related to the timing of option exercises, while the third proxy is associated with the acquisition of company stock. Following the latter measure, a CEO can be considered overconfident if they were net buyers of company equity, while already having high exposure to company risk. Thus, being a net buyer implies that an individual bought more stock than they sold during a specific period of time. Moreover, the LongHolder measure indicates a CEO being overconfident if they hold an option, at least once, until the year of expiration. The Holder 67 measure, however, focusses on the end of the vesting period of the option rather than the expiration date. Following the Holder 67 measure, a CEO is considered overconfident if the CEO holds stock options that are equal to or more than 67% in-the-money (Hall & Murphy, 2002; Malmendier & Tate, 2005; Malmendier & Tate, 2008; Campbell et al., 2011). The Holder 67 measure can be obtained from public data. Unfortunately, the Longholder measure can only be retrieved from proprietary data. Consequently, the Holder 67 measure is used in this study.

Since the data obtained from Compustat and Execucomp is less detailed compared to the data used by Malmendier and Tate (2005), Core and Guay's (2002) approximation method is applied to construct the Holder 67 measure. To determine if a CEO holds options at least 67% in-the-money, the average option moneyness should be at least 0.67, which is computed by Equation (1).

$$Average\ option\ moneyness = \frac{Option\ realizable\ value}{Average\ exercise\ price\ of\ options} - 1 \quad (1)$$

$$Average\ exercise\ price\ of\ options = Stock\ price\ FYE - Option\ realizable\ value \quad (2)$$

$$Option\ realizable\ value = \frac{Value\ of\ unexercised\ exercisable\ options}{Number\ of\ unexercised\ exercisable\ options} \quad (3)$$

By multiplying Equation (1) by 100%, the percentage of average moneyness is obtained. First, the realizable value for each option is estimated from the total realizable value of unexercised exercisable options divided by the number of unexercised exercisable options, as detailed in Equation (3). Subsequently, the estimated average exercise price of the options is computed by subtracting the realizable value per option from the stock price at fiscal year-end, as reflected in Equation (2).

A dummy variable is constructed, indicating CEO overconfidence, which will take the value of one for CEOs that hold options equal to, or more than 67% in-the-money, at least twice during the sample period, and zero otherwise. Similarly, a proxy of high and low overconfident CEOs is incorporated in the dataset to check for robustness. For the CEOs that are identified to be even more overconfident, a cut-off of 100% of average option moneyness is assumed. Additionally, low overconfidence is indicated by CEOs who exercise stock options that are less than 30% in-the-money (Campbell et al., 2011).

3.3 Leverage

Literature employs various measures for leverage, with the most general reflecting the ratio of total liabilities to total assets. However, the latter ratio tends to overestimate leverage as it includes short-term liabilities, such as accounts payable, that are generally irrelevant to financing decisions. Hence, the ratio of total debt to total assets is considered to be more accurate. In contrast, Agion and Bolton (1992) propose the interest coverage ratio (ICR), reflecting the ratio of earnings before interest and taxes (EBIT) to interest expenses, to be an accurate proxy for leverage. However, utilizing the ICR presents two limitations. The ICR assumes short-term liabilities and short-term debt to be rolled over and assumes equal treatment of a company's inability to make interest payments. However, the consequences of a highly levered firm that is not able to pay interest tends to result in reorganization, in contrast to a firm with lower levels of debt, that generally results in liquidation (Jensen, 1986; Rajan & Zingales, 1995). Accordingly, this study utilizes the ratio of total debt to total assets as a proxy for firm leverage.

3.4 Control variables

Macroeconomic, firm-specific-, and CEO-specific variables are obtained. Since Narayan et al. (2021) indicate that macroeconomic factors have a significant effect on leverage, this study includes variables on U.S. interest rate, inflation and GDP. Moreover, following previous research, there are several important determinants of capital structure, including firm size, tangibility of assets, profitability, and the growth and investment opportunity of a firm (Rajan & Zingales, 1995). This study uses return on equity (ROE) and return on assets (ROA) as measures for profitability, and the stock market return is utilized as proxy for growth opportunity. Moreover, board size is included as a firm-specific control variable, proxying corporate governance, as proposed by Malmendier and Tate (2005). Based on the definition of an efficient board size by Brickley et al. (1994) and Malmendier and Tate (2008), indicating that the board should consist of four until 12 members, a dummy variable is constructed. The board size dummy takes a value of one in case the board size is efficient, and zero otherwise. Additionally, previous research highlights the relationship between CEO characteristics, including age, gender, tenure, CEO duality, educational background and previous financial experience, and corporate decision-making (Malmendier & Tate, 2005, 2008; Hambrick & Mason, 1984). Hambrick and Mason (1984), however claim that

indirect psychological measures, specifically educational background and previous financial positions, may contain noise in the data. Therefore, these two variables have been handpicked in Malmendier and Tate's (2005, 2008) research. While the option to copy the collection of the hand-picked data is not appropriate in this study due to time constraints, two databases available on WRDS, BoardEx and Institutional Shareholder Services (ISS), do include measures of education and financial experience. However, these specific indicators are considered unreliable because of a significant number of missing values and a lack of detailed information, leading to less valid observations. Furthermore, Malmendier and Tate (2005, 2008) chose to collect the variables by hand, despite having access to the BoardEx and ISS database, indicating the unreliability of the variables in these databases. In order to generate results and minimize the amount of noise, this study will control for the following CEO characteristics: CEO gender, CEO age, CEO tenure and CEO duality. Gender and CEO duality are incorporated as dummy variables. The dummy variable of gender takes a value of one if male, and zero if female, and the dummy variable of CEO duality equals one if the CEO is both titled CEO and chairman, and zero otherwise.

Furthermore, other dummy variables are constructed, with most importantly the dummy reflecting Covid-19, taking a value of one for the financial year 2020, and zero otherwise. Moreover, a dummy variable is constructed indicating one if the firm operates in an innovative industry, and zero otherwise. Following Hirshleifer et al. (2012), innovation is measured by the ratio between R&D expenses and total assets. Unfortunately, the R&D data acquired in this study includes a significant amount of missing data, consequently rendering them inadequate. Therefore, an alternative approach is implemented by employing the methodology suggested by Kile and Phillips (2009). As detailed in Appendix A, the authors have identified sub-industries encompassing the innovative, or high-technology, industry, according to their three-digit Standard Industrial Classification (SIC) code. These SIC codes, which are extracted from WRDS, are transformed into four-digit SIC codes by using Stata. Lastly, a dummy variable is constructed reflecting whether the company is classified as a financial firm. Firms are categorized as a financial firm if included in the four-digit SIC codes ranging from 6,000 to 6,999.

The different datasets are merged by using the CUSIP identifiers. After the merge, the total dataset consists of 14,085 observations (CEO years). Some variables in the dataset included the financial

years 2011 and 2022, which have been dropped subsequently. Moreover, observations with missing values have been excluded from the dataset, yielding 6,307 (CEO years) valid observations in the sample employed in this study.

Definitions and computations of the described variables included are represented in Appendix B. Moreover, the correlation matrix is presented in Appendix C.

Methodology

The methodology section will provide further detail on particular assumptions necessary to guarantee a valid and reliable study. Additionally, it will entail an in-depth analysis of descriptive statistics. Most significantly, the section will provide essential details on the models utilized and the corresponding regression formulas aimed at either confirming or refuting the proposed hypotheses.

4.1 Descriptive statistics

In Table 1, the descriptive statistics of the dependent variable, independent variable and all control variables are shown. Normal distribution of the data is tested by looking at the descriptive statistics. It is particularly important to look at the skewness, a measure of symmetry, and kurtosis, which determines the mass of the distribution of the tails, of the variables. The leverage, ROA, ROE, and annual stock return variables were found to be non-normally distributed in the clean data and were winsorized to exclude extreme values beyond the 1st and 99th percentiles. This approach avoids removing too many observations and diminishing data quality. Another way to normalize the data is to take the logarithm of a variable characterized with a non-normal distribution. This technique has been applied to the firm size. The values of the variables in the descriptive statistics in Table 1 represent convenient levels of skewness and kurtosis, indicating a normal distribution of the data.

In this study, 1,025 firms are analyzed, as shown in Table 1. The dependent variable has a mean value of 0.270, indicating that approximately 27.0% of the total capital for these firms is represented by debt. The binary overconfidence measure has a mean value of 0.165, indicating that approximately 16.5% of the CEO sample can be classified as overconfident according to the Holder 67 measure. The proportion of overconfident CEOs in the sample is in line with the proportion of CEOs found to be overconfident in the study of Malmendier and Tate (2005), which reports 17.2% of CEOs to be overconfident. The high and low overconfidence variable indicate that 4.94% of the CEOs are identified with high levels of overconfidence, and 29.3% with low levels of overconfidence, respectively. These statistics indicate not to be in line with the findings of Campbell et al. (2011), reporting 8.9% of the sample to be low overconfident, and 24.1% to be high overconfident.

Table 1 Descriptive statistics

Table 1. This table reports the normalized descriptive statistics for the dependent variable, leverage (Panel A), and the independent variables, CEO overconfidence (OC), computed by the Holder 67 measure, and multiple control variables (Panel B), used in the regression models. To eliminate the effect of potential outliers, leverage, ROA, ROE and stock market return are winsorized at the 1% level, and log-transformation is applied to firm size to conform to normality. Inflation and GDP are standardized to mitigate for multicollinearity. μ is the mean value, σ is the standard deviation, M is the median value, Min is the minimum value, Max is the maximum value, Skewness, a measure of symmetry, Kurtosis, determines the mass of the distribution of tails, and N is the number of observations. See Appendix B for a detailed description on all the variables.

Variables	μ	σ	M	Min	Max	Skewness	Kurtosis	N
Panel A: Dependent variable								
Leverage	0.270	0.215	0.251	0	0.980	0.774	3.438	16,346
Panel B: Independent variables								
OC	0.165	0.371	0	0	1	1.807	4.266	7,027
High OC	0.049	0.217	0	0	1	4.160	18.31	18,532
Low OC	0.293	0.455	0	0	1	0.907	1.823	18,532
Gender	0.941	0.236	1	0	1	-3.745	15.030	10,822
Age	57.270	6.805	57	28	88	0.310	3.798	10,790
Tenure	10.150	8.038	8.005	0	54.040	1.498	5.948	10,652
Duality	0.404	0.491	0	0	1	0.389	1.152	10,822
Interest rate	0.623	0.738	0.160	0.050	2.420	1.178	2.927	18,532
Inflation	0.000	1.000	-0.348	-1.347	2.240	0.900	2.758	18,532
GDP	0.000	1.000	-0.256	-1.614	2.034	0.530	2.393	18,532
Firm size	8.162	1.782	8.073	0.040	15.104	0.187	3.445	18,310
Asset tangibility	0.484	0.472	0.341	0	9.273	3.316	34.860	15,756
Stock market return	0.016	0.028	0.0150	-0.066	0.110	0.251	4.429	14,391
ROA	0.119	0.099	0.114	-0.229	0.418	0.015	5.093	15,409
ROE	0.107	0.247	0.0998	-0.897	1.217	0.237	11.130	15,409
Efficient board size	0.943	0.232	1	0	1	-3.820	15.590	18,532
Number of firms	1,025	1,025	1,025	1,025	1,025	1,025	1,025	1,025

In addition, there are a few values of control variables that merit attention. First, the following CEO characteristics are of interest: gender, tenure, and duality. The sample predominantly consists of male CEOs, with men accounting for 94.1% of the sample. The average CEO tenure is 10.15 years, with a maximum of 54.04 years, indicating a relatively stable leadership structure in the sampled firms. Additionally, 40.4% of CEOs hold both the title of CEO and chairman. Second, the interest rate is worth highlighting. The average interest rate is 0.62%, which implies to be quite low throughout the study period. Third, regarding the firm-specific characteristics, firm size, asset tangibility, the profitability measures, annual stock market return, and board size, are of particular

importance to point out. The average firm size is $8.16 billion, with a range from $0.04 to $15.14 billion. These descriptive statistics are consistent with the values conducted by the research of Malmendier and Tate (2005, 2008). Moreover, on average 48.4% of the firm's total assets can be worn to tangible assets, to be specific to property, plant and equipment (PP&E) assets, with a minimum value of zero and a maximum value of 9.27. Furthermore, the average firm can be considered profitable based on the profitability ratios used in the study. The firms make an average ROA of 11.9% and an average ROE of 10.7%. Although the mean value of the annual stock return of the firms is relatively small, the value does suggest that the firms are likely to generate growth opportunities. In addition, the average board size is considered efficient for 94.3% of the firms' boards analyzed. In conclusion, these descriptive statistics offer crucial contextual information that can aid in the interpretation of the findings obtained in our study.

4.2 Model assumptions

In addition to interpreting the descriptive statistics, it is necessary to conduct multiple statistical tests on both the dependent and independent variables. Prior to running the regression model, it is crucial to evaluate whether the assumptions of linearity, homoscedasticity, and multicollinearity are met. First, the Residual Versus Fitted (RVF) plot shows that the residuals are randomly scattered around zero without any noticeable pattern. This provides evidence that the relationship between the dependent and independent variables is linear. In addition to the RVF plot, heteroscedastic tests are performed to determine the variance of the error term across all observations in the model. The Breusch-Pagan test for heteroskedasticity shows that the data does not confirm the assumption of homoscedasticity, because the p-value is less than the desired significance level of 1%. Moreover, the assumption of multicollinearity, among the independent variables, is tested by constructing the variance inflation factors (VIF) of all explanatory variables. Following the test, multicollinearity is relatively high for inflation and GDP, which can be explained by their interrelated nature of the economy and is possibly more pronounced due to the study's panel data sample. Multicollinearity of inflation and GDP is accounted for by standardizing both variables, as demonstrated in Table 1. Post-standardization, the VIF values did not exceed 1.91, providing no incentive to additionally standardize variables and the assumption of no multicollinearity can be satisfied.

4.3 Empirical model

To correct for the violation of the homoscedasticity assumption, a robust standard error analysis is implemented to attain consistent standard errors and therefore facilitating a valid statistical inference of the regression parameters. Moreover, the model fit is assessed by means of a Hausman test. This statistical test is deemed significant, as indicated by the test-statistic exceeding the critical value derived from the chi-square distribution. This finding suggests that the Fixed Effects model is more appropriate than the Random Effects model for the current data. Thus, the Fixed Effects model in combination with the robust standard error analysis is used throughout the hypothesis testing explained hereafter.

This study controls for five specifications of variables with Equation (4), reflecting all variables considered. Hypothesis 1, indicating the effect of CEO overconfidence on financial leverage, is tested by Specification (1), reflecting an OLS regression, by merely including the overconfidence dummy. Hypothesis 2, examining whether other factors may explain the relationship between CEO overconfidence and financial leverage, is tested by a multivariate regression, as presented in Specifications (2) up to and including Specification (5). In addition to Specification (1), Specification (2) includes a set of CEO-specific characteristics. Specification (3) incorporates three macroeconomic variables as well. Lastly, the firm-specific variables are added in Specification (4). Specification (5), controls for time-invariant effects, by including year fixed effects in addition to the firm fixed effects already incorporated in the previous specifications.

Second, in order to test Hypothesis 3 and 4, Equation (5) is computed. In Equation (5), the same specifications and estimation methods, as detailed in Equation (4), are applied to the Covid-19 sample specifically. However, this particular model only controls for firm fixed effects since the addition of the Covid-19 dummy leads to an analysis of one financial year. Therefore, the model includes four specifications only. The first specification tests Hypothesis 3, indicating the effect of CEO overconfidence on financial leverage during Covid-19, and Specification (2) up to and including Specification (4) test Hypothesis 4, examining whether other factors may explain the relationship between CEO overconfidence and financial leverage during Covid-19.

$$LEV = \beta_0 + \beta_1 * OC + \beta_2 * CEOcontrols + \beta_3 * Macrocontrols + \beta_4 * Firmcontrols + \varepsilon \quad (4)$$

$$LEV = \beta_0 + \beta_1 * OC + \beta_2 * CEOcontrols + \beta_3 * Macrocontrols + \beta_4 * Firmcontrols + \beta_{C19} * C19 + \varepsilon \quad (5)$$

The dependent variable in Equation (4) and Equation (5) is identified by *LEV*, which measures financial leverage. In addition, β_0 is a constant term and *OC*, the overconfidence variable, is classified as the independent variable with β_1 being its corresponding coefficient. β_2, β_3 and β_4 are coefficients of the corresponding set of variables: CEO-specific characteristics, macroeconomic indicators and firm-specific variables, respectively. Both Equation (4) and Equation (5) are considered vector equations because coefficients β_2, β_3 and β_4 correspond to one of the latter collections of control variables (See Appendix B for a description of the variables included in each set). Moreover, *C19* represents the Covid-19 dummy variable with β_{C19} displaying its corresponding coefficient, and ε is the error term.

Additional analyses will be performed to assess whether several influences of CEO overconfidence can alter its subsequent effect on financial leverage. As mentioned by the UET, personal characteristics of CEOs have impact on the level of overconfidence. Therefore, the inclusion of the interaction terms, Age∗OC and Tenure∗OC, in the regression models allow to assess the differential impact of CEO overconfidence on leverage for different levels of either the CEO's age or tenure. Moreover, two other interaction terms, Covid-19 dummy∗OC and Interest rate∗OC, are included in the regression models to further analyze whether Covid-19 affects the relationship.

4.4 Endogeneity

The majority of panel data analyses are concerned with endogeneity issues, which can take several forms. In this study, measurement error, unobserved heterogeneity, sample selection bias and simultaneity bias need to be considered. Measurement error occurs in case of imperfect measurement of the variables incorporated in the model. The measure of overconfidence used in this study potentially addresses this error, which is further detailed in Section 5.4. Moreover, this

study is likely to be influenced by the unobserved heterogeneity bias, which arises when some unobserved characteristics, or the error term, are correlated to the dependent variable and the independent variables. Consequently, the independent variables may falsely estimate the dependent variable. As briefly mentioned before, the study includes multiple variables and will control for year and firm fixed effects in the regression models, shown in Equation (4) and Equation (5), with the aim of reducing the potential unobserved heterogeneity. However, the results may still be biased due to endogeneity of firm leverage. To be specific, firms led by CEOs who exhibit overconfidence may have fundamental differences compared to those led by non-overconfident CEOs. For example, a firm with more growth opportunities might hire a relatively more overconfident CEO (Hirshleifer et al., 2012). If this hypothesis is supported, the study is vulnerable to the simultaneity bias, since firm-specific variables impact both leverage and CEO overconfidence. This can lead to biased estimates and a potential issue in identifying the true causal effect of CEO overconfidence on firm leverage. Additionally, a different potential source of endogeneity is the sample selection bias, which, in context of this study, indicates that the hiring of CEOs might not be random. Therefore, these endogeneity issues can result in a spurious correlation found between CEO overconfidence and firm leverage.

To address the three latter endogeneity concerns, the PSM model will be performed, controlling for firm characteristics specifically (Rosenbaum & Rubin, 1983). The PSM model will create a control sample consisting of CEOs who do not exhibit overconfidence, while they operate in firms similar to those with overconfident CEOs. Each firm in the latter group, or the treatment group, will then be matched to a firm with similar characteristics from the control group.

To perform the PSM, a logistic regression will be run initially to analyze the effect of firm-specific characteristics on overconfidence:

$$OC = \beta_0 + \beta_1 * Firmcontrols + \varepsilon \quad (6)$$

Where, OC is the dependent variable, the overconfidence variable, the independent variables include all firm-specific control variables with their corresponding coefficient β_1, and β_0 is a constant term.

The logistic regression will estimate the propensity scores using the formula below:

$$p(Y = {}^{1}\!/\!_{X} = x) \tag{7}$$

The propensity score represents the likelihood of receiving a binary treatment, denoted by Y, subject to all control variables represented by x. In this formula, Y is defined as overconfidence, and x are all firm-specific control variables. The nearest-neighbor matching method is used to carry out the matching, by using the computed propensity scores as a matching criterion. In other words, for each firm with an overconfident CEO, the firm with a non-overconfident CEO that has the closest propensity score is matched. To ensure that the matching estimation method is reliable, the absolute difference in the propensity scores between pairs cannot exceed 0.05.

Upon conducting the PSM, the impact of CEO overconfidence on firm leverage is re-assessed by running the main regressions, as shown in Equation (4) and Equation (5), whereby the original overconfidence variable is substituted for the matched overconfidence variable. Subsequently, the main regressions will only control for the CEO-specific-, and macroeconomic variables.

Results

In this section, the results of the different regression models are discussed that will either accept or reject the hypotheses. First, the findings of the OLS and multivariate regressions, analyzed in both samples, will be discussed. Second, this section presents the results of the additional analyses performed. Specifically, the results of the impact of interaction effects, sensitivity analyses, and the PSM model are summarized.

5.1 Correlation matrix

Prior to analyzing the regression results, it is important to identify the relationships between the variables included in the model. While the VIF test already controls for multicollinearity between variables, a Pearson correlation matrix can be used to assess the relationships more clearly (See Appendix C). According to the correlation matrix, the majority of correlations between the variables are significant at the 10% level and are relatively low. However, some correlations are significantly higher than others. As detailed in Appendix C, leverage exhibits relatively high correlations with firm size, asset tangibility, ROA, CEO tenure, inflation and GDP, with the highest value reflecting a correlation of 0.189. However, these values do not raise any concern since these do not exceed the threshold of multicollinearity, which is determined at 0.8 according to Field's (2009) definition. Therefore, consistent with the results of the VIF test, there is no evidence of multicollinearity among the predictors. Furthermore, the correlation between overconfidence and leverage presented in the correlation matrix should be addressed. Surprisingly, the correlation is negative and significant, but relatively weak, at the 10% level, with a value of -0.035. The correlation suggests that overconfident CEOs will decrease the firm’s leverage, ceteris paribus.

5.2 Regression model

According to the first specification in Table 2, the study uses a sample of 1,061 firms over the time period investigated. In the three specifications following, the number of firms decreases since more independent variables are added to the model. The fourth and fifth specification still study 1,025 firms which is a representative number of firms, considering the focus on the U.S. S&P 1,500.

The goodness of fit of the model can be gathered by analyzing either the R-squared or the adjusted R-squared. In the first model and second model, independent variables are added to the regression for each specification. Thus, it is more appropriate to examine the adjusted R-squared. As demonstrated in Table 2, the adjusted R-squared increases from Specification (1) to Specification (5). The value of the adjusted R-squared of Specification (5) suggests that 17.3% of the variation in leverage can be explained by the independent variables included in the regression model. In addition, the adjusted R-squared of Specification (4) in Table 3 illustrates a value of 16.1%. These values are considered moderate. However, it is coherent to the adjusted R-squared of Huang et al.' (2016) research, analyzing the effect of CEO overconfidence on the preference of external financing. In order to be consistent, both models do include the R-squared values. Overall, the regression analyses manifest moderate values of both the R-squared and adjusted R-squared but can be considered appropriate in terms of the variables' explanatory power.

Specification (1) in Table 2 indicates that there is no statistically significant correlation between CEO overconfidence and firm leverage. Nevertheless, the independent effect of CEO overconfidence on leverage has not been examined in prior studies, as studies have only inferred conclusions based on either a sub-hypothesis or by controlling for various factors in addition. Unfortunately, the lack of significance persists when including specific control variables in the model, as demonstrated in Specification (4) in Table 2. Two recent studies, which investigate the impact of overconfidence on debt by incorporating different sets of control variables, report similar findings (Mundi, 2022; Gurdgiev & Ni, 2023). However, the insignificant result is not consistent with expectations, as the majority of previous research has demonstrated that overconfident CEOs exhibit a preference for either debt or equity financing when investing in projects (Heaton, 2002; Hackbarth, 2008; Malmendier & Tate, 2008; Graham et al., 2013; Huang et al., 2016; Gurdgiev & Ni, 2023). The preference of equity financing is indirectly in line with the outcome observed in Specification (3), which shows a significant negative correlation between overconfidence and firm leverage at the 10% significance level. However, the change in the adjusted R-squared indicates that macroeconomic factors have a substantial influence on leverage. This result is in line with previous research by Narayan et al. (2021) that stress that macroeconomic indicators affect firms' debt. Moreover, it should be noted that the observed significance of the correlation between

overconfidence and leverage is modest in a relatively extensive sample. Interestingly, the positive and significant correlation between GDP and leverage is the only relationship that persists to be significant in the fourth specification, as demonstrated in Table 2. Apart from that, the firm-specific variables, particularly firm size, profitability measures, and asset tangibility, have a significant impact on leverage. Firm size and asset tangibility show a positive correlation with leverage, whereas profitability measures display a negative correlation. These findings are consistent with the studies of Harris and Raviv (1991) and Rajan and Zingales (1995), which examine the firm-specific determinants of capital structure. Conversely, the annual stock return and board size variable do not exhibit any significant relationship with leverage. Therefore, no conclusion can be drawn about the company's growth prospects and corporate governance in relation to leverage. The insignificant result for stock return can be attributed to the data's relatively low mean value. The lack of variation in the board size variable, where 94.3% of the firms in the sample are deemed to have an optimal board size, may account for the insignificant correlation, as is being supported by Gurdgiev and Ni's (2023) results as well.

In Specification (5), shown in Table 2, additional control for year fixed effects is included. Although the correlation between CEO overconfidence and the firm's leverage remains insignificant, it is noteworthy that there are changes in the impact of interest rate, GDP, and stock market returns, on leverage. The influence of interest rate on leverage is found to be significant and negative, indicating that firms will tend to take on less debt when interest rates increase. This finding is inconsistent with the trade-off theory, which suggests that firms balance the benefits and costs of debt financing. Rather, it suggests that increased borrowing costs may deter firms from taking on more debt (Myers, 1984; Bernanke et al., 1990). Additionally, the effect of GDP remains significant, but becomes negative. Lastly, the correlation between a firm's annual stock market returns and leverage becomes significant and negative, implying that firms with more growth opportunities tend to acquire less leverage. These latter two significant changes in the estimates may be attributed to unobserved heterogeneity across firms that was not fully controlled for in the first regression, shown in Specification (4). Overall, the results show a consistent insignificant effect between CEO overconfidence and firms' leverage and therefore Hypothesis 1 cannot be rejected. Although the correlation is not significant, the results do show that control variables, particularly firm-specific control variables, have a significant impact on the relationship. As

further elucidation regarding the impact of control variables is required, the second hypothesis cannot be rejected nor accepted yet.

Table 2 Results regression model

Table 2. This table reports estimates of the OLS regression (1) and multivariate regressions (2,3,4,5). The dependent variable is leverage. In Specification (1), CEO overconfidence (OC), computed by the Holder 67 measure, is used as explanatory variable. In Specification (2), CEO-specific control variables are included to the model. In Specification (3), macroeconomic control variables are incorporated as well. In Specification (4), firm-specific control variables are added. Specification (5) controls for year fixed effects, in addition to the firm fixed effects already incorporated in the previous four specifications and includes the estimates of the interaction terms tested. The estimates are based on a Fixed Effects model, since that is preferred over a Random Effects model based on the Hausman test performed. Standard errors (stated in parentheses) are heteroskedasticity robust *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Variables	(1)	(2)	(3)	(4)	(5)
OC	-0.008	-0.009	-0.012*	-0.001	-0.001
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Gender		-0.011	-0.011	-0.007	-0.009
		(0.024)	(0.023)	(0.021)	(0.022)
Age		0.002***	0.000	-0.000	-0.000
		(0.001)	(0.000)	(0.000)	(0.000)
Tenure		-0.007***	-0.002	-0.002	-0.001
		(0.002)	(0.002)	(0.002)	(0.002)
Duality		0.020	0.018	0.017	0.020
		(0.027)	(0.027)	(0.025)	(0.025)
Interest rate			-0.005**	-0.001	-0.029***
			(0.002)	(0.002)	(0.009)
Inflation			-0.430**	0.006	0.020
			(0.215)	(0.006)	(0.491)
GDP			0.024***	0.012**	-0.016*
			(0.006)	(0.006)	(0.009)
Firm size				0.060***	0.050***
				(0.012)	(0.012)
Asset tangibility				0.085***	0.061**
				(0.029)	(0.029)
Stock market return				-0.078	-0.137**
				(0.058)	(0.064)
ROA				-0.241***	-0.220***
				(0.068)	(0.068)
ROE				-0.056***	-0.056***
				(0.014)	(0.014)
Efficient board size				-0.009	-0.006
				(0.011)	(0.011)

Table 2 (continued)

Age * OC					-0.001 (0.001)
Tenure * OC					0.001 (0.001)
Interest rate * OC					-0.011** (0.005)
Constant	0.260*** (0.001)	0.209*** (0.041)	-0.186* (0.105)	-0.426*** (0.125)	0.121 (0.180)
Observations	6,307	6,232	6,232	6,071	6,071
Number of firms	1,061	1,051	1,051	1,025	1,025
R-squared	0.001	0.015	0.080	0.160	0.181
Adjusted R-squared	0.001	0.014	0.079	0.158	0.173
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	Yes

Consistent with the findings represented in Table 2, there is no statistically significant association between CEO overconfidence and leverage during the Covid-19 pandemic (Table 3). As shown in Table 3, an identical model as presented in Table 2 is demonstrated with specific modifications made to fit the Covid-19 context. Similar to the first model presented and in accordance with the UET, personal characteristics, the CEO's age, and tenure specifically, are significantly, but relatively weakly, correlated to leverage (Hambrick & Mason, 1984). A comparison of both models highlights a notable difference though. Specification (2) in Table 3, only incorporating CEO characteristics as controls, indicates a significant negative correlation between overconfidence and leverage, at the 10% level of significance. Similarly, as observed in Specification (3) in Table 2, a significant relationship was evident in the third specification of Table 3 as well. Hence, this strengthens the proposed influence of firm-specific control variables, except for board size, on the relationship between overconfidence and leverage, since the significant correlation disappears in both samples, as is detailed in the fourth specification of both Table 2 and 3. Since multicollinearity cannot be an issue as is determined from the correlation matrix and the VIF table, endogeneity may be a concern, and therefore, the impact of firm characteristics will be further examined in an additional analysis (See Section 5.4.2).

Additionally, Table 3 shows a positive and significant effect, at the 1% level, between Covid-19 and firm leverage in all four specifications. This finding indicates that firms have relied more on debt financing in 2020, compared to other years examined in the study. However, it should be

taken into account that U.S. firms' liabilities may have increased due to support received from the U.S. government. To be specific, the government support programs increase their total debt outstanding. Similarly, as detailed in Specification (5) in Table 2, the correlation between GDP and leverage is negative, indicating that during economic downturns, firms are more likely to increase leverage.

Table 3 Results regression model, Covid-19

Table 3. This table reports estimates of the multivariate regressions during Covid-19. The dependent variable is leverage. In Specification (1), CEO overconfidence (OC), computed by the Holder 67 measure, and Covid-19, reflecting one if financial year is 2020, are used as explanatory variables. In Specification (2), CEO-specific control variables are added to the model. In Specification (3), macroeconomic control variables are included. In Specification (4), firm-specific control variables are appended, and the estimates of the interaction terms tested are incorporated. The specifications control for firm fixed effects only. The estimates are based on a Fixed Effects model, since that is preferred over a Random Effects model based on the Hausman test performed. Standard errors (stated in parentheses) are heteroskedasticity robust *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Variables	(1)	(2)	(3)	(4)
OC	-0.010	-0.011*	-0.012*	-0.001
	(0.006)	(0.006)	(0.006)	(0.006)
Gender		-0.012	-0.013	-0.008
		(0.021)	(0.022)	(0.021)
Age		0.002***	0.000	-0.000
		(0.001)	(0.000)	(0.000)
Tenure		-0.005***	-0.002	-0.002
		(0.002)	(0.002)	(0.002)
Duality		0.019	0.018	0.017
		(0.026)	(0.027)	(0.025)
Interest rate			0.000	0.001
			(0.003)	(0.003)
Inflation			-0.414*	-0.218
			(0.213)	(0.202)
GDP			0.022***	0.011**
			(0.006)	(0.006)
Firm size				0.057***
				(0.012)
Asset tangibility				0.079***
				(0.029)
Stock market return				-0.087
				(0.058)
ROA				-0.232***
				(0.068)
ROE				-0.055***
				(0.014)
Efficient board size				-0.009
				(0.011)
Covid-19 dummy	0.048***	0.043***	0.034***	0.018***
	(0.004)	(0.004)	(0.004)	(0.004)

Table 3 (continued)

Age * OC				-0.001 (0.001)
Tenure * OC				0.001 (0.001)
Covid-19 dummy * OC				-0.005 (0.010)
Constant	0.255*** (0.001)	0.217*** (0.039)	-0.146 (0.104)	-0.387*** (0.125)
Observations	6,307	6,232	6,232	6,071
Number of firms	1,061	1,051	1,051	1,025
R-squared	0.027	0.036	0.091	0.163
Adjusted R-squared	0.0272	0.0354	0.0896	0.161
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No

5.3 Interaction effects

To delve deeper into the impact of Covid-19, an additional analysis will examine the interaction effect between Covid-19 and CEO overconfidence, of which the results are presented in Table 3. Surprisingly, the correlation between Covid-19 and overconfidence, ceteris paribus, is positive at a significance level of 10% (See Appendix C). However, the results shown in Table 3 contradict expectations since the interaction between the two variables does not exhibit a significant relationship with leverage. The insignificant outcome of the interaction effect can be explained by the unprecedented nature of the Covid-19 pandemic. To further investigate the potential relationship between CEO overconfidence and firm leverage during periods of macroeconomic uncertainty, the study proposes a hypothesis that the impact of Covid-19 on the relationship between CEO overconfidence and firm leverage can be more accurately reflected by interest rate levels, which were remarkably low in 2020. As demonstrated in Table 2, the correlation between the interaction effect of interest rates and CEO overconfidence on leverage is statistically significant, at the 5% significance level, and negative. Since no statistically significant effect between CEO overconfidence and leverage is analyzed, the result suggests that the effect of CEO overconfidence on leverage is different during periods of crisis and noncrisis periods. If assumed that the stand-alone effect of CEO overconfidence on leverage is significant and positive, then the result can conclude that overconfident CEOs will be more likely to increase leverage during periods of low interest rates, such as those associated with Covid-19 (Ho et al., 2016). The opposite

reasoning is applied if assumed that the stand-alone relationship is significant and negative. Overall, the latter result can reject Hypothesis 3.

Since the results of the latter two interaction variables do not correspond in terms of significance, the Covid-19 interaction variable is potentially attributed to the measurement error. The Covid-19 variable reflects a proxy for a period of crisis and is computed by a dummy variable, yielding one for observations in 2020. However, interest rates reflect a broader subset of macroeconomic conditions and therefore may be considered a more accurate proxy.

According to the main regressions and the correlation matrix, the CEO's age and tenure are the only CEO characteristics that have a significant negative and positive correlation with overconfidence, respectively (See Table 2; Table 3; Appendix C). Besides literature confirming the respective negative and positive correlation, the latter relationship is confirmed since a longer tenure can potentially lead to holding stock options longer (De Bruin et al., 2012; Cai & Sevilir, 2012). Since the relationships are identified, the regression models include the interaction effects of CEO age, and CEO tenure, with overconfidence. However, as shown in Table 2 and Table 3, the results indicate that neither CEO age' nor CEO tenure's interaction effect with overconfidence has a significant impact on the firm leverage. This suggests that older overconfident CEOs, or overconfident CEOs who already serve for a relatively long period of time as an executive, will not necessarily acquire more or less leverage compared to overconfident CEOs with average age or tenure. Thus, the insignificant results conclude that the relations between CEO characteristics and overconfidence do not alter its effect on leverage.

5.4 Additional analyses

This section aims to conduct additional analyses to assess the plausibility of any non-rejected hypotheses. The section will interpret the results of the robustness tests performed, which evaluate the sensitivity of the findings to variations in parameter values. First, an alternative measurement approach for assessing CEO overconfidence will be employed, using two other distinct thresholds. Secondly, the investigation will differentiate firms within the U.S. S&P 1,500, either in the financial or innovative industry, with the objective of exploring potential differences in the results

across these groups. The section will culminate with a PSM model conducted to scrutinize the effects of firm-specific variables with greater clarity.

5.4.1 Robustness checks

Appendix D.1 presents the results incorporating the three distinct thresholds for overconfidence. The findings indicate that highly overconfident and low overconfident CEOs do not significantly acquire more or less leverage. The insignificant correlation of high overconfident CEOs can be explained by the fact that only 4.94% of the sample is considered to exhibit a high level of overconfidence. Additionally, while the subsample of low overconfident CEOs includes relatively more observations, the binary nature of the overconfidence measure may limit the variation in the data for this subsample specifically, making it difficult to find a significant correlation. Although the more appropriate sample size of the two specific groups used in Campbell et al.' (2011) is incomparable, their results do support the insignificant results found for both samples. The two different definitions of CEO overconfidence applied to test sensitivity, confirm the prior insignificant results represented in Table 1 and Table 2. The consistent findings point out that the measurement methodology utilized to quantify overconfidence may influence this study's analysis. In line with the latter, Gurdgiev and Ni (2023) also highlight that the results are sensitive to the overconfidence measure employed. Hence, the computation of CEO overconfidence by using option holding data may be vulnerable to the measurement error.

Appendix D.2 demonstrates the results for the two specific industries examined. According to Specification (2) and Specification (5), a significant positive correlation between CEO overconfidence and firm leverage is observed within the financial industry. This suggests that overconfident CEOs managing financial firms are more likely to increase the firms' leverage than non-overconfident CEOs between 2012 and 2022, and during Covid-19 particularly. These findings are consistent with previous research by Ho et al. (2016), who studied the effect of CEO overconfidence on leverage for financial firms specifically, during noncrisis and crisis periods. The similar results potentially imply that no changes have been made in financial firms' CEO selection, corporate governance structures or capital structure policies since the GFC. Furthermore, the striking difference between the samples is that the subsample of financial firms only includes

90 firms, compared to 1,025 firms in the total sample. In addition, there are relatively fewer significant correlations between the control variables and leverage, which can be partly attributed to the different asset structures of financial firms. However, the R-squared does not decrease significantly. The latter three arguments stress that overconfidence explains a relatively high proportion of the variation in leverage and accordingly strengthens the reliability of the positive and significant correlation observed in the financial industry.

An interpretation of the significant result found for financial firms specifically is that CEOs of financial firms potentially tend to hold their stock options for a more extended period, compared to CEOs of nonfinancial firms. Financial firms play a crucial role in facilitating economic growth and enhancing a country's resilience by providing greater market liquidity. Therefore, it can be expected that CEOs of financial firms are more likely to believe that their performance will result in an increase of the firm's stock returns, compared to CEOs of nonfinancial firms. If this behavior is evident, it can potentially result in CEOs managing financial firms, holding stock options for a longer period of time.

The analysis of the innovative industry, as detailed in Specification (3) and Specification (6) in Appendix D.2., presents contrasting results, demonstrating an insignificant correlation between CEO overconfidence and firm leverage. The result implies that the likelihood of overconfident CEOs in innovative firms to increase or decrease the firms' leverage is not significantly different from that of non-overconfident CEOs in innovative firms. The results diverge from the assumption that can be made from previous research, particularly Barker and Mueller (2002) and Hirshleifer et al. (2012), who reported a significant positive correlation between debt financing and innovation, and CEO overconfidence and innovation, respectively. However, both studies have measured innovation through R&D expenditures which can result in different findings since the methodology of Kile and Phillips (2009) used may also incorporate firms with relatively low R&D intensity. In addition, it is worth noting that the panel study conducted by Hirshleifer et al. (2012) covers the time period of the millennial high-tech boom, a period which may not be fully representative for comparison of the current study's results. Another possible explanation for the insignificant result is that the innovative firms included in the analysis are characterized by a wide range of firm sizes, potentially leading to a heterogeneous distribution of financing choices

(Aghion et al., 2004). Interestingly, the current study finds a shift in the correlations between gender and leverage, as well as tangibility and leverage. Specifically, the innovative industry sample may include more variation in the gender variable, resulting in a significant and positive correlation between gender and leverage. In line with the findings of Huang and Kisgen (2013), the latter result implies a greater propensity for male CEOs, compared to female CEOs, to increase the firms' leverage. One alternative explanation posits that innovative firms integrate risk mitigation in their corporate strategies by selecting female CEOs instead of male CEOs (Martin et al., 2009). Additionally, the significant correlation between asset tangibility and leverage has vanished for the innovative industry sample. Since innovative firms tend to have a higher proportion of intangible assets due to the substantial costs involved in R&D, the mean value of asset tangibility will decrease and therefore the correlation may become insignificant. Lastly, the sample size of the innovative industry is a significant subset of the total sample, especially compared to the financial industry sample size, and therefore lends credibility to the findings. Overall, the results emphasize that there is no significant difference between the two samples.

5.4.2 Propensity Score Matching

The first specification in panel A in Appendix E.1 shows a logistic regression between the firm-specific variables and CEO overconfidence. As indicated by the pseudo R-squared of 0.131, detailed in Specification (1), a significant amount of variation in CEO overconfidence can be explained by the firm-specific variables (See Appendix E.1, Panel A). The significant correlations imply that firms with overconfident CEOs are smaller, more profitable, have more growth opportunities and intangible assets, and are likely to have less than four board members, compared to firms with non-overconfident CEOs.

Subsequently, the treatment and control group constructed by the propensity scores, as shown in Equation (7), are matched and result in 1,190 unique pairs of matched observations (See Appendix E.1, Panel B). Due to the matching, two tests can be performed to verify that there are no significant firm-specific differences in the treatment and control group. First, the logistic regression, as shown in Equation (6), is run again using the matched sample. As presented in Specification (2), the results show that the regression coefficients of the firm-specific variables are

insignificant (See Appendix E.1, Panel A). Moreover, the variation explained by the observable characteristics drops significantly, as can be observed from the difference in the pseudo R-squared between the pre-match, 13.1 %, and post-match sample, 0.3 % (See Appendix E.1, Panel A). These results indicate that by using the PSM method, the differences in the observable firm characteristics between the treatment and control group, other than the difference of a CEO being overconfident, are successfully removed. However, the correlation between the annual stock return and overconfidence is still significant, at a 5% significance level, in the post-match specification. A possible interpretation for the significance is that the measures of CEO overconfidence and stock market return are interrelated, since both variables are associated with the return on stocks. Nevertheless, Panel B, in Appendix E.1, showing the t-test mean differences between firms with and without overconfident CEOs after propensity matching, highlights that the difference of each observable firm-characteristic between the two groups is insignificant at the 5% significance level (See Appendix E.1, Panel B). Overall, the insignificant results obtained from both the logistic regressions and the PSM increase the likelihood that any difference in firms' leverage observed is due to the presence of CEO overconfidence.

The results of running the main regressions by substituting the matched overconfidence variable for the initially used overconfidence variable, and controlling for CEO characteristics and macroeconomic indicators only, still results in an insignificant correlation between CEO overconfidence and leverage in all specifications (See Appendix E.2). Surprisingly, the R-squared is very low for all five specifications, indicating that firm-specific characteristics have a substantial influence on CEO overconfidence. In other words, the results suggest that overconfident CEOs operate in firms that are fundamentally different from those led by non-overconfident CEOs. Moreover, the low value of R-squared implies that CEO characteristics and macroeconomic indicators explain only a very small amount in the variation of a firm's leverage. Overall, the insignificant results are robust to the findings of the main regressions, as demonstrated in Table 2 and Table 3. Thus, still Hypothesis 1 cannot be rejected. However, Hypothesis 2 and Hypothesis 4 can be rejected since this study finds empirical evidence that stresses the substantial impact of firm-specific characteristics on the insignificant correlation found.

Several models and tests have been incorporated in this study to minimize the potential endogeneity issues of the panel data. Still, the results do not reveal a significant correlation between CEO overconfidence and leverage. These findings provide additional support for the notion that the option holder measure, which is a relatively indirect method used to estimate overconfidence, may be susceptible to the measurement error bias.

Conclusion

Based on the hypotheses established for this paper, an answer to the research question will be provided in this section. Additionally, this study will be granted some implications, limitations and recommendations for further research to be conducted. The research question posed for this paper was:

How do overconfident CEOs, managing U.S. firms included in the S&P 1,500 index, affect the firms' leverage and what is the impact of the Covid-19 pandemic on this relationship?

Accordingly, the following hypotheses were constructed in order to answer the above-mentioned research question:

$H_{1,0}$ = *CEO overconfidence does not affect the level of firm leverage*

$H_{2,0}$ = *There are no factors that can influence the correlation between CEO overconfidence and firm leverage*

$H_{3,0}$ = *CEO overconfidence does not affect the level of firm leverage during Covid-19*

$H_{4,0}$ = *There are no factors, other than the impact of Covid-19, which can influence the correlation between CEO overconfidence and firm leverage*

By examining the stand-alone effect of CEO overconfidence on firm leverage, the first hypothesis cannot be rejected. The findings indicate an insignificant relationship between the measure of the CEO's option holder behavior and the corresponding firm's ratio of total debt to total assets. The study's findings complement the existing empirical evidence on this topic, as no previous research has identified a significant stand-alone effect. Moreover, the results indicate that leverage is driven by several factors. CEO-specific characteristics, specifically age and tenure, as well as macroeconomic indicators, have a significant effect on leverage. Nonetheless, the significant influence of firm-specific variables dominates the relationship and renders the other control variables insignificant, except for GDP.

Additionally, the third hypothesis is rejected as evidenced by one of the additional analyses performed, which manifests that the effect of CEO overconfidence on firm leverage differs

significantly across various levels of interest rates. Similar to the first model analyzed, the same control variables exhibit significant explanatory power on leverage during Covid-19. In both models, the incorporation of firm-specific variables invalidates the identified negative relationship between overconfidence and leverage found in previous specifications, which further addresses the data's sensitivity to endogeneity issues. In order to mitigate these concerns, a PSM model is executed, and the findings indicate that the second and fourth hypotheses can finally be rejected as the firm-specific variables have a significant impact on the relationship analyzed.

Based on the rejection and acceptance of the above hypotheses, an answer can be given to the research question. The study concludes that firms managed by overconfident CEOs can exhibit different levels of leverage, depending on interest rate. If assumed that the stand-alone effect of CEO overconfidence on leverage is significant and positive, then the conclusion can be drawn that overconfident CEOs will be more likely to increase leverage during a period of low interest rates, such as Covid-19. In addition to the tendency of overconfident CEOs to underestimate the probability of failure and engage in more risk-taking, it is imperative to consider the impact of government support programs extended to firms during the Covid-19 pandemic. Unfortunately, the same conclusion cannot be drawn during noncrisis periods. But the results of the robustness tests do manifest a statistically significant and positive correlation between CEO overconfidence and firm leverage for financial firms. This finding can imply that spill-over effects may lead financial firms to increase their lending, as the behavior of other banks can influence their lending practices. Consequently, overconfident CEOs of financial firms may be more likely to engage in riskier lending practices to capitalize on the potential benefits of spill-over effects. Worth noting is the relevance to policy makers to acknowledge the latter significant correlation, as the correlation can contribute to U.S. financial instability. Moreover, by controlling for endogeneity concerns, the study uncovers that the significant correlations between firm-specific characteristics and leverage are influenced by overconfidence. Surprisingly, overconfident CEOs tend to operate in smaller firms, those with higher profitability, more growth opportunities, fewer tangible assets, and a board size of less than four members. These findings have implications for further research in exploring the potential reinforcement of the impact of overconfidence on the firms' leverage. Overall, the significant results stress the financial and social consequences of a firm acquiring excessive leverage. Therefore, the results underscore the need for U.S. firms to enhance their

regulatory frameworks regarding debt overhang and implement mandatory diversity protocols within their boards.

6.1 Limitations and further research

The main limitation of this study concerns the measure of CEO overconfidence. First of all, due to inaccessible data, it is not possible to directly measure the level of CEO overconfidence. Moreover, quantifying individual traits is generally a challenging task and subjective proxies are often used as alternative measures. Therefore, in this study, a relatively indirect computation, by incorporating the CEO's option behavior, is used to compute the variable, resulting to an insignificant relationship found. The latter is also evidenced by the limited amount of variation of leverage to be attributable to overconfidence. The second limitation pertains to the issue of endogeneity, which renders the causal interpretation of the initial and insignificant relationship found infeasible. Malmendier and Tate's (2005) and Hirshleifer et al.' (2012) research studying CEO overconfidence previously highlighted this issue as well.

The latter limitations underscore the need for further research. Firstly, it is imperative to examine the relationship by using several measures, specifically with different computations, of CEO overconfidence. Such an analysis will enhance the tangibility of the measure and induce more refined analyses to be conducted, leading to a better understanding of its impact on firm leverage. Secondly, to address the limitation on the issue of endogeneity, other control variables should be incorporated into the model to mitigate the effects of unobserved heterogeneity. Based on the outcomes derived from the analyses that have tackled the issue of endogeneity thus far, it is worthwhile to conduct a more extensive analysis of the relationship between overconfidence and firm-specific variables. Such research would provide valuable insights for managers responsible for hiring and firing CEOs, assisting them in their decision-making processes.

Furthermore, the analyses conducted in this study uncover certain gaps in the literature that necessitate further research. Specifically, future research should consider studying the relationship between CEO overconfidence and leverage during periods of macroeconomic uncertainty, by using a proxy of interest rate. In addition to the particular interest rate environment identified in

2020, the year 2021, reflecting the Covid-19 recovery phase, and the year 2022, affected by the Russian invasion in Ukraine in February 2022, are also characterized by distinct interest rate environments. The latter period is of particular urgency to investigate due to the considerable impact that high interest rates can have on the firm's future debt obligations. Accordingly, this indicates that employing the interest rate, as proxy for macroeconomic uncertainty, yields a research gap that should be further examined. Additionally, the significant correlation between CEO overconfidence and firm leverage among financial institutions demands more in-depth scrutiny. The potential tendency of overconfident CEOs, managing financial firms, holding stock options relatively longer, compared to overconfident CEOs managing nonfinancial firms, is specifically interesting.

Moreover, future studies should stress if the relationship between CEO overconfidence and firm leverage exhibits heterogeneity across nations. The relationship can be considered different across countries or continents due to differences in corporate governance structures, culture, monetary policies, financial regulations and laws, and the impact of Covid-19. In addition, this study is limited to public companies due to data availability. However, it would be valuable to investigate how the relationship may vary for private companies, by taking into account their structural differences and potential growth opportunities. Lastly, it would be startling to explore how the relationship between CEO overconfidence and leverage changes when focusing specifically on the life sciences industry during Covid-19 and its aftermath. Generally, companies in this industry have experienced significant stock price fluctuations in the past three years due to the development of new vaccines and innovations. Moreover, their balance sheets are often cash constrained and these firms are characterized by having a very short cash runway, leading them to potentially prefer issuing equity over debt. In light of the latter arguments, the mentioned suggestions should be borne in mind when examining the relationship between CEO overconfidence and leverage in further research.

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Appendix

Appendix A Standard Industrial Classification (SIC) codes of innovative firms

Appendix A. The following table reports the SIC codes and corresponding name of industries that belong to the high-technology firms, as classified by Kile and Philips (2009). The SIC codes that are denoted with *, represent the SIC codes with the highest association with high-tech firms in the sample of Kile and Philips (2009).

SIC Code	Industry Name
283*	Drugs
284	Soap, Detergents, and Toilet Preps
351	Engines and Turbines
353	Construction, Mining, and Materials Handling
355	Special Industry Machinery
356	General Industry Machinery and Equipment
357*	Computer and Office Equipment
360	Electronic and Other Electrical Equipment
361	Electrical Transmission and Distribution Equipment
362	Electrical Industrial Apparatus
363	Household Appliances
364	Electric Lighting, Wiring Equipment
365	Audio, Video Equipment, Audio Receiving
366*	Communication Equipment
367*	Electronic Components and Accessories
369	Miscellaneous Electrical Machinery, Equipment, and Supplies
371	Motor Vehicles, Motor Vehicle Equipment
372	Aircraft and Parts
373	Ship and Boat Building and Repairing
375	Motorcycles, Bicycles, and Parts
379	Miscellaneous Transportation Equipment
381	Navigation, Guidance, Aeronautical Systems
382*	Laboratory, Optic, Measure, Control Instruments
384*	Surgical, Medical, Dental Instruments
387	Watches, Clocks, Clockwork Devices, and Parts
481*	Telephone Communications
484	Cable and Other Pay TV Services
489*	Communication Services, NEC
737*	Computer Programming, Data Processing, etc.
873*	Research, Development, Testing Services

Appendix B Variables description

Appendix B. The following table provides the description and measurement approach for the dependent, independent and control variables used in this study.

Variable	Description
Leverage	Dependent variable that is computed by $\frac{Total\ Debt}{Total\ Assets}$
CEO overconfidence	Independent variable which is a dummy variable yielding 1 if $\frac{Per\ option\ realizable\ value}{Average\ exercise\ price} - 1 > 0.67$, and yielding 0 for all other values
CEO-specific control variables	
Gender	Dummy variable yielding 1 if gender is male, and 0 if gender is female
Age	Age is a number, in years
Tenure	Time that a CEO has been a CEO is computed by $\frac{Date\ became\ CEO - Date\ left\ as\ CEO^{1}}{365}$, in years
Duality	Dummy variable yielding 1 if CEO is titled both CEO and chairman, and yielding 0 if only titled CEO
Macroeconomic control variables	
Interest rate	Interest rate is equal to the monthly US Federal Funds Rate, in percentages
Inflation	Inflation is equal to the monthly $\frac{CPI^{2}}{100} - 1$
GDP	GDP is retrieved on a quarterly basis, in millions of dollars
Firm-specific control variables	
Firm size	Size variable is computed by taking the natural logarithm of total assets: *ln (Total Assets)*
Asset tangibility	Tangibility measure that is computed by $\frac{PP\&E}{Total\ Assets}$
Annual stock market return	Growth opportunity measure that is computed yearly by the cumulative monthly stock return
Return on Assets (ROA)	Profitability measure that is computed by $\frac{EBITDA}{Average\ Total\ Assets}$
Return on Equity (ROE)	Profitability measure that is computed by $\frac{Net\ Income}{Average\ Book\ Equity}$
Efficient board size	Dummy variable yielding 1 if the board size directors of the firm is efficient, a number between 4 and 12, and 0 if otherwise

Appendix B (continued)

Other dummy variables	
Covid-19	Dummy variable yielding 1 if the financial year is 2020, and 0 if otherwise
Innovative industry	Dummy variable yielding 1 if firm is considered to be incorporated in the innovative industry by three-digit SIC code, and 0 if otherwise[3]
Financial industry	Dummy variable yielding 1 if firm is considered to be incorporated in the financial industry by four-digit SIC code, and 0 if otherwise[4]

1.Or date of 01-01-2022; 2. Consumer Price Index; 3. See Table 1 for detailed description on the industries incorporated in the innovative industry, according to Kile and Philips (2009); 4. Four-digit SIC code, 6000-6999, is defined as financial industry.

Appendix C Pearson correlation matrix

Appendix C. This table reports the correlations between the dependent and independent variables used in the regression models. All correlations are rounded to three decimals and *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) LEV	1.000															
(2) OC	-0.035*	1.000														
(3) Gender	0.009	-0.014	1.000													
(4) Age	0.006	-0.064*	0.023*	1.000												
(5) Tenure	-0.189*	0.084*	0.094*	0.162*	1.000											
(6) Duality	-0.043*	-0.022	0.124*	0.154*	0.359*	1.000										
(7) Interest rate	0.053*	-0.043*	-0.005	0.026*	-0.037*	-0.020	1.000									
(8) Inflation	0.179*	0.039*	-0.028*	0.086*	-0.172*	-0.067*	0.157*	1.000								
(9) GDP	0.189*	0.042*	-0.031*	0.086*	-0.174*	-0.065*	0.266*	0.321*	1.000							
(10) Firm size	0.188*	-0.153*	0.016	0.126*	-0.160*	0.151*	-0.001	0.086*	0.089*	1.000						
(11) Asset tangibility	0.193*	-0.136*	0.015	0.096*	-0.076*	-0.007	0.013	-0.004	0.004	0.059*	1.000					
(12) Stock market return	-0.017	0.251*	-0.007	-0.037*	0.020	-0.014	-0.155*	0.051*	0.023	-0.086*	-0.065*	1.000				
(13) ROA	0.109*	0.128*	-0.024*	-0.010	-0.069*	-0.013	0.026*	-0.007	-0.011	-0.034*	0.107*	0.022	1.000			
(14) ROE	0.025*	0.098*	-0.055*	0.025*	-0.038*	0.054*	0.021	0.040*	0.036*	0.178*	-0.079*	0.028*	0.385*	1.000		
(15) Efficient board size	0.101*	-0.117*	0.029*	0.058*	-0.049*	0.031*	-0.022	-0.011	-0.017	0.256*	0.079*	-0.072*	0.118*	0.085*	1.000	
(16) Covid-19 dummy	0.093*	0.033*	-0.015	0.039*	-0.076*	-0.025*	-0.270*	0.329*	0.293*	0.042*	0.000	0.088*	-0.059*	-0.044*	-0.001	1.000

Appendix D Robustness analyses

Appendix D.1. Robustness test on overconfidence. This table reports estimates of the multivariate regression including all explanatory variables, with a distinction being made in the level of CEO overconfidence to control for robustness of the results. The dependent variable is leverage. Specification (1) and (2) represent the Holder 67 measure, with Specification (1) reflecting the total sample and Specification (2) demonstrating the Covid-19 sample. Specification (3) and (4) represent the high level of overconfidence, indicating CEOs who hold stock options that are more than 100% in-the-money, with Specification (3) reflecting the total sample and Specification (4) demonstrating the Covid-19 sample. Specification (5) and (6) represent the low level of overconfidence, indicating CEOs who exercises stock options that are less than 30% in-the-money, with Specification (5) reflecting the total sample and Specification (6) demonstrating the Covid-19 sample. The estimates are based on a Fixed Effects model, since that is preferred over a Random Effects model based on the Hausman test performed. Specification (1), (3) and (5) control for firm and year fixed effects, while Specification (2), (4) and (6) control for firm fixed effects only. Standard errors (stated in parentheses) are heteroskedasticity robust *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Holder 67 OC		High OC		Low OC	
Variables	(1)	(2)	(3)	(4)	(5)	(6)
OC	-0.001	-0.001	-0.008	-0.008	0.004	0.004
	(0.006)	(0.006)	(0.007)	(0.007)	(0.005)	(0.005)
Gender	-0.009	-0.008	-0.009	-0.008	-0.009	-0.008
	(0.022)	(0.021)	(0.022)	(0.021)	(0.022)	(0.021)
Age	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tenure	-0.001	-0.002	-0.001	-0.002	-0.001	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Duality	0.020	0.017	0.020	0.017	0.020	0.017
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Interest rate	-0.029***	0.001	-0.029***	0.001	-0.029***	0.001
	(0.009)	(0.003)	(0.009)	(0.003)	(0.009)	(0.003)
Inflation	0.020	-0.218	-0.005	-0.239	0.015	-0.231
	(0.491)	(0.202)	(0.490)	(0.202)	(0.489)	(0.202)
GDP	-0.016*	0.011**	-0.015*	0.012**	-0.016*	0.012**
	(0.009)	(0.006)	(0.009)	(0.006)	(0.009)	(0.006)
Firm size	0.050***	0.057***	0.050***	0.057***	0.050***	0.057***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Asset tangibility	0.061**	0.079***	0.061**	0.079***	0.061**	0.079***
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Stock market return	-0.137**	-0.087	-0.125*	-0.075	-0.127*	-0.077
	(0.064)	(0.058)	(0.064)	(0.057)	(0.065)	(0.059)
ROA	-0.220***	-0.232***	-0.215***	-0.227***	-0.216***	-0.228***
	(0.068)	(0.068)	(0.068)	(0.068)	(0.068)	(0.068)
ROE	-0.056***	-0.055***	-0.055***	-0.054***	-0.056***	-0.055***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Efficient board size	-0.006	-0.009	-0.006	-0.009	-0.006	-0.009
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Covid-19 dummy		0.018***		0.018***		0.018***
		(0.004)		(0.004)		(0.004)
Constant	0.121	-0.387***	0.110		0.114	
	(0.180)	(0.125)	(0.181)		(0.180)	

Appendix D.1 (continued)

Observations	6,071	6,071	6,071	6,071	6,071	6,071
Number of firms	1,025	1,025	1,025	1,025	1,025	1,025
R-squared	0.181	0.163	0.181	0.163	0.181	0.163
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	No	Yes	No	Yes	No

Appendix D.2. Robustness test on industries. This table reports estimates of the multivariate regression including all explanatory variables, specifically analyzing two industries in addition, to control for robustness of the results. The dependent variable is leverage. The first three specifications demonstrate the results of the total sample analyzed, with Specification (1) reflecting all firms, Specification (2) incorporating financial firms only, and Specification (3) exclusively including innovative firms. The second three specifications represent the results of the Covid-19 sample particularly, with Specification (4) reflecting all firms, Specification (5) incorporating financial firms only, and Specification (6) including innovative firms specifically. The estimates are based on a Fixed Effects model, since that is preferred over a Random Effects model based on the Hausman test performed. Specification (1), (2) and (3) control for firm and year fixed effects, while Specification (4), (5) and (6) control for firm fixed effects only. Standard errors (stated in parentheses) are heteroskedasticity robust *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Total Sample			Covid-19 sample		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
OC	-0.001	0.039**	0.002	-0.001	0.039**	0.003
	(0.006)	(0.016)	(0.009)	(0.006)	(0.016)	(0.009)
Gender	-0.009	-0.025	0.066	-0.008	0.000	0.072**
	(0.022)	(0.036)	(0.030)	(0.021)	(0.034)	(0.035)
Age	-0.000	0.001	0.000	-0.000	0.000	0.000
	(0.000)	(0.002)	(0.001)	(0.000)	(0.002)	(0.001)
Tenure	-0.001	-0.003	-0.003	-0.002	0.003	-0.003
	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)	(0.004)
Duality	0.020	-0.003	0.018	0.017	-0.010	0.020
	(0.025)	(0.044)	(0.044)	(0.025)	(0.041)	(0.046)
Interest rate	-0.029***	-0.116**	-0.015	0.001	0.002	-0.001
	(0.009)	(0.052)	(0.012)	(0.002)	(0.007)	(0.004)
Inflation	0.020	0.982	-0.720	-0.218	0.097	-0.569
	(0.491)	(1.959)	(0.811)	(0.202)	(0.508)	(0.350)
GDP	-0.016*	0.077*	-0.018	0.011**	-0.003	0.020**
	(0.009)	(0.043)	(0.014)	(0.006)	(0.014)	(0.010)
Firm size	0.050***	0.062*	0.038**	0.057***	0.064**	0.042**
	(0.012)	(0.032)	(0.017)	(0.012)	(0.032)	(0.017)
Asset tangibility	0.061**	0.252	-0.080	0.079***	0.220	-0.068
	(0.029)	(0.240)	(0.060)	(0.029)	(0.227)	(0.060)
Stock market return	-0.137**	-0.527***	-0.202**	-0.087	-0.372**	-0.165*
	(0.064)	(0.186)	(0.102)	(0.058)	(0.177)	(0.092)
ROA	-0.220***	0.061	-0.158	-0.232***	0.040	-0.174*
	(0.068)	(0.337)	(0.100)	(0.068)	(0.334)	(0.100)
ROE	-0.056***	-0.193	-0.100***	-0.055***	-0.019	-0.092***
	(0.014)	(0.100)	(0.026)	(0.014)	(0.100)	(0.026)
Efficient board size	-0.006	-0.012	0.004	-0.009	-0.014	0.003
	(0.011)	(0.012)	(0.016)	(0.011)	(0.013)	(0.016)
Covid-19 dummy				0.018***	0.007	0.020***
				(0.004)	(0.009)	(0.007)
Constant	0.121	-1.671***	0.172	-0.387***	-0.401	-0.484***
	(0.180)	(0.714)	(0.268)	(0.125)	(0.301)	(0.189)
Observations	6,071	549	2,524	6,071	549	2,524
Number of firms	1,025	90	198	1,025	90	198
R-squared	0.181	0.145	0.155	0.163	0.117	0.143
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	No	No	No

Appendix E Propensity score matching

Appendix E.1. Propensity score matching estimates. This table reports the propensity score matching estimation results for the overconfident CEO sample. Panel A reports parameter estimates from the logistic regressions. The dependent variable is the CEO overconfidence variable, computed by the Holder 67 measure. The independent variables include the firm-specific variables, which are defined in Appendix B. Specification (1) in Panel A represents the estimates of the logistic regression pre-matching and Specification (2) details the estimates of the logistic regression post-matching. Panel B reports the univariate comparisons of firm characteristics between firms with (OC=1) and without (OC = 0) overconfident CEOs and the corresponding *t*-statistics. The matching results in 1,190 treated groups, or 1,190 pairs of matched observations, out of 6,306 valid observations. The estimates are based on a Fixed Effects model, since that is preferred over a Random Effects model based on the Hausman test performed. Standard errors (stated in parentheses) are heteroskedasticity robust *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A – Logistic regression results

	Pre-match	Post-match
Variables	(1)	(2)
Firm size	-0.158***	-0.010
	(0.024)	(0.029)
Asset tangibility	-1.221***	-0.191
	(0.116)	(0.138)
Stock market return	24.080***	3.712**
	(1.409)	(1.564)
ROA	3.727***	0.575
	(0.453)	(0.496)
ROE	0.494***	0.027
	(0.165)	(0.184)
Efficient board size	-0.656***	-0.060
	(0.137)	(0.146)
Constant		
Observations	6,306	2,218
Pseudo R-squared	0.131	0.003

Panel B – Differences in firm characteristics

	Treatment Group (OC = 1)	Control Group (OC = 0)	Difference	t-test
Firm size	7.675	7.715	-0.040	-0.560
Asset tangibility	0.333	0.351	-0.018	-1.330
Stock market return	0.032	0.030	0.002	1.640
ROA	0.151	0.147	0.004	0.810
ROE	0.177	0.165	0.013	0.980
Efficient board size	0.884	0.894	-0.010	-0.740

Appendix E.2. Regression models with matched overconfidence variable. This table presents estimates of the OLS regression (1) and multivariate regressions (2,3,4,5). The dependent variable is leverage. In Specification (1), OC_Matched identifies the CEO overconfidence (OC), computed by the Holder 67 measure, matched on firm-specific characteristics by propensity scores, and is used as explanatory variable. In Specification (2), CEO-specific control variables are added to the model. In Specification (3), macroeconomic control variables are included. Specification (4) controls for year fixed effects, in addition to the firm fixed effects already included in the previous three specifications and includes three interaction terms. Specification (5) represents the results of the Covid-19 sample specifically, not including year fixed effects, and substitutes the Interest rate * OC interaction term for the Covid-19 * OC interaction term. The estimates are based on a Fixed Effects model, since that is preferred over a Random Effects model based on the Hausman test performed. Standard errors (stated in parentheses) are heteroskedasticity robust *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Variables	(1)	(2)	(3)	(4)	(5)
OC_Matched	0.006	0.003	0.001	0.003	0.002
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Gender		-0.000	0.025	0.029	0.021
		(0.058)	(0.034)	(0.026)	(0.030)
Age		0.004***	0.000	-0.000	-0.000
		(0.001)	(0.001)	(0.001)	(0.001)
Tenure		-0.008**	-0.003	-0.002	-0.002
		(0.003)	(0.003)	(0.003)	(0.003)
Duality		0.068*	0.070**	0.057*	0.061*
		(0.037)	(0.034)	(0.034)	(0.035)
Interest rate			-0.009	0.009	-0.003
			(0.006)	(0.017)	(0.006)
Inflation			-1.024**	-0.476	-0.957**
			(0.440)	(1.113)	(0.436)
GDP			0.040***	-0.014	0.037***
			(0.012)	(0.020)	(0.012)
Covid-19 dummy					0.031***
					(0.007)
Age * OC				-0.001	-0.001
				(0.001)	(0.001)
Tenure * OC				0.001	0.001
				(0.001)	(0.001)
Covid-19 dummy * OC					0.017
					(0.014)
Interest rate * OC				-0.011**	
				(0.050)	
Constant	0.245***	0.102	-0.518**		-0.444**
	(0.005)	(0.080)	(0.214)		(0.210)
Observations	2,155	2,155	2,155	2,155	2,155
Number of firms	753	753	753	753	753
R-squared	0.001	0.019	0.065	0.090	0.074
Adjusted R-squared	0.000	0.017	0.062	0.082	0.072
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	Yes	No