Essays on Financial Constraints: Text Analysis and Social Network Analysis

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by

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Abstract

This thesis delves into the relationship between financial constraints and board characteristics, including board interlocks, board expertise, and CEO overconfidence. Based on assumption that firms disclose information about incapability of raising capital in the financial statement, I adopt an innovative measure of financial constraints using textual analysis of firms' annual reports, which indeed captures typical characteristics of firms that are conventionally perceived financially constrained. For example, constrained firms pay less dividend, are smaller, showing higher R&D intensity, holding higher cash holding, having higher Tobin's Q. Chapter 2 focuses on the effect of board interlocks on financial constraints. It is assumed that with more board interlocks, firms tend to have better information environment and thus mitigate information asymmetry, leading to lower financial constraints. Consistent with this assumption, I find that firms with well-connected directors face less risk of financial constraints. Two tests are conducted to mitigate the endogeneity concerns, including instrumental variable approach, and a difference-in-difference test based on propensity score matching process using directors' death as external shock. Chapter 3 investigates the relationship between board expertise and financial constraints. Although previous literature highlights the merits of board expertise, I find that board experience in the focal industry indeed increases the risk of financial constraints. The proportion and number of independent directors who have industry experience are positively related to financial constraints. The results are robust to fixed effects, inverse causality test, and alternative measures of financial constraints. Chapter 4 deals with the effects of CEO overconfidence on financial constraints. The results indicate that firms run by CEOs having low level of overconfidence faces more risk of financial constraints. However, the effect of high level of overconfidence is insignificant. The results are validated through robustness tests of alternative measure of financial constraints. Additionally, a quasi-experimental test based on propensity score matching also confirms the results.

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Lastly, I dedicate this thesis to all those who faced hardships, loss, and unprecedented challenges during the COVID-19 pandemic. May the lessons we've learned and the resilience we've shown guide us towards a brighter, more empathetic future.

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1. Introduction

1.1 Motivation and background

Corporate governance, the system by which companies are directed and controlled, has been the subject of extensive research and debate in recent years. Central to this discourse is the role of the board of directors, given its responsibility in overseeing management and ensuring the alignment of corporate strategies with shareholder interests (Tricker, 2015). Board characteristics, encompassing elements such as composition, diversity, size, tenure, and independence, have been posited to significantly influence various facets of firm performance and decision-making (Adams et al., 2010).

One dimension of corporate performance that has gained attention is the issue of financial constraints. Financial constraints refer to the challenges and limitations firms face when attempting to secure external financing. These constraints can arise from a myriad of factors, including market imperfections, information asymmetry, and agency problems, and can critically impact a firm's investment decisions, operational flexibility, and growth trajectories (Almeida and Campello, 2007; Whited, 1992). While individual studies have delved into the dynamics of board characteristics and financial constraints separately, less attention has been paid to the investigation of the interplay between these two concepts. Such an exploration is crucial. If board characteristics can be empirically linked to the degree of financial constraints a firm experiences, it could reshape the understanding of effective board structures and their broader implications for financial management and corporate strategy. In addition, this study argues for the importance of text-based methods as a complementary approach to traditional methods in measuring financial constraints. The assessment of financial constraints is a pivotal concern for scholars, policymakers, and industry professionals aiming to understand the financial well-being and investment behaviours of firms. Traditional approaches for this measurement often rely on quantitative financial ratios or survey methods (Kaplan and Zingales, 1997). However, these methods come with inherent limitations, such as data availability, timeliness, and potential subjective bias, which underlines the importance of using alternative measures, such as text-based method.

This research endeavors to extend the understanding of the relationship between financial constraints and board attributes, especially focusing on board interlocks, board expertise, and CEO overconfidence. Through this investigation, the aim is to shed light on whether specific board characteristics can mitigate or exacerbate the financial constraints faced by firms, and thereby provide stakeholders with actionable insights into optimizing board structures for financial robustness.

1.2 Analytical framework and major findings

1.2.1 Measure of financial constraints based on textual analysis

The assessment of financial constraints in firms has previously often relied on accounting ratios and survey methods, which may come with limitations such as data availability, timeliness, and potential subjective bias (Kaplan and Zingales, 1997; Campello et al., 2010). Text-based methods, leveraging unstructured data sources like news articles, social media, and earnings call transcripts, offer a complementary approach that addresses some of these limitations. Text-based methods capture the nuanced context that numerical data often overlooks (Tetlock, 2007). For instance, the language used in the Management Discussion and Analysis (MD&A) sections of annual reports can offer nuanced insights that quantitative metrics may overlook (Loughran and McDonald, 2011). Text-based methods are particularly useful for smaller firms or those in emerging markets where traditional financial data may be sparse. Moreover, these methods are highly adaptable, capable of capturing industry-specific jargon and trends, and can be used in conjunction with traditional methods to provide a more comprehensive understanding of a firm's financial constraints (Hoberg and Maksimovic, 2015; Bodnaruk et al., 2015; Buehlmaier and Whited, 2018). Therefore, text-based methods should be considered a valuable tool for researchers and practitioners interested in a more nuanced and timely understanding of financial constraints.

Specifically, this paper assumes that when managers indicate the potential need to curtail or delay investment in the MD&A section, it implies that the firm is investing less than what might be optimal due to challenges to its liquidity, i.e. falling into financial constraints. Briefly, to gauge financial constraints, I first pre-process the Management's Discussion and Analysis (MD&A)

section of each 10-K filing to remove noise and standardize the text. Second, I create a training sample which captures the statement of incapability of raising capital in MD&A. Finally, with the training sample, I use a naïve Bayes algorithm to classify each MD&A based on the similarity with the training sample. I find that the text-based measure indeed captures characteristics typically associated with financially constrained firms. For instance, compared with unconstrained firms, constrained firms pay less dividends and are smaller. They also have higher cash holding, higher research and development intensity, and higher Tobin's Q.

1.2.2 Financial constraints and board interlocks

One intriguing aspect of board structures that has gained scholarly attention is the phenomenon of board interlocks—situations where a director of one firm also serves on the board of another firm (Mizruchi and Stearns, 1988). While board interlocks have been studied in the context of information sharing, strategic alliances, and antitrust implications (Davis, 1997; Haunschild, 1993), there is a notable gap in the literature concerning their relationship with financial constraints faced by firms. This research aims to bridge this gap by investigating the relationship between board interlocks and the degree of financial constraints experienced by firms, seeking to contribute to the extant literature in both corporate governance and corporate finance, providing stakeholders with a nuanced understanding of how board structures can impact financial decision-making and firm performance.

Board interlocks can influence financial constraints through two primary channels: information dissemination and monitoring, both of which have mixed effects. For information dissemination, board interlocks can facilitate the transfer of private information, reducing information asymmetry and potentially easing financial constraints. However, there's also a risk that these interlocks can increase information asymmetry if directors discreetly share sensitive information for personal gain, leading to more informed sophisticated investors and potentially exacerbating financial constraints (Akbas et al., 2016). Misunderstanding or misusing disseminated information can also weaken their monitoring capabilities (Ahmed and Duellman, 2007). Regarding monitoring, board interlocks can enhance the oversight of managerial practices, reducing agency costs and financial constraints. Directors with more connections can better monitor and avoid mistakes. However,

there's a downside: directors on multiple boards might be less effective due to their divided attention, leading to the adoption of practices that don't add value. (Palmer et al., 1986; Fich and Shivdasani, 2006). In summary, the impact of board interlocks on financial constraints remains ambiguous and requires further exploration.

To empirically investigate the relationship between board interlocks and financial constraints, I employ five specific metrics: degree centrality, betweenness centrality, closeness centrality, eigenvector centrality, and a weighted average score derived from these four centralities. I measure financial constraints using the text-analysis methods previously described. Analysing a dataset that includes 15,537 annual observations for U.S. publicly traded companies from 2008 to 2019, I discover that having well-connected independent directors can significantly alleviate financial constraints. These findings are further validated through robustness tests, including instrumental variable techniques and a difference-in-difference approach that utilizes propensity score matching process.

1.2.3 Financial constraints and board expertise

In the realm of corporate governance, the composition and capabilities of a firm's board of directors play a pivotal role in shaping its strategic trajectory and overall performance (Tricker, 2015). Among the various facets of board composition, prior experience in the firm's industry has been a notable element in many reports (Coca-Cola Co., 2011; Hewlett-Packard, 2011; PricewaterhouseCoopers LLP, 2012; Society of Corporate Secretaries and Governance Professionals and Deloitte Development LLC, 2014; NYSE, 2016). While numerous studies have delved into the role of industry expertise on firm outcomes such as innovation, risk-taking, and financial performance (Masulis et al., 2012; Faleye et al., 2014; Von Meyerinck et al., 2016; Cohen et al., 2014; Wang et al., 2015; Bradley et al.,2017; Wang, 2017; Meng and Tian, 2020), effect of board expertise on financial constraints has received limited attention. This research tries to illuminate this relationship, exploring the extent to which board expertise influences financial constraints.

Theoretically, industry expertise exerts mixed effects on financial constraints. On one side, industry mitigate financial constraints through deeper understanding of business mode, lowering information, better information environments, and effective board governments (Wang et al., 2015; Oehmichen et al., 2017; Bradley et al., 2017). On the other side, more industry expertise may exacerbate financial constraints due to excessive tolerance for monitoring, lowering board diversity (Faleye et al., 2018; Dass et al., 2014).

I find that more board expertise is related to higher risk of financial constraints. The sample contains 11,638 firm-year observations for 2,389 listed firms in U.S. between 2008 and 2019.I adopt three measure of industry expertise, the number of industry experts in board, the fraction of industry experts to independent directors, and a dummy variable which equals 1 if there is any industry expert in board, 0 otherwise. The results pass robustness check of inverse causality and alternative measures of financial constraints.

1.2.4 Financial constraints and CEO overconfidence

The dynamics of corporate decision-making are profoundly influenced by the psychological attributes of its leaders, particularly the Chief Executive Officer (CEO). Among the myriad of CEO characteristics that have gained scholarly attention, overconfidence stands out as a trait with potentially significant implications for firm behaviour and performance (Malmendier and Tate, 2005). Overconfident CEOs, characterized by their excessive belief in their own abilities and the accuracy of their information, can shape a firm's investment decisions, risk-taking propensity, and financial policies (Malmendier and Tate, 2005; Malmendier and Tate, 2008; Malmendier et al., 2011; Hirshleifer et al., 2012; Deshmukh et al., 2013; Hribar and Jenkins, 2004; Phua et al.,2018; Aktas et al., 2019; Chen et al., 2020).

There are also several papers investigating relationship between CEO overconfidence and financial constraints, employing investment-cash flow sensitivity as measure of financial constraints (Malmendier and Tate,2005; Lin, 2007; Glaser et al., 2008; Huang et al., 2014; Mohamed et al., 2014; Maditinos et al., 2015; Koo and Yang, 2018). However, there remain several challenges in understanding the relationship between CEO overconfidence and financial constraints. Firstly,

while overconfident CEOs show sensitivity to cash flow, this doesn't necessarily equate to difficulties in raising funds, since investment decisions are influenced by various factors, making it hard to pinpoint the sole impact of financial constraints (Whited, 1992). Secondly, most research on this topic has focused on investment sensitivity as a proxy for financial constraints, which points to using diverse proxies for deeper understanding (Kaplan and Zingales, 1997; Hadlock and Pierce, 2010). Lastly, overconfident CEOs theoretically can have both positive and negative impacts on financial constraints. While their strong belief in their strategies might align with shareholder interests and thus reduce capital-raising difficulties (Malmendier and Tate, 2005), overconfident CEOs might also make decisions misaligned with shareholder goals, increasing risk of financial constraints (Jensen and Meckling, 1976). This underscores the need for a comprehensive review of the relationship between CEO overconfidence and financial constraints.

The primary analysis reveals a positive relationship between low CEO overconfidence and the risk of financial constraints, after accounting for known determinants. This suggests that the benefits of low overconfidence outweigh its potential downsides regarding financial constraints. While these findings differ from prior research that linked CEO overconfidence to increased financial constraint risks, they remain consistent after accounting for yearly and industry fixed effects. Robustness test using tangibility as alternative measures of financial constraints confirms these results. Additionally, a propensity score matching (PSM) process, inspired by Aktas et al. (2019), is employed to create parallel sample to ensure that the observed impact of CEO overconfidence is not just due to observable differences between firms. Regression based on the parallel sample also support the initial findings.

1.3 Thesis structure

This thesis is divided into five chapters, addressing three central issues. Chapter 2 investigates the relationship between board interlocks and financial constraints. Chapter 3 delves into the effect of board expertise on financial constraints. Chapter 4 focuses on the relation between CEO overconfidence and financial constraints. Chapter 5 concludes.

2. Board interlock and financial constraints

2.1 Introduction

The relationship between board interlock and financial constraints is a subject of considerable interest in corporate governance and financial management literature. Board interlock, the phenomenon where directors serve on multiple boards, has been shown to influence various aspects of firm performance and strategic decision-making. Financial constraints, referring to limitations in a firm's ability to obtain external financing at reasonable costs, are critical factors that can affect a firm's growth and operational efficiency. The interplay between these two elements is complex, involving both positive and negative effects.

Board interlock can impact financial constraints through two main channels: information dissemination and monitoring. In terms of information dissemination, board interlocks can reduce information asymmetry by transferring private information between insiders and outsiders (Cai and Sevilir, 2012; Renneboog and Zhao, 2014), thereby lowering the cost of external funds and alleviating financial constraints. However, they can also increase information asymmetry if directors spread sensitive information within a small group for personal benefit, leading to more informed sophisticated investors (Akbas et al., 2016). Regarding monitoring, board interlocks can lower agency costs by spreading knowledge of managerial practices and improving monitoring abilities, thus reducing financial constraints (Palmer et al., 1986; Haunschild, 1993; Gulati and Westphal, 1999). Nonetheless, directors who sit on multiple boards may be less effective at monitoring due to busyness, and they may also misuse disseminated information, which can impair their monitoring capabilities (Fich and Shivdasani, 2006; Ahmed and Duellman, 2007).

Board interlocks are the links established by the overlapping board members between firms. Following existing board connection literature (Fracassi, 2017; Larcker et al., 2013; Intintoli et al., 2018; Akbas et al., 2016; Amin et al., 2020), I use four proxies to measure board interlocks, including degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality. Degree centrality measures how many connections firms have directly. Betweenness centrality measures firms' ability as an information broker. Closeness centrality measures how quickly a

firm can get information from direct and indirect firms. Eigenvector centrality measures is an upgraded degree centrality that considers the importance of each board. For comparability and additivity between years, the four measures are divided by the standard deviation across all firms for any year. Firms are then divided into five quantiles according to each measure. Finally, to capture the four measures, I then take an average of quantile ranking of the four board centrality measures and define it as centrality. In this study, board interlocks only focus on professional networks, which includes the interlocks from previous work experience. In addition, interlocks exclude duplication between firms and connections within firms.

Financial constraint describes a phenomenon where due to financial frictions firms faces costlier external funds than internal funds. In some circumstances, firms may curtail potential programs due to the costlier external funds. There are several ways to measure financial constraints, such as investment sensitivity, credit score, KZ index. In current study, motivated by Hoberg and Maksimovic (2015), and Bodnaruk et al. (2015) and Buehlmaier and Whited (2018), I construct a measure of financial constraint based on text-analysis. The rationale behind is that managers are mandated to report in 10-Ks about how the sources of capital satisfy financing needs and specifically whether there are programs delayed by insufficient funds. This information reveals the status of financial constraint. A text-based measure of financial constraint can thus be developed. Empirically, based on a wordlist, I first draw one training sample of financially constrained firms and another one of financially unconstrained firms. Then I use the training sample to train an algorithm which gives an estimated probability of financial constraint based on the words in annual reports. Finally, I use the algorithm to predict the status of financial constraint in the whole sample. The characteristics of financially constrained firms measured through this way are found to be consistent with what traditionally associated with financial constraint. For instance, firms categorized as financial constraint are found to be smaller, paying less dividend, and higher R&D investment.

Then I empirically investigate the effect of board interlock on financial constraint. There are 3,125 unique firms with 15,537 firm-year observations from 2008 to 2019 in my sample. The baseline analysis includes financial constraint as dependent variable, board centrality as independent variable, several control variables, and firm, year fixed effects. Results show that there is a

significantly negative relation between financial constraint and board centrality, which supports the hypothesis. The result indicates that the possibility of falling into financial constraint for the firms at the top quantile in centrality is 5.2572% lower than those in the bottom. Four of the other five measures of centrality also provide evidence for the negative relation between financial constraint and board centrality. The results of baseline analysis support the hypothesis that well-connected independent directors are helpful to mitigate financial constraint.

However, the causality may be reversed where firms facing financial constraint tend to hire well-connected independent directors for their better information accessibility. In addition, there also might be omitted variables. To mitigate the concerns of endogeneity, I then augment the baseline analysis through two ways. First, I use instrumental variable estimation. Motivated by prior literature (Faleye et al., 2014; Intintoli et al., 2018; Amin et al., 2020), two instruments are adopted, the fraction of independent directors having elite MBA degree and the average number of Fama-French 48 industries the independent directors worked for. The two instruments satisfy relevance and exclusion conditions. The results of the instrumental variable regression indicate that there is a significantly negative association between board centrality and financial constraint, which is consistent with the baseline analysis. Second, using independent directors' death as exogenous shock to the board centrality, a difference-in-difference (DiD) approach is applied. Propensity score matching is used to build the sample. The results suggest a causal direction from board interlocks to financial constraint.

This study is related to the literature that investigates the relation between social connections and firm's performance. For example, Faccio et al. (2006) showcase that there is more likelihood to be bailed out for politically connected firms compare with those not. Cull et al. (2015) document that in China investments by firms with political connections is highly sensitive to cash flow, while those not is not found. Hu and liu (2015) demonstrate that hiring diversely experienced CEO reduce the possibility of facing insufficient cash flow. One important hypothesis behand these studies is that the connections help firms mitigate informational asymmetry and thus gain accessibility to more external funds.

This study is also related to the literature of using text-analysis to measure financial constraint. For instance, using 10-Ks reports, Bodnaruk et al. (2015) measure financial constraint based on a dictionary consisting of constraining words. They further find a predictive association between this text-based index and liquidity events. Adopting a similar method, Hoberg and Maksimovic (2015) focus on the Management's Discussion and Analysis in 10-Ks and separate financially constrained firms for equity-caused and debt-caused. Buehlmaier and Whited (2018) manually read 120 reports and use naïve Bayes algorithm to distinguish financially constrained firms. To the best of my knowledge, current paper is the first one that investigate the relation between board interlock and financial constraint. I find that firms with more board interlock significantly faces less financial constraint. The paper is also unique due to the usage of text-based technique on measuring financial constraint, instead of accounting ratio-based.

The rest of the section is organized as follows. Section 2.2 is literature review and development of hypothesis. Section 2.3 describes the construction of variables and research design. Section 2.4 provides the baseline results. Section 2.5 deals with endogeneity problems. Section 2.6 concludes.

2.2 Literature review

2.2.1 Literature review of board interlock

Board interlock delineate a phenomenon when a person sits on multiply boards. The aim of this section is to review the extant literature on board interlock. Related theories and empirical studies are discussed. In following section, I first review the theoretical background of board interlock and then the formation of board interlock from two perspective, directors and firms. Finally, I delve into the impacts of board interlock on firm.

2.2.1.1 Theoretical background of board interlock

There are several theories related to board interlock. Scholars usually consider the consequence of board interlock from two prominent theoretical perspectives, agency theory and resource dependence theory.

2.2.1.1.1 Perspective of agency theory

Agency theory focus on the inherent conflict between shareholders and managers. Agency theory assumes that the management sacrifice the expense of shareholders to maximize their own private interest. The separation of ownership and management rises the problem of agency cost. Board is responsible to decrease agency cost through monitoring corporate governance and arranging incentive schemes (Jensen and Meckling, 1976; Fama, 1980). The relationship between the agency problem and board interlock is complex and multifaceted. Board interlocks can both alleviate and exacerbate agency conflicts, depending on various contextual factors.

On one side, board interlock could mitigate agency problem. Interlocking directors may bring a wealth of experience and insights from other boards, enhancing their ability to monitor and advise management effectively. They can identify and implement best practices, leading to better governance outcomes and reduced agency costs (Fich and Shivdasani, 2006). Additionally, board interlocks can facilitate access to valuable networks, providing firms with strategic advantages such as partnership opportunities and market intelligence. These benefits can lead to better managerial decision-making aligned with shareholder interests (Omer et al., 2014).

On the other side, board interlocks may exacerbate the Agency Problem. Directors serving on multiple boards may face conflicts of interest, where their duties to one firm conflict with their responsibilities to another. This can lead to biased decision-making and compromised oversight, exacerbating agency problems (Ferris et al., 2003). The demands of serving on multiple boards can overextend directors, reducing their ability to effectively monitor and engage with each firm's management. This can diminish board effectiveness and weaken governance structures, allowing agency problems to persist (Fich and Shivdasani, 2006; Ahmed and Duellman, 2007).

2.2.1.1.2 Perspective of resource dependence theory

The resource dependence theory emphasizes the functions of providing resource as the primary responsibility of board directors. The theory delineate that firms are open to the uncertain environment, and how to acquire and utilize resources are vital for survival and development (Pfeffer and Salancik, 1978). As explained by Pfeffer and Salancik (2003), board members offer four types of resources: (1) advice and counsel, (2) a channel of communicating information between firms, (3) legitimacy and reputation, (4) Preferential access to external resources.

According to resource dependence theory, interlocks can be beneficial in several ways. First, board interlocks serve as a mechanism for firms to broaden sources of information and improve information quality, relevance, and timeliness (Haunschild and Beckman, 1998). Second, as a type of social connections, board interlocks transfer managerial practices (Davis, 1991; Palmer et al., 1986). The new learned practices can help firms reduce environmental uncertainty and dependence. Third, board interlocks with prestigious firms are regarded as a signal of the good quality of the focal firms (Certo, 2003). The positive signal might further enhance firm value. fourth, from the perspective of social capital, board interlocks generate influence (Amin et al., 2020). Overlapping directors can utilize their influence on others and therefore benefits the firms.

2.2.1.2 Formation of board interlock

Board interlock is a phenomenon where board members serve multiple organizations (Mizruchi, 1996). When interlocked, firms are connected via the overlapping board members. Metaphorically, firms are nodes and members are ties. Scholars thus developed three perspectives to forming board interlocks: interlocking firms, interlocking directors, and by-product perspective. The three theoretical perspectives focus difference primary assumptions of how board interlocks form. This section reviews these three perspectives respectively.

2.2.1.2.1 Perspective of interlocking firms

From the firm perspective, there are mainly three reasons to form board interlocks, resource dependency, monitoring, and information spreading. First, firms believe that forming board

interlocks could provide accessibility of valuable resources for firm survival and development (Martin *et al.*, 2015; Mizruchi and Stearns, 1988; Ong *et al.*, 2003; Shrader *et al.*, 1991; Stearns and Mizruchi, 1986). To face the uncertainties in resources environment, organizations appoint important individuals, including board of directors, in their decision-making structure (Burt, 1983; Pfeffer and Salancik, 1978). Later research also supports the idea that organizations form board interlock is primarily to mobilize resources (Benton, 2019; Kim et al., 2016; Withers et al., 2018; Zona et al., 2018). Empirically, board interlocks are reported to be positively related with reducing resource uncertainties (Pennings, 1980; Schoorman et al., 1981). In industries highlighting the importance of resource dependency, firms tend to form board interlocks for better financial performance (Burt, 1980; Simoni and Caiazza, 2012; Haija, 2009). In addition, for better financial environment, firms also form board interlocks. For example, when firms lack financial resources, they tend to invite external representatives from financial institutions to the board for capital (Palmer et al., 1986; Stearns and Mizruchi, 1986; Mizruchi and Stearns, 1994; Buch-Hansen, 2014). Reversely, interlocked financial institutions give focal firms important information, such as the flow of capital in the economy (Zeitlin, 1974). There is evidence that large commercial banks are interlocked with a group of boards (Mariolis, 1975; Mintz and Schwartz, 1987).

Another reason is that firms form interlocks for better monitoring (Gulati and Westphal, 1999; Carpenter and Westphal, 2001; Hillman *et al.*, 2008). Financial institutes are reported through sharing board members to monitor target firms (Mizruchi, 1982). If target firms' financial performances are in downward tendency, financial institutes might reinforce the interlocks by sharing more board members (Mizruchi and Stearns, 1988). Third, out of spreading information, firms also form board interlocks (Higgins and Gulati, 2003; Certo, 2003; Connelly *et al.*, 2011). For example, forming the interlocks with prestigious firms could spread the information that the focal firms are also good quality.

2.2.1.2.2 Perspective of interlocking directors

From the perspective of interlocking board members, the primary reasons of forming interlocks are better social capital and career progression. Directors form board interlock for benefits of social capital. It is suggested that the elite strengthen the connections among each other through board

interlocks for their economic and political interests (Zeitlin, 1974; Domhoff, 1975; Koenig et al., 1979; Useem, 1984). It is also reported that board members tend to appoint board candidates with similar social status, education, and family background (Koenig and Gogel, 1981; Useem and Karabel, 1986). For example, business leaders are reported to support their social group through board affiliations in multiple business firms for their corporate leadership (McDonald and Westphal, 2011).

As suggested by social capital theory, the gained social capital could further advance the board members career (Hillman *et al.*, 2009; Johnson *et al.*, 2011). It is worth noting that the relation between more social capital and career progression could be interactive. Career advance due to social capital accumulation can also help gain more social capital. These interactive effects reflect the social cohesion of dominant social class (Mizruchi, 1989).

2.2.1.2.3 By-product perspective

By-product perspective regarding board interlock as an unintended results of board recruitment. Scholars summarize two dimensions of this perspective, career advancement motivations and network generative dynamics. Idea of career advancement assumes that board interlock is a random consequence out of board members pursuing self-interest. Career advancement motivations of joining multiple boards include business opportunity scanning, the prestige of serving on boards of well-known companies, potential to expand business contacts, and compensation (Lorsch and Young, 1990; Zajac, 1988). On the other hand, the view of network generative dynamics assumes that board interlock is a random consequence out of board pursuing self-interest. Boards prefer to choose a kind of candidates with certain characteristics. Candidates with multiple board interlock in this situation are possibly preferred. In addition, candidates already sitting in other boards may enjoy the consequent social connections and therefore have advantages in board appointments. Literature reports that the possible reasons for network generative dynamics may arise from preferential recruitment and transitivity. The former means that people tend to connect with the popular (Kesner, 1988; Zweigenhaft and Domhoff, 1998; Hillman et al., 2002; Hillman et al., 2007; Withers et al., 2012). The latter means people tend to

connect with whom they have mutual relationship (Useem, 1984; Westphal et al., 2001; Koskinen and Edling, 2012; Kim and Zhang, 2016).

2.2.1.3 Impacts of board interlock

2.2.1.3.1 Information dissemination

Board interlock can influence information dissemination. Interlocked directors have accessibility to information only available to the board members. The overlapping board members circulate the information between the affiliated organizations. Davis et al. (2003) find that American corporate directors share the information obtained from other board that they seat. Myint et al. (2005) Investigate the Cambridge hi-tech cluster and find that firm benefits from board interlock by taking more business opportunities and transferring management expertise. More board interlocks are also connected to higher portfolio return in investment institution (Rossi et al., 2015) and higher efficiency of M&A transactions (Cai and Sevilir, 2012; Renneboog and Zhao, 2014). Via board interlocks, information is disseminated to the top decision-makers in firms (Bouwman, 2011; Haunschild and Beckman, 1998). Related to these findings, scholars find that board interlocks exert positive influence on perceived legitimacy of new management strategies and practices (Shipilov et al., 2010; Carpenter and Westphal, 2001). Information about of corporate management strategies and practices, such as takeovers, acquisition, and financial reporting decisions are impacted by board interlock as well (Felix, 2016; Shropshire, 2010). However, scholars find that the diffusion of management strategies and practices may not be always beneficial for investors. Interlocked firms in some situations tend to benefit management more instead of shareholders through decreasing taxable incomes and opposing takeover (Bizjak et al., 2009; Brown, 2011).

It is worth mentioning that the information spreading through interlocks is not necessarily always authentic and timely. Part of the information spread through interlocks is private, which is not formally endowed. The transmitted information may also be miscommunicated, misleading or incorrect. To confirm the authenticity of the relevant information could increase the costs of time for interlocked directors (Fich and Shivdasani, 2006). Additionally, because of the duty of

confidentiality, directors may be reluctant to reveal sensitive information to outside, which could limit the extent of information dissemination through board connectedness.

2.2.1.3.2 Corporate governance

Another impact of board interlock is corporate governance. Through monitoring and advising, board interlock influence corporate governance. It is found that board interlock with financial institutions could improve the quality of boards' monitoring over the top management, including board recruitment, corporate practices, and financial decision-making process (Carpenter and Westphal, 2001; Gulati and Westphal, 1999). There is evidence that financial profits, stock return, and firm value are positively related to board interlock (Barroso-Castro et al., 2016; Harris and Shimizu, 2004). Some scholars also report that board interlocks with financial institutions increase the possibility of acquiring capitals (Mizruchi and Stearns, 1994; Stearns and Mizruchi, 1993). In addition, it is reported that reputable board members are helpful to the social endorsements of firms, which further increases the organizations' credibility (Pfeffer and Salancik, 1978; Abzug and Galaskiewicz, 2001).

However, some studies report negative or mixed relationship between board interlock and corporate governance. A possible reason might be that board members serving multiple boards are too busy to take the responsibility. The limitation of time and attention leads to lack of engagement of board activities, such as monitoring and board evaluating (Devos et al., 2009; Falato et al., 2014). Zona et la. (2018) find that firms with different level of resources influence the relationship between board interlock and financial performance. Ahn et al. (2010) and Fich and Shivdasani (2006) find a negative relation between firm performance and board interlocks.

2.2.2 Literature Review of Financial constraints

Before diving into the literature of financial constraints, it is worth mentioning that financial constraints and financial distress are distinct. Financial distress is usually related to bankruptcy. A firm with financial distress cannot pay for its financial obligations and thus faces the risk of bankruptcy. However, financial constraints have nothing to do with bankruptcy, which emerges

from a situation where the firm must forgo its desired projects due to inability to collect capital for it.

In this section, several aspects of financial constraint are reviewed, including the causes of financial constraints, empirical measure of financial constraint, theories of financial constraint, characteristics of financially constrained firms, and factors easing financial constraint.

2.2.2.1 The causes of financial constraints

In a perfect capital market, according to Modigliani and Miller Theorem (1958)**,** internal finance perfectly substitutes for external finance and thus there is no financial constraints. However, there are several unrealistic assumptions in Modigliani and Miller theorem. A perfect capital market has no taxes. Transaction cost of securities, including bankruptcy cost, is zero. The information is symmetrical between buyers and sellers. The cost of capital is equal for investors and companies. Under these assumptions, it is mathematically concluded that the value of a corporation does not change with its leverage and its value is only related to its expected performance. Furthermore, an important implication of this conclusion is that the external finance, including stock and debt, can perfectly substitute internal finance, i.e. earning retentions. It is therefore a reasonable conclusion that the investment of a firm does not have relationship with its finance and firms do not face financial constraints. However, in practice, capital market is not perfect. Theoretically, three factors cause the wedge between external finance and internal finance, i.e. financial constraints, including information asymmetry between outsiders and insiders, the type I agency conflict between managers and shareholders, the type II agency conflict between large and small investors.

Information asymmetry occurs when one party possesses more information than the others in a trade, which may give economic advantage to the one party with more information. Myers and Majluf (1984) first connect asymmetry information and issuing stocks. It is assumed that the inside managers know more about the value of the investment than the outside investors. By establishing an equilibrium model of stock-issuing and investment decision, they find that stock issuing may be rejected, and the prospect project can further be cancelled, since potential investors may ask for too high compensation for the losses on information asymmetry. The compensation is regarded as

a part of the cost wedge between internal finance and external finance. Myers and Majluf (1984) find some scenarios in which exists asymmetric information. The financial department in a firm naturally have strong impetus to be more optimistic on the financial condition and the return of the new projects. Furthermore, firms tend to ask for compensations for the revealing information about intellectual property to maintain their competitive position. In some cases, it can be expensive for the investors, as outsiders, to assess the information within the firms. For example, the quality of a same loan could vary between different industries due to the idiosyncratic characteristics. Another key contribution is that they establish the link between internal finance and investment. Theoretically, there is information asymmetry between existing investors and new investors. If the new investment must be financed by the new investors, the existing investors might decline it for their own benefits. Instead, if the firm can use internal sources, the conflict between existing investors and new investors disappears. As a result, a positive relation between internal finance and investment is predicted. Fazzari and Athey (1987) also highlight the impact of information asymmetry and financial constraints on investment. 637 manufactory firms during the period between 1975 to 1985 are investigated. They find that cash flow and interest rates add more explanatory power to the investment behaviour. Cash flow represents internal source of finance and interest rates of its bonds is a signal for the worthiness of investing on the firm. In addition, they emphasise the importance of internal finance in another scenario of information asymmetry between lender and borrower. Lenders do not know the new projects well and can be reluctant to invest it, but if the firm uses its own cash on the investment, there appear a signal that the firm believe the new projects worth investment and this signal can boost confidence for the loan provider.

Type I agency conflict is another factor that my cause financial constraints. Type I agency conflict is between managers and investors, which is usually called the “control-ownership divergence”. These two groups do not share the same benefits. In some cases, managers, as the more direct controller, tend to sacrifice the profits of the investors for their owns. For instance, managers with control rights of excessive cash flow may have strong incentive to take advantage of abovementioned agency costs, since they do not take the proportionally responsibility of financial consequences, including financial constraints (Shleifer and Vishny, 1997; Johnson et al., 2000; Lin et al. 2011). Wei and Zhang (2008) further state that managements seizing abundant cash tend

to overinvest and thus later fall into financial constraints. In addition, Lin et al. (2011) find that the outside investors anticipate the managers' incentives to expropriation and thus are reluctant to invest these firms in case that they cannot materialize their profit. As a result, these firms can be financially constrained due to the lack of external capital.

Type II agency conflict is the third factor causing financial constraints. Type II agency conflict is between large and small investors. These two groups are opposite to each other in some scenarios that large investors take advantage or sacrifice the benefits of the small investors for their own. For example, bankruptcy is found to be used by the managers and insiders to exploit the small investors and creditors (Friedman et al. ,2003). In addition, Almeida and Wolfenzon (2006) focus on the family-controlled firms and find that insufficient investor protection can lead the families' possession of private benefits at the expense of the small investors when the focal firms are financially constrained. Like family ownership, ownership concentration exerts similar influence on investment. some managers, although hold small shares, are excessively allocated power, which gives them the similar position as large investors in dispersed ownership structure. A consequence is that due to the potential lose in the conflict between managers and investors, the small investors tend to refuse to invest these power-concentrated firms in fear of the abuse of excessive control on cash flow and the firms are therefore not able to fund the desired investments (Luo et al., 2015). Luo and Hu (2011) also find that potential investors require higher compensation against the risk of moral hazard. Investors anticipating the expropriation tend to discount these projects, which in turn, might lead the controlling shareholders to save cash and reluctantly reject desirable projects.

2.2.2.2 Measures of financial constraints

In this section, the previous measures of financial constraints are reviewed. The assumptions and developments of each measure are demonstrated with the consideration of merits and drawbacks. In general, the existence and degree of financial constraints is not on balance sheet and thus not empirically observable. Researchers create several methods to measuring financial constraints, including Q-theory model, cash-flow sensitivity, Euler equation model, survey, text-analysis, and three often used index, KZ, WW, HP. However, the measures abovementioned are not perfect. As demonstrated in Farre-Mensa and Ljungqvist (2016), five mainstream methodologies, KZ, WW,

HP, dividend payment and credit rating, do not reflect the real status of firms. Their results are reasonably persuasive due to the natural experiment adopted. The logic is that if a firm is measured as financial constraints, this focal firm is theoretically not able to issue debt or equity even if issuing debt or equity is beneficial for the focal firm. They collect the data of 43 corporate debt policy increment events during 1989 to 2011 and find that firm labelled with financial constraints using abovementioned five measures empirically have no trouble raising debt. Additionally, Silva and Carreira (2012) set a standard for a good measure of financial constraints, which should be objective, firm-specific, continuous, and time varying, but to my best knowledge, there is no such measure. Nevertheless, several commonly used measures are present as follows.

2.2.2.2.1 Dividend

Theoretically, high dividend payout come from several internal sources, such as sufficient retained earnings, high free cash flows and low investment opportunities. The firms with sufficient internal fund are less dependent from external sources and are able to fund their desired projects. The usage of dividend as a measure of financial constraints starts from Fazzari et al. (1988). Sampling on 422 firms from 1970 to 1984, they augment the Q-investment model and find a significant sensitivity of investment and cash flow. They find that 49 firms with no or low dividend in the sample have the largest sensitivity and further conclude that cash flow sensitivity is a measure of financial constraints. It is implicitly assumed that low or no dividend is the ultimate measure of financial constraints.

Dividend as a measure of financial constraints is controversial. On one side, it is found that the investment to cash flow sensitivity is less for low payout firms (Cleary, 2006; Arslan et al., 2006). For example, Cleary (2006) find that using investment-cash flow sensitivity as financial constraints measure, firms with higher dividend payout are more financially constrained than lower payout firms after controlling of size and financial strength. However, most researchers find that positive dividend and dividend ratio are related to less financial constraints. For example, Bodnaruk et al. (2015), using text-analysis, demonstrate that more financially constrained firms have high cash holdings, keep higher leverage, and pay lower dividends. Nevertheless, as research of financial constraints becomes more extensive in recent days, dividends payout policy is usually used as a

test for identifying how accurate a new measure is, rather than as a measure itself. One important reason is that dividend policy is not stable over time and across industry and has idiosyncratic characteristic. For example, some firms tend to pay out dividend stably for a positive signal to equity investors if they plan to issue seasoned equity offering (SEO) (Brav et al., 2005).

2.2.2.2.2 Credit rating and the existence of credit rating

Credit rating is the credit rating agencies' opinion on the credit issuer's ability and willingness to fulfil its financial obligations on time and in full. Commonly, AAA to C is used to represent the discrete risk classes. In measuring financial constraints, credit rating and existence of credit rating are distinct.

Whether a firm is rated on credit decides how the firm is able to access external finance. Theoretically, the information asymmetry between investors and firms is reduced due to the periodical disclose of the firm's rating reports and close monitor on firms from credit rating agencies. Therefore, firms with credit rating tend to be less financially constraint. Although credit rating is about debt, it is empirically found that equity investors also care about credit rating for the disclosed information in rating reports (Norden and Weber, 2004). However, the number of publicly credit-rated firms is limited although some of them are financially strong. The sole usage of existence of credit rating may not reflect the real financial constraints of those firms. Another weakness is that dividing firms into two categories, rated and unrated, may lead a problem of generalization, since most firms do not have credit rating and the findings may be not consistent across those firms.

Credit rating grade is also used as a measure of financial constraints. There are several advantages of relating credit rating grade with financial constraints except for less information asymmetry and adverse selection. It is empirically found that firms with better credit rating have better access to external funds (Boot et al., 2006; Hann et al., 2013). Additionally, lower rated firms are usually linked to default risks, which substantially decrease the firms' ability to raise outside funds (Datta et al., 1999). Moreover, better rated firms are allowed to issue more financial instruments, such as commercial papers, and they therefor have more access to financial market. Nevertheless, several

weaknesses worth mentioning. Firstly, credit rating tends to be not timely. There is empirical evidence that rating agencies respond new information slowly (Holthausen and Leftwich, 1986; Goh and Ederington, 1999; Steiner and Heinke, 2001; Hull et al., 2004; Norden and Weber, 2004; Finnerty et al., 2013). Also, the beginning status of a period is used to estimate financial constraints in some studies, which may lead to a misrepresentation. Secondly, rated firms are usually large, which means that small firms, which is substantially more than large firms, are out of sample and not proper to be generalized. Thirdly, as mentioned by Finnerty et al. (2013), in most research credit rating is empirically measured by specific financial instruments, such as bonds and commercial papers, however those measure do not represent the credit of the issuers. In other word, the rating level of the issuer and the financial instrument are different, and most studies may suffer from the weakness of misrepresentation of the real credit rating.

Besides credit rating agencies, bank-internal ratings and external credit risk assessments through financial service providers are claimed to be an appropriate measure of financial constraints. For example, several studies focus on a credit rating index from CeBi. CeBi (Centrale dei Bilanci, Ce-Bi-CERVED) is an Italian company owned by some major Italian banks. Bottazzi et al. (2014) argue that CeBi hold predominant reputation and is therefore regarded as an official credit rating agency in Italian financial markets. They use Cebi credit rating index as measure of financial constraints and find similar results in Hadlock and Pierce (2010), firm age and size is the dominant factors related to financial constraints. They highlight that credit ratings include firm's credit risk assessment, which is the ultimate determinant of allocating funds. Additionally, unlike credit rating agencies, CeBi credit ratings are available for extensively numerous firms and focus on the firm's overall creditworthiness. Panetta et al. (2009), Guiso et al. (2013), and Bottazzi et al. (2014) find similar results. Another example is Creditreform credit score. Creditreform is a German enquiry agency. Czarnitzki (2006) uses this score as classifier of financial constraints. His result suggests a weak relationship between financial constraints and R&D in German, though it is worth to note that his measure of financial constraints is robust under several tests. In terms of credit risk assessments, Garmaise (2008) exemplify this usage as measure of financial constraints. The rationale behind is that loan application rejection reflects financial constraints of small firms, which is strongly related to local bank concentration, the owner's home equity, net worth, and ethnic status, and the firm's credit score. He adopts the credit scores from Dun and Bradstreet. Rice

and Strahan (2010) also use Dun and Bradstreet credit scores to measure credit constraint and find that small firms tend to be more financially constrained than large, public firms. Although Gatchev et al. (2009) use similar method, further studies are yet limited. There exist several advantages of using bank-internal ratings and external credit risk assessments as measure of financial constraints in general. Firstly, bank-internal ratings and external credit risk assessments are more extensive than credit rating agencies for both public and private corporates, which provide more observations. Secondly, they reflect the whole financial status of a specific firm instead of a specific financial instrument.

2.2.2.2.3 Cash flow sensitivity

Fazzari et al. (1988) first introduce investment to cash-flow sensitivity as a measure of financial constraint. They argue that external funds are prohibitively high for financially constrained firms and internal funds are therefore main source for potential investment, while there is no such behaviour in financially unconstrained firms. In another word, constrained firms tend to use internal funds for investment, which means a high investment to cash-flow sensitivity, compared with unconstrained firms. Empirically, Fazzari et al. (1988) sample 422 U.S manufactory firms and classify them into financial constraint and financial unconstraint based on their dividend policy. They assume that constrained firms pay less dividends for keeping enough internal funds to finance future investment. They find that 49 of those firms with low dividend pay-out ratio have substantially high cash flow sensitivity to investment and conclude that investment to cash-flow sensitivity can be used to measure financial constraint. Several studies follow this method (Gilchrist and Himmelberg, 1995; Chapman et al., 1996; Hadlock, 1998; Bond et al., 2005; Guariglia, 2008).

However, this method is criticized by Kaplan and Zingales (1997), Opler et al. (1999) and Almeida et al. (2004) due to the possible misinterpretation of the low dividend pay-out ratio. It is highlighted that dividend pay-out ratio is impacted by idiosyncratic characteristics, such as focal firm's specific financial policy. Additionally, Kaplan and Zingales (1997) also criticize the implicit suggestion that dividend pay-out ratio is monotonically related to financial constraints and the ultimate measure. Kaplan and Zingales (1997) are reasonably persuasive, since they manually read

the financial reports and related public news of the 49 firms and find limited literal evidence of financial reports. Only 15% firm-years in the 49 firms investigated in Fazzari et al. (1988) are regarded as financial constraints in Kaplan and Zingales (1997). In the other 85% firm-years, firms are observed to be able to increase their investment substantially if they want. Nearly 40% of the sample firms increase investment every year in the sample period. They then categorize firm-years into five groups from "not financially constrained" to "definitely financially constrained" and find a non-monotonic relationship between financial constraints and investment-cash flow sensitivity. They therefore conclude that this non-monotonic relationship suggest that higher investment-cash flow sensitivity cannot be the evidence of being more financially constrained. Many further research support Kaplan and Zingales (1997) (Kadapakkam et al., 1998; Cleary, 1999; Almeida and Campello,2001; Cleary, 2006; Cleary et al., 2007; Dasgupta and Sengupta, 2007; Lyandres, 2007; Guariglia, 2008; Hovakimian, 2009; Hovakimian and Hovakimian, 2009).

The method used in Fazzari et al. (1988) is also criticized in two theoretical aspects. Firstly, the usage of Tobin's Q in the model may cause mismeasurement. Average Q is market value of an existing unit of capital to its replacement cost, and marginal Q is market value of an additional unit of capital to its replacement cost. The Tobin's conjecture uses marginal Q, but empirical research substitute average Q with marginal Q for simpleness in measure (Kaplan and Zingales, 1997; Hayashi, 1982; Gomes, 2001). Secondly, cash flow may contain information of future investment opportunities and therefore cause endogenous problem when measuring financial constraints (Erickson and Whited, 2000; Alti, 2003; Brown and Petersen, 2009; Chen and Chen, 2012).

Several attempts are made to avoid above mentioned weaknesses of investment-cash flow sensitivity. as an alternative way to measure financial constraints, Almeida et al. (2004) introduce the cash flow sensitivity of cash, namely, a firm's propensity to save cash out of cash inflows. The rationale behind is that financially constrained firms tend to save more cash from cash flow for future possible illiquidity compared with unconstrained firms, since unconstrained firms are able to collect capital from equity and debt market. It is claimed that this method avoids endogeneity problem and misrepresentation of Q, so the cash flow sensitivity of cash is better than investment-cash flow sensitivity on reflecting financial constraints. Further research supports this idea (Han and Qiu,2007; Lin, 2007; Denis and Sibilkov, 2010; Baum et al.,2011; López-Gracia and Francisco,

2015). However, the study from Pál and Ferrando (2010) do not agree with Almeida et al. (2004). They investigate euro area firms instead of US firms in Almeda et al. (2004) and find that unconstrained firms have the highest cash flow sensitivity of cash. Another contribution is made by Acharya et al. (2007), who introduce "hedging needs" into the allocation of cash flows across their cash and debt accounts. They highlight that financially constrained firms prefer saving cash instead of paying back debt if there tend to be investment opportunities in the states of low cash flow, namely, to be in "high hedging needs". The low correlation between cash flow and investment opportunities means "high hedging needs" and in contrast, high correlation means "low hedging needs". The theory predicts that financially constrained firms prefer higher cash to lower debt if investment opportunities tend to arrive in the states of low cash flow, but they prefer lower cash to higher debt if investment opportunities tend to arrive in the states of low cash flow.

2.2.2.2.4 Inelastic curve of cost supply

A firm with more inelastic supply of capital finds it more expensive to raise an additional unit of debt or equity, which is regarded as being more financially constrained. In an extreme case, the firms with vertical curve of supply of capital do not have credit rationing and are regarded as the most financially constrained. This method is exemplified by Stiglitz and Weiss (1981), Whited (1992), Almeida and Campello (2002), Whited and Wu (2006) and Andrén and Cociorva (2019).

Almeida and Campello (2002) attack a key assumption in previous literature, such as Kaplan and Zingales (1997) and Fazzari et al. (1988), which is that financial constraints only involve higher costs of external funds. They highlighted that in real world, financially constrained firms also face credit rationing. They consider two more factors in their theory, credit quantity constraints and endogenous amplification effects to explain the relationship between corporate investment and cash flow.

Whited (1992) and Whited and Wu (2006) disagree with the usage of Tobin's q in measuring financial constraints, since there is great deal of measurement error within Tobin's q, as investment opportunity. To overcome this problem, a structural model based on a standard intertemporal investment model is developed. They assume that being financially constrained influences the

shadow price of external capital and further the substitution of the current investment and the future investment. WW index is created to capture the shadow price of external fund, which is composed of cash flow to assets, a dummy capturing whether the firm pays a dividend, long-term debt to total assets, size, firm sales growth, and industry sales growth. The model directly estimates the shadow price of external finance, although the functional form of the model can be restricted.

Andrén and Cociorva (2019) investigated the credit rating as a measure to capture financial constraints. They highlighted that the rating process can reduce information asymmetry between investors and issuers and unrated firms are more likely to be rationed from external fund. Another motivation of using credit rating is that unrated firms are not shut out from the public financial intermediaries and thus have less external fund sources. However, a limitation is that firms can be private and only reveal information to specific qualified sources, like banks and they may not face financial constraints. In addition, the process of credit rating can be swayed by some scheming stakeholders and does not reflect the real informative situation of the firms.

2.2.2.2.5 Index

The development of KZ index is based the paper from Kaplan and Zingales (1997), which challenged Fazzari et al. (1988). They manually read the financial statement of the 49 financially constrained low-dividend firms in Fazzari et al. (1998) sample and find only 7 of them are not able to fund their desired investment. In addition, they find that in Fazzari et al. (1998), those firms that estimated to have the greatest cash flow sensitivities are those least financially constrained firms, based on their investigation into their financial statements.

Due to the implication that dividend and cash flow sensitivity might not reflect financial constraints, Kaplan and Zingales (1997) create their own measure. The fundamental idea is that financial constraints exert impact on firms' ability to obtain external finance, which could be represented by several accounting ratios. Previous literatures choose to select accounting ratios manually to represent financial constraints, however Kaplan and Zingales (1997) choose to select financially constrained firms manually and then use it as a label to find how accounting ratios are affected in financially constrained firms. The coefficients of those accounting ratios are further

used to identify financial constraints in out-of-sample. Using the 49 firms in Fazzari et. al (1988), the accounting ratios and respectively coefficients constitute KZ index, which including positive market-to-book, positive leverage, negative cash flow, negative dividends, and negative cash (Lamont et. al, 2001).

There are several drawbacks of KZ index. Firstly, financially constrained firms are manually selected by the author, which raises the problem of subjectivity and sampling problem. Secondly, the coefficients are regressed on 49 firms and further used to predict the out-of-sample. There is an implicit assumption that the corresponding coefficients are universally same through those two different groups, sample and out-of-sample, which is not sufficiently reasonable. Thirdly, without a very good fit, the non-linear regression used can be biased due to the problem of unobserved and omitted variables.

HP index updates KZ index, which is created by Hadlock and Pierce (2010). They randomly sample 10-K reports of 356 firms during the period from 1995 to 2004. The coefficients chose are negative size, positive size-squared and negative age. Although Hadlock and Pierce (2010) claim that HP index overcome the instability of coefficients in KZ index, it shares similar problems abovementioned in KZ index.

Whited and Wu (1996) adopt a structural model from Whited (1992) to calculate the shadow cost of equity finance. The idea is to estimate the reduced Euler equation models for related financial coefficients. WW index is composed of negative cash flow to assets, negative dummy variable if dividend is paid, positive long-term debt to assets, negative size, negative sales growth, and positive industry sales growth. Since this method is limited to its specific sample, researchers direct using of the Whited and Wu's reported coefficient on other sample may counter the bias of over-generalization.

2.2.2.2.6 Survey

Survey is a self-evaluating measure, which is to ask the firm whether they are difficult to access financial resource and other related questions, such as the firms' policies to overcome the limited

access to financial resource. Savignac (2008), Beck et al. (2008), Campello et al. (2010), Del Giovane et al. (2010), and Stucki (2014) conduct survey-based research, for example.

One of the main advantages is that survey studies on the best-informed agents, usually CFO or CEO. Another advantage is that survey can include small and young firms, which are often excluded in other measures due to the difficulty of access to their financial information. The main disadvantage is that survey involves subjectivity problem, due to self-evaluation. For example, although a CFO perceives the focal firm is financially constrained, it in fact has more ability to collect capital than many other firms reporting lower level of constraints.

2.2.2.2.7 Text-analysis

Text analysis is the process of automatically extracting machine-readable information from unstructured text. In the usage of text analysis on measure of financial constraints, researchers usually collect the financial reports of sampled corporates and apply natural language process techniques. Usually based on an algorithm trained from a sample of firms manually labelled with an index of how financially constrained they are, firms are classified into different categories.

There are several merits of using text-analysis technique in measuring financial constraints. One important advantage is its ability to extract the information in the large-size data that is traditionally not feasible for manual process due to the magnitude. For example, the samples in Kaplan and Zingales (1997) and Hadlock and Pierce (2010) are 49 and 356, and, as a comparison, the sample in Hoberg and Maksimovic (2015) is 44,441. Advocates of text-analysis claim as well that this technology does not suffer from human bias. Kaplan and Zingales (1997) and Hadlock and Pierce (2010) read manually the financial reports to identify financial constraints, however Hoberg and Maksimovic (2015) rely on machine-reading by an automated textual analysis based on a dictionary specifically selected for financial constraints, which reduces the involvement of human subjectivity. In addition, compared with classic measures, text-based measure suffers less bias of time changing. The classic measures of financial constraints are mostly based on accounting ratio, which seems to be unstable during long period, because time changes and the standard changes. Due to the rapidly changing dynamics of market style, firms with same accounting-ratio data may

be de facto classified into different categories in different times, because accounting-ratio measures do not capture the changes and still classify them into one category. It thus might not be reasonable to rely on a standard of accounting-ratio from too long period ago (for example, KZ index is created in 1997). Nevertheless, text-analysis relies on language, the style of which changes far less in formal financial reports, and therefore suffer less bias of time changing.

The detailed explanation of text-analysis can be found in the methodology part. This method is exemplified by Hoberg and Maksimovic (2015), Bodnaruk et al. (2015) and Buehlmaier and Whited (2018).

Hoberg and Maksimovic (2015) construct a dictionary to capture the essence of financial constraints in debt market, equity market and private placement. They highlight that financial constraints normally occur in firms that have good investment projects but struggle to find funding. As a result, they investigate how frequent managers states their inability in MD&A part to support their prospect projects. More frequent the managers demonstrate, more financially constrained the firm is. Their method is more advantageous than survey and random samples, since they do not suffer from the risk of generalizing small sample to the whole population.

Bodnaruk et al. (2015) use a similar approach of calculating the frequency. They calculate the frequency of the words that carry the meaning of financial constraints when used in financial reports. Although the words are manually selected and may carry human bias, they find their measure predicts events with characteristics of liquidity constraint, such as dividend omissions or increases, equity recycling, and underfunded pensions, which is better than widely used financial constraints indexes, KZ index, HP index and WW index.

Buehlmaier and Whited (2018) extend the study of Hoberg and Maksimovic (2015). They manually read Factiva database and selected 120 as training set for their logarithm. In addition, they use a similar method from Hoberg and Maksimovic (2015) to capture the inability of collecting capital from debt and equity market. Three indices are created to capture the access to equity markets, debt markets, and external financial markets in general. They find a higher return

within the category of financial constraints, which move together and cannot be explained by Fama and French (2015) factor model.

2.2.2.3 Neoclassical and evolutionary explanations of financial constraints

In this section, two theoretical perspectives, neoclassical and evolutionary, discuss the existence of financial constraints. The two streams diverge in answering the question whether current financial performance should have impact on investment. Neoclassical studies tend to support that there should be no impact, while evolutionary support the other. The following reviews the two streams.

2.2.2.3.1 Neoclassical explanations

Neoclassical perspective attributes financial constraints to information asymmetries. It is stated that firms' owners have better understanding of the value of investment opportunity than investors. The informational asymmetry between owners and investors creates a lemon problem. To avoid risk, investors claim higher cost of capital and thus a wedge between internal fund and external fund. Those firms facing high wedge are regarded as financially constrained. Constrained firms find the cost of access to external capital significantly high. Therefore, they rely on internal capital for future investment opportunities. However, the cost of external funds for financially unconstrained firms are lower. Sensitivity of cash flows to investment reflect this difference between constrained firms and unconstrained. Positive sensitivity means financial constraint, and negative sensitivity means financial unconstraint. However, cash-flow sensitivity approaches may lack consideration of manager's preference. Cash-flow sensitivity could arise when managers prefer to be independent from external finance or keep cash for future investment (Myers and Majluf, 1984).

Q theory can also explain financial constraint. Q theory claims that Q should be the only indicator for investment. It is presumed that value of investment is determined by future return and stock prices can accurately reflect future return. In other word, the value of investment opportunities is determined by the ratio of the market value of new additional investment goods to their

replacement cost (marginal Q). However, as defined, marginal Q is not observable, so empirically average Q (market value of assets divided by book value of assets) is used as a proxy under several assumptions, including perfect competition, perfect capital markets, and linear homogeneity of the (gross) production and adjustment cost functions (Hayashi, 1982). If further assuming firm aims to maximizing shareholder value and possess rational expectations, marginal Q summarizes all future information about investment and thus should be the only predictor for investment (Chirinko, 1993). Based on Q-Theory, a reduced form Euler equation model is used to identify financial constraints (Whited, 1992). Assuming perfect capital market, Euler equation model describes the optimal path of investment under consideration of parametric adjustment costs, which states that the marginal costs of investment in the present are set equal the future's marginal costs of foregone investment. The firms fail to verify the parameters is interpreted as being financially constrained. The main advantage of Euler equation model is that it does not require measure Q.

2.2.2.3.2 Evolutionary explanations

The basic view of evolutionary theory is that fit firms survive, and unfit firms die away. In other words, not all firms should grow. The fitness of a firms is reflected by its productivity relative to others. The limited resources should be allocated to the more productive firms. In contrast, the least productive firms should be shut down. As to the implication for financial constraints, it is argued that firms always want to grow and thus are always financially constrained.

Evolution theory also highlight the concept of 'bounded rationality', in the sense that future information is not accessible, and decisions are made only based on present information. So, it is reasonable to further claim that only highly productive firms can access financial resources due to their capacity to be persistently profitable in the past (Simon, 1991; Geroski and Jacquemin, 1988; Dosi, 2007; Coad, 2010).

However, it could happen that firms with right capacity but not sufficient capital for its promising projects die away, especially among small and young firms engaging in radical innovation, although the process is regarded as cleansing unfit firms in evolutionary theory. In this sense, how to balance fitness and innovation remain questionable within evolutionary theory.

2.2.2.4 The characteristics of the financially constrained firms

Previous literatures summarize several characteristics that financially constrained firms tend to have. First, small size is usually regarded as a typical characteristic of financially constrained firms (Carpenter and Petersen, 2002; Czarnitzki and Hottenrott, 2011; De Maeseneire and Claeys, 2012; Ullah, 2020). For example, using credit rating as measure of financial constraints, Czarnitzki and Hottenrott (2011) study the German manufacturing sector and find a positive relationship between firm size and external financial constraints. They further conjecture that small and young firms cannot generate sufficient profit or cash flow for supporting its R&D investments and therefor face internal financial constraints. From the perspective of external finance, investors tend to reject small firms as well, and possible reasons include information asymmetry, high stock price volatility and insufficient collateral (Carpenter and Petersen, 2002).

Second, financially constrained firms are usually in the initial stage of industry life cycle (Müller and Zimmermann, 2009; Zhao and Xiao, 2019; Huang et al., 2014). According to the life cycle theory, firms in different stages face different problems (Adizes, 2004). In the initial stage, firms tend to invest large and growth-oriented projects, while in the mature stage, firms tend to invest maintenance of the assets in place. In general, small and young firms are financed through private equity and debt, however large and mature firms through public markets (Richardson, 2006).

Third, firms with political connections are usually financially unconstrained. In China's capital market, credit supply and financial subsidies are more obtainable for firms with political connections. (Claessens et al., 2008; Poncet et al., 2010; Shen and Lin, 2016; Lin et al., 2017).
Shen and Lin (2015) find that financially constrained firms invest more when they have political connections to the ruling party. Cull et al. (2015) demonstrate that investment by non-state firms is highly sensitive to cash flow, while state-owned firms do not. They also find that large firms with weak political connections are especially financially constrained.

2.2.2.5 Empirical factors easing financial constraints

The empirical factors that can relieve financial constraints is widely studied. Researchers investigate the factors that may ease financial constraints from two respects, internal finance, and external finance. The meaning of internal and external refer to the financial sources generated inside and outside the firm. The results are collected in several empirical studies related to financial constraints. The factors in internal finance contain working capital, relationship with enterprise group and cash-flow related events, while external finance includes information disclosure, capital market improvements and inter-bank competition.

2.2.2.5.1 Internal finance

Firstly, good working capital management enable firms to alleviate internal financial constraints (Fazzari and Petersen, 1993). Ding et al. (2013) find that when facing adverse cash flow shocks, firms with high working capital in China invest the most due to the high liquidity provided by working capital. They conjecture that through effective working capital management Chinese firms maintain high fixed investment and growth rates.

Secondly, firms belonging to an enterprise group tend to have less problems with internal financial constraints due to the access to the in-group capital market (Billett and Mauer, 2003; Erel et al., 2015). As demonstrated in Erel et al. (2015), firms become less financially constraint after acquisition, especially among those small firms. It is further pointed that the in-group financial firms exert positive impact on easing the internal financial constraints.

Thirdly, another factor may influence internal financial constraints is the events hurting internal cash flow. For example, Campbell et al. (2021) find that as mandatory pension contributions increase, firms that already face greater external finance constraint tend to be more internally financially constrained. They further conclude that financial market frictions negatively influence corporate investment, which also is supported by Rauh (2006) and Almeida and Campello (2007).

2.2.2.5.2 External finance

Firstly, improvement in information disclosure alleviates external financial constraints (Diamond and Verrecchia, 1991; Botosan, 1997; Hribar and Jenkins, 2004; Dhaliwal et al., 2011; El Ghoul et al., 2011; Kim et al., 2016; Kim and Sohn, 2013; Cheng et al., 2014; Chan et al., 2017; Zhao and Xiao, 2019). Kim et al., (2012) point that managers concerning CSR disclosure are likely to be more ethical and therefore provide high-quality financial reports, which further prevents the firms from aggressive earning managements and potential financial constraints. In addition, it is believed that information disclosure is helpful to reducing information asymmetry and agency costs (Cheng et al., 2014).

Secondly, improvements in capital markets reduce the occurrence of external financial constraints. It is reported that domestic firms benefit from the capital supply from Foreign direct investment (FDI) (Harrison et al., 2004; Héricourt and Poncet, 2010). Foreign direct investment also helps private domestic firms bypass legal obstacles, sharing investment risk and absorb financial resources (Héricourt and Poncet, 2009; Henry, 2000; Chen and Luo, 2014). FDI is regarded as reducing information asymmetry between firms and financial institutions and therefore improve the allocation efficiency. Besides FDI, financial liberalization reform is reported as being helpful to restraining credit rationing and thus alleviating financial constraints as well, especially among small and young firms (Love, 2003; Laeven, 2003; Gelos and Werner, 2002; Ghosh, 2006; Chan et al., 2012).

Thirdly, inter-bank competition can exert positive influence on easing financial constraints. It is pointed that fierce inter-bank competition leads to lower interest rates and less borrower discouragement (Love and Martínez Pería, 2014; Ryan et al., 2014; Leon, 2015). While on the contrary, several studies highlight that bank competition is detrimental to financial access. It is reported that fierce competition restricted loan supply and higher lending rates, which leads to credit constraints among SME (Ratti et al., 2008; Carbo et al., 2009), because fierce competition deprives banks of the incentives to build lending relationship and investment in information acquisition techniques (Petersen and Rajan, 1995; Hauswald and Marquez, 2006).

Fourthly, the characteristics of management, such as CEO personality, education and work experience is closely related to the access to social resources and therefore financial constraint (Hu

and Liu, 2015; Muravyev et al., 2009; Gupta et al., 2020). For example, Hu and Liu (2015) investigate the relationship between CEOs' career experiences in corporate investment and financing decisions in China. They assume that diverse career experiences lead to more social connections and therefore less information asymmetry and easier access to external capital. They find diversely experienced CEOs in focal firms are related with lower investment-cash flow sensitivity.

2.2.3 Hypothesis development

Board interlock can affect financial constraint via two channels. Both effects are mixed. The first channel is information dissemination. The second channel is monitoring.

Board interlocks can affect financial constraint through information dissemination. On one hand, many studies report that board interlocks can transfer private information between insiders and outsiders, which can reduce information asymmetry between the focal firms and their potential capital providers. Lower Information asymmetry is helpful to decrease the cost of external funds and alleviate financial constraint. On the other hand, several research report that board interlock can enhance information asymmetry. The rationale is that although abiding by the promise of confidentiality, directors may spread sensitive information within a small group for personal benefits if the directors' risk of being revealed is low. Spreading private information within a small group could cause higher information asymmetry among investors. For example, Akbas et al. (2016) find that for better connected firms, sophisticated investors, such as short sellers, option traders and financial institutions are significantly more informed.

The second channel is monitoring. By better monitoring, agency costs can be lower, which is an important way to reduce financial constraint. On one hand, the knowledge of managerial practices and monitoring can transmit via board interlocks. Independent directors with more connectedness can acquire better ability of monitoring and avoid critical mistakes (Mizruchi, 1982). Board interlocks can thus reduce agency costs, which further decrease the risk of financial constraint. There is evidence that board interlocks are positively related to the spread of value-enhancing

corporate practices (Palmer et al., 1986; Haunschild, 1998; Gulati and Westphal, 1999). On the other hand, studies show that board interlock can impair the ability of monitoring. For example, directors sitting on multiple boards can be less effective monitoring due to busyness and thus adopt value-reducing practices (Fich and Shivdasani, 2006; Ahmed and Duellman, 2007). In addition, directors may incorrectly understand the information disseminated via board interlocks and thus misuse the information, which may further impair their ability of monitoring (Hann et al., 2019).

Overall, whether the board interlocks can relieve financial constraint is a priori unclear and there are two competing hypotheses.

H1: With more board interlocks, firms tend to be more financially constraints.
H2: With more board interlocks, firms tend to be less financially constraints.

2.3 Empirical design

2.3.1 Board interlock measure

Director information is from BoardEx database. A board interlock is defined as two firms share one independent director, or non-executive director. If two firms share one independent director, those two firms both have one more direct links. Following previous research (Freeman, 1979; Borgatti and Everett, 2006; Renneboog and Zhao, 2014), four measures of board interlock are used, including degree centrality, closeness centrality, eigenvector centrality, and betweenness centrality. Each measure is explained as flows.

Degree centrality is the number of direct links a firm in board interlock network. This is a basic and commonly used measure. For example, a firm linked to ten firms via their mutual independent directors will have a degree score of 10. However, degree centrality may not capture the positional advantage of a firm, because two firms with the same degree score can enjoy very different positional advantage when information spreading over the social network. The other three measure are adopted to capture those positional advantage.

Closeness centrality measures how quickly one firm can reach other firms, which considers both direct and indirect links a firm has. It is the number of the inverse of the average distance between one firm and another. For example, in a network where firm A is directly linked to firm B and firm B is directly linked to firm C. For firm A, it takes 1 step to firm B and 2 step to firm C, and therefore it takes 1.5 steps on average for firm A to all other firms in the network, which gives firm A closeness centrality 2/3 (the inverse of 1.5). For firm B, it takes 1 step to firm A and 1 step to firm C, so it takes 1 step on average for firm B to all other firms in the network, which gives firm B closeness centrality 1 (the inverse of 1). As can be seen from this example, information to firm B takes less steps than firm A, so information averagely reaches firm B quicklier than firm A and thus firm B has higher score of closeness centrality. The formula is:

$$C_c(v) = \frac{N-1}{\sum_{t=1}^{N-1} d(v,t)}$$

Cc(V) is the closeness centrality score of firm *v*, *d(v,t)* is shortest path distance from firm *v* to firm *t*. *N* is the number of total number of firms in the network.

Betweenness centrality measures the frequency of a firm being the intermediary between two other firms, which shows how often the firm is an information broker. Firms with higher betweenness centrality can spread its information more quickly since information more frequently pass through them. The formula is:

$$C_B(v) = \sum_{\substack{s \neq t \neq v \in V \\ s \neq v}} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

$C_B(v)$ is betweenness centrality score of firm *v*, which is the sum of its betweenness ratios. Betweenness ratio is defined as the number of shortest paths from firm *s* to firm *t* passing through firm *v*, divided by the number of shortest paths from firms *s* to firm *t*. This score is standardized by dividing the measure by the standard deviation of the Betweenness Centrality for each year.

Eigenvector centrality includes two aspects, degree centrality of focal firm and the degree centrality of firms connected to focal firm (Larcker et al., 2013). If focal firm establishes a new link to a firm with higher degree centrality, its eigenvector centrality increases higher. Those firms linked to well-connected firms usually has higher score of eigenvector centrality compared to those

not. Technically, firms with higher score of eigenvector centrality may spread information quicker due to its connections to well-connected firms. The formula is:

$$C_E(v) = \frac{1}{\lambda}\sum_{j=1}^{N} A_{v,j} C_E(j)$$

where λ is a constant (the largest eigenvalue of the adjacency matrix). $A_{v,j}$ is the adjacency matrix, which is 1 if there is a connection between firms v and j, and 0 otherwise. $C_E(j)$ is the eigenvector centrality of firm j. N is the number of total number of firms in the network.

All the four measures are standardized by dividing by the standard deviation of each measure for any given year and then divided into five quantiles in each year.

Finally, centrality is defined as the quantile ranking of the sum of the four centrality measures for capturing the overall interlock centrality of a firm. In addition, other centrality is defined as the quantile ranking of the sum of the three centrality measures (except degree) for robustness test.

2.3.2 Financial constraint measure

Naive Bayes algorithm is used to measure financial constraints based on text data. The standard processes of text-based methods include data collection, preprocess, pre-classification, classification, and training. First, relevant text data is collected from sources such as financial reports, news articles, and company filings. In my study, motivated by Hoberg and Maksimovic (2015), and Bodnaruk et al. (2015) and Buehlmaier and Whited (2018), the raw data is from 10-k reports, which is downloaded from the EDGAR database from the Securities and Exchange Commission (SEC). Text from "Management's Discussion and Analysis" (MD&A) section is extracted for each firm from 2008 to 2019. MD&A section contains the information of how the managers consider the firm's financial liquidity and the tactics adopted in financial market, which is required under SEC Regulation S-K. It is assumed that managers disclose the information of financial constraint in MD&A section and by using text-analysis, this information can be transformed to a score of financial constraint. Specifically, the firms that state more often that they

are financially constrained in MD&A are regarded as more financially constrained and the firms that less state as less financially constrained.

This foundational data is then preprocessed, which involves several steps. Tokenization refers to breaking the text into individual words (tokens), which helps in analyzing the text at a granular level. Stop words removal involves eliminating common words like “the” and “and” that do not carry significant meaning, thereby focusing on more important words. Stemming/Lemmatization reduces words to their base or root forms (e.g., “running” to “run”), ensuring consistency and improving analysis.

Once the data is prepared, the sample is split into training and testing sets. The training sample is consisted of the reports pre-classified as financially constrained and unconstrainted. Then a Naive Bayes classifier is trained on this training set. Additionally, I perform cross-validation to ensure the model’s robustness and to avoid overfitting. Cross-validation is a critical technique in machine learning and data analysis for evaluating model performance. By dividing the dataset into multiple parts and systematically training and testing the model, cross-validation ensures that the model performs well on unseen data, helps prevent overfitting, and aids in selecting and tuning the best model. This method provides a reliable and comprehensive assessment of a model’s ability to generalize to new data, making it an essential tool for developing robust and effective predictive models. Finally, the trained classifier is applied to the testing sets to measure financial constraints. The Naive Bayes classifier calculates the probability that a given instance belongs to each possible class. Specifically, reports in the testing sets are given a score, which essentially represents the probability of similarity between these reports and the training sample.

The main challenge lies in selecting the key features that indicate financial constraints, which is essentially the process of pre-classification. In current research, following the methodology established by Hoberg and Maksimovic (2015), specific wordlists that indicate delays in investment are utilized to pre-classify the sample data. The underlying assumption here is that if a firm is financially constrained, its managers are more likely to frequently mention delays in investment within the Management Discussion and Analysis (MD&A) section of their financial reports. These wordlists capture phrases and terms commonly associated with investment delays,

such as “postponed projects,” “deferred expenditures,” or “investment delays.” By identifying and analyzing the frequency and context of these terms, researchers can infer the financial constraints faced by the firm. This pre-classification step helps streamline the analysis by filtering the sample to focus on firms that exhibit signs of financial distress as evidenced by their reported investment delays. This approach leverages the narrative disclosures in MD&A sections, providing a nuanced understanding of a firm’s financial health beyond traditional quantitative measures.

The detailed processes of measuring financial constraints based on text-analysis is given as following.

2.3.2.1 Preprocessing

The first step is pre-processing, which aims to standardizing the text through reducing unnecessary noise in the text. Textual documents may contain noises including emotions, punctuation, text in a different case. After cleaning these noises, the textual documents are ready to feed data to the algorithm. I adopt several methods of pre-processing. All non-alphanumeric characters are deleted. All letters are converted to lowercase. All stop words are deleted (e.g., “am” or “and”). All reports are stemmed. In information retrieval systems, removing stop words can enhance the performance of search queries. It allows the system to focus on the important terms, thereby improving the precision and relevance of the search results. Stemming is the process of conflating related words through reducing inflected or derived words to their stem. Stemming enhances search performance. Users searching for “running” will also find documents containing “runs,” “ran,” or “runner,” increasing the recall of the search results. The abovementioned methods of pre-processing are all standard procedure in computational linguistics. Finally, words that do not occur in at least 99% of the MD&A statements are removed for saving computing power. Those words occur so infrequent that they are unsignificant for the textual analysis. This threshold of removing infrequent words follows Buehlmaier and Whited (2018). After pre-processing, financial reports are transformed into bags of words, disregarding grammar and word order. The only relevant information in the bags of words is how frequent each word appears.

2.3.2.2 Classification

The second step is classifying. Classification is the process of classifying textual documents into different categories, depending on the contents of textual documents. Following Buehlmaier and Whited (2018), I use naïve Bayes algorithm, which often outperforms more sophisticated alternatives, although it is one of the oldest tools in computational linguistics. The logic of naïve Bayes algorithm is relating the frequencies of words in a financial report to its status of financial constraint. In formulaic form, this is:

$$P(financially\ constrained) = f(w_1, w_2, \dots, w_n)$$

Where *P* is the probability measure, function *f* is the naïve Bayes algorithm, w_i is the frequency of word *i* appearing. If we know the function f and have a specific bag of words, we can determine the probability of a firm being financially constrained for a given year. This probability ranges from zero to one, with zero indicating no constraints and one indicating full constraints. The Naive Bayes classifier calculates the probability that a given instance belongs to each possible class. Specifically, reports in the testing sets are assigned a score that represents the probability of their similarity to the reports pre-classified as constraint in the training sample.

There are several motivations to implement naïve Bayes algorithm. It is the oldest, most established method. In addition, there is no researcher subjectivity involved in the process of measuring after the rules are set out. More usage of naïve Bayes algorithm can be found in Antweiler and Frank (2004), Das and Chen (2007), Li (2010), Jegadeesh and Wu (2013), Buehlmaier and Zechner (2013), Huang et al. (2014), Purda and Skillicorn (2015).

2.3.2.3 Training

Training is the third step, aiming to obtain the function f. Training is a process of constructing the algorithm using pre-classified samples. In current study, the pre-classified sample are samples that the statuses of financial constraints are known before training, which are also called training sample. In a small pre-classified sample within which the firm's status of financial constraint and its financial reports are known, then the function f is known. Then the function f can further predict

the status of financial constraint out-of-sample. This method provide reliable predictions as computational linguistics literature demonstrates (McCallum and Nigam, 1998; Rish, 2001; Zhang, 2005). For example, in its 2009 10-K report, Denbury Resources stated, "Although we remain interested in acquiring mature oil fields that we believe have potential as future tertiary flood candidates, with the general lack of liquidity in the capital markets, our ability to fund any significant acquisitions will be limited." The financial constraints score for Denbury Resources in 2009 is 0.967. This score indicates that, after classifying the 10-K report, the algorithm determined there is a 96.7% probability that the firm belongs to the sample of financially constrained companies.

For doing the training, pre-classified sample must be known, which is the main challenge. In next part I present the method adopted to pre-classify samples.

2.3.2.4 Pre-classification

There are primarily two directions of pre-classifying. Firstly, whether the firms in pre-classified sample are financially constrained is decided by human reading. For example, Buehlmaier and Whited (2018) searched Dow Jones Factiva database for identifying which firms are financially constrained through manually reading. However, the pre-classified samples generated from this method is under subjectivity. The authors' subjective recognition might not accurately reflect the real statuses of financial constraint in sample. Secondly, whether the firms in in pre-classified sample are financially constrained is decided by machine reading. For example, Hoberg and Maksimovic (2015) construct a wordlist that indicating delaying investments and issuance of equity. The logic is if a firm is unable to fund desired projects and must delay them, there will appear words referring delays around words referring projects. Then the whole sample are ranked based on how frequent the words combination of delays and projects appear. The top 250 firm-years are regarded as financially constrained, and the bottom 1000 firm-years as financially unconstrained. However, this method may not accurately reflect the real statuses of financial constraint as well because the wordlist may not contain all the accurate statements of financial constraint. In addition, the managers' style of using languages also influence this pre-classifier. For example, if the managers tend to state less frequent words combination of delays and projects,

according to this classification the firm therefore is regarded less financially constrained, although the firm can be experiencing a substantial one.

In current research, following Hoberg and Maksimovic (2015), wordlists containing delays of investment are used to pre-classify sample. The assumption behind is that if a firm is financially constrained, the managers tend to state more often about the delays of investment in the MD&A. The wordlists used are as follows:

delay list: delay, abandon, elimin, curtail, scale back, postpon

general investment list: construct, expans, acquisit, restructur, project, research, develop, explor, product, expenditur, manufactur, entri, renovat, growth, activ, capit improv, capit spend, capit proj, commerci releas, busi plan, transmitt deploy, open restaur

The words in wordlists are stemmed for improving search and retrieval. For instance, a firm might describe their financial constraints with phrases like "postponed the expansion" or "postponing the expansive plan." By stemming, these phrases are reduced to their root forms, "postpon" and "expans." This allows the search process to recognize both expressions as related to the concept of financial constraints, thereby improving the accuracy and comprehensiveness of the search results. This means that when a search is conducted for "postpon," it will match both "postponed" and "postponing," ensuring that all relevant documents are retrieved.

Specifically, to identify the financially constrained firms, I first search for the scenarios in all financial reports where the words from delay list appears within twelve-word distance from the words in general investment list. Then I count the frequency of the appearance for each financial report. Finally, the top 250 reports are pre-classified as financially constrained firms, and the bottom 1000 reports are pre-classified as financially unconstrained firms. It worth mentioning that the reason of using larger unconstrained training sample is that most firms appear to be unconstrained and the possibility of including constrained firms in the bottom 1000 reports are remote, which follows Buehlmaier and Whited (2018).

One of the common concerns in Naïve Bayes classification is overfitting. It occurs when a model performs exceptionally well on the training data but fails to generalize to new, unseen data. This happens because the model learns the noise and details in the training data to an excessive degree, which negatively impacts its performance on other datasets. Cross-validation is a statistical method used to deal with overfitting, which evaluates and improves the performance of the algorithm. It involves dividing a dataset into multiple subsets and systematically training and testing the model on these subsets. The primary aim of cross-validation is to ensure that the model generalizes well to new, unseen data rather than merely performing well on the training data.

Following Buehlmaier and Whited (2018), I perform a fivefold cross-validation, which divides the training sample into five parts and then estimate out of four to test on the fifth one.The first step in cross-validation is to prepare the dataset. This involves gathering the complete dataset, which includes both features (input variables) and labels (output variables). It is essential to randomly shuffle the dataset to ensure an even distribution and to prevent any order-related biases that could affect the model's performance. Specifically, the input data is the pre-classified samples, consisting of 250 firms pre-labeled as financial constraints and 1000 firms pre-labeled as financial unconstraints. Next, the dataset is divided into five equal parts or folds. Each fold should contain 250 random pre-classified firms of samples, and the folds should be mutually exclusive. This partitioning sets the stage for multiple iterations of training and validation.Then, for each of the five iterations, the model undergoes a cycle of training and testing, where 4 folds are used as the training set and the remaining one fold serves as the validation set. The model is trained on the training set using the selected algorithm and hyperparameters, and then evaluated on the validation set, with performance metrics of accuracy. This process is repeated five times, ensuring that each fold is used as the validation set once. By doing so, every data point is used for both training and validation, providing a comprehensive assessment of the model's performance. The results indicate that the naïve Bayes model correctly classifies 78% for financial constraint averagely, which is similar to Buehlmaier and Whited (2018) and means the model successfully predicts the majority of the sample.

2.3.3 Control variables

2.3.3.1 Investment opportunities

Firms with more investment opportunities may face more financial constraint because they need more funds to seize the investment opportunities. Tobin's *Q* is usually adopted to measure investment opportunities, but Tobin's *Q* may involve measurement errors regarding marginal investment opportunities (Erickson and Whited, 2000). Therefore, I use Tobin's *Q* and *sales growth* to proxy investment opportunities.

2.3.3.2 Board characteristics

For board-specific controls, *CEO chairman duality*, *CEO founder duality* and *board size* are included. Founders have privileged position in firm and therefore special impact on firm. Founder-CEOs may use the impact on the investment decisions and change the financial status. Following similar logic, CEO-chairman have more power on financial decisions. The variable of *ceo_chairman_duality* and *ceo_founder_duality* is 1 for firms with CEO-founders and CEO-Chairmans, and 0 otherwise. Board size is the number of board members. Board size may influence the board information environment (Guest, 2009). Better information environment could be helpful to mitigate financial constraint. Bigger board size increases the possibility of board's interaction with the outside and finding more opportunities to relieve financial constraint.

2.3.3.3 Firm characteristics

In terms of firm-level controls, it is reported that *firm size* and *firm age* are negatively related to financial constraint (Hadlock and Pierce, 2010). Thus, I control for the two variables.

2.3.4 Empirical specifications

To test the relationship between financial constraints and board interlock, the following regression model is used:

$$Financial\ Constraint_{\ it} = \beta_0 + \beta_1 Board\ Interlock_{\ it-1} + \boldsymbol{\beta} Controls_{it-1} + \varepsilon$$

Where *Financial Constraints* (*fc*) is the score given by the naïve Bayes algorithm, *Board Interlock* is the *centrality* score given by the social network analysis, Controls includes *Q*, *sales growth*, *board size*, *CEO-founder duality*, *CEO-chairman duality*, *firm size*, *firm age*. Industry dummy is added in the regression. All the explanatory variables are lagged by 1 year to mitigate endogeneity concerns. The dependent variable is financial constraints, and the main independent variable of interest is board interlock. The detailed definitions of these variables are presented in the Appendix A.

2.4 Sample and data

I have four data sources: BoardEx, Compustat, the Center for Research in Security Prices (CRSP), and the EDGAR database from the SEC. All the data are from 2008 to 2019. Reports for text-analysis are from EDGAR, and information of board interlock are from BoardEx. Then the data merged with accounting information from Compustat and CRSP.

Following Whited and Wu (2006), I adopt several exclusion criteria. Regulated firms with SIC between 4900 and 4999 are omitted. Financial firms with SIC between 6000 and 6999 are excluded. For eliminating coding errors, firms reporting smaller total debt than short-term debt are deleted, and firms undergoing a merger accounting for more than 15% book value of assets are deleted as well. Firms with negative total assets, book equity and sales are deleted. Then I match firms from the four databases according to Central Index Key (CIK). The final sample consists of 15,537 firm-year observations with 3,125 unique firms. All the continuous variables are winsorized at 99%.

Table 2-1 reports the summary statistics of the variables used in this study. Centrality is the quantile ranking of the four centrality measures. The mean is 2.56 and the median is 2.5.

Table 2-1 Summary statistics

This table presents summary statistics for all the variables used in current study. The centrality data are from BoardEx and financial constraint data are from Edgar database. The other data are from Compustat and CRSP. The data span is from 2008 to 2019. The final sample consists of 3,125 firms and comprises 15,528 observations. The data from above-mentioned sources are finally merged with the firm-level accounting variables. All continuous variables are winsorized at the 1st and 99th percentiles. The detailed definitions of all the variables are in appendix A.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
centrality	15,528	2.56	0.82	1.25	2.00	2.50	3.25	4.00
degree	15,528	2.57	1.07	1	2	3	4	4
closeness	15,528	2.32	1.06	1	1	2	3	4
betweenness	15,528	2.89	0.85	2	2	3	4	4
eigenvector	15,528	2.44	1.07	1	2	2	3	4
other_centrality	15,528	2.55	0.80	1.33	2.00	2.67	3.33	4.00
fc	15,528	0.13	0.33	0.00	0.00	0.00	0.00	1.00
firm_age	15,528	21.67	15.27	2	9	18	31	50
firm_size	15,528	7.00	1.91	1.28	5.69	7.05	8.33	11.23
Q	15,528	2.03	1.50	0.54	1.16	1.55	2.32	12.12
sales_growth	15,528	0.13	0.57	-0.74	-0.03	0.05	0.15	4.70
capital_expenditure	15,528	0.05	0.06	0.00	0.02	0.03	0.06	0.37
ceo_chairman_duality	15,528	0.39	0.49	0	0	0	1	1
ceo_founder_duality	15,528	0.001	0.02	0	0	0	0	1
board_size	15,528	8.68	2.08	2	7	9	10	19
kz	15,528	0.93	1.55	-6.74	0.19	0.95	1.73	5.56
ww	15,528	-0.33	0.11	-0.57	-0.41	-0.34	-0.26	0.04
sa	15,528	-3.63	0.67	-4.58	-4.18	-3.62	-3.17	-1.58
tangibility	15,528	0.49	0.19	0.10	0.36	0.48	0.58	0.97

Table 2-2 shows the summary statistics with stratification of constrained and unconstrained firms. My text-based measure indeed captures typical characteristics about financially constrained firms. The characteristics are closely consistent with previous text-based measures of financial constraint. Specifically, it is demonstrated that, compared with unconstrained firms, the constrained firms have lower cash flow and pay less dividends. In addition, they are smaller in size and have lower leverage. Usually, constrained firms are also associated with higher cash holding, higher research

and development intensity and higher Tobin's Q. All the differences between constrained and unconstrained firms are significant on 1% level.

Table 2-2 Firm characteristics and constraint variables

This table presents the mean and standard deviation of corporate characteristics in unconstrained and constrained firms. The difference and its significance between the two groups are report in the third column. $***p < 0.01$; $**p < 0.05$; $*p < 0.1$.

	Unconstraint	Constraint	Difference
firm_size	5.8619 (2.0526)	4.9222 (1.7693)	-0.9397***
Q	2.0978 (1.6145)	3.2948 (2.5284)	1.197***
leverage	0.1992 (0.2113)	0.1508 (0.2336)	-0.0484***
cash_holding	0.2086 (0.2077)	0.5139 (0.2820)	0.3053***
cash_flow	0.0328 (0.2036)	-0.1943 (0.3507)	-0.2271***
rd_to_sales	0.3591 (2.9349)	4.6015 (11.1485)	4.2424***
capital_expenditure	0.0447 (0.0464)	0.0343 (0.0452)	-0.0104***
dividend	0.0102 (0.0263)	0.0064 (0.0273)	-0.0038***

Table 2-3 shows the correlation matrix between text-based measure of financial constraint and other accounting-ratio based measures of financial constraint. The main finding is that the correlation between text-based measure, *fc*, and other measures are low. For example, the correlation between *fc* and *kz* index is only 1.7%. Among the correlation coefficients between fc and other accounting-based measure, the highest correlation coefficient is between fc and tangibility, which is 36.2%. The low correlation imply that text-based measure may capture more information. The findings of low correlation between text-based measure and accounting-based measures are consistent with Hoberg and Maksimovic (2015) and Bodnaruk (2015). It is also noted that fc is negatively related to firm size.

Table 2-3 Correlation Matrix

This table shows Pearson correlation coefficients between different measures of financial constraint, including the text-based measure, *fc*. Apart from *fc*, I also include accounting-ratio based measure of financial constraint, include *kz*, *ww*, *sa*, *tangibility*, and *firm size*. The detailed definitions are in Appendix A.

	fc	*kz*	*ww*	*sa*	*tangibility*	*firm_size*
fc	1	0.017	0.190	0.248	0.362	-0.184
kz	0.017	1	0.048	-0.018	-0.212	0.135
ww	0.190	0.048	1	0.715	0.456	-0.904
sa	0.248	-0.018	0.715	1	0.418	-0.728
tangibility	0.362	-0.212	0.456	0.418	1	-0.505
firm_size	-0.184	0.135	-0.904	-0.728	-0.505	1

2.5 Baseline results

Table 2-4 reports the results of baseline analysis. The dependent variable is financial constraint measure from text-analysis. The independent variables are lagged centrality measures and control variables. Column (1) and (2) present the effects of aggregate board interlock measure, *centrality* and *other centrality*, on the status of financial constraint. Column (3) to (6) reports the results of each individual measures of board interlock. All the six regressions include firm fixed effects, year fixed effects and control variables.

In column (1), the first measure is *centrality*, an aggregate measure that takes the average of all the four board centrality measures. *centrality* is negatively related to financial constraint. The coefficient is -0.013143, which implies the possibility of a firm falling into financial constraint at the top quantile of board interlock is 3.9429% (-0.013143*(4-1)) less than those in the bottom quantile, all else equal. In column (2), very similar results are reported in the measure of *other centrality*. The point is -0.013208. The effects are significantly different from 0 at the 1% level.

In column (3), I examine the effect of the quantile ranking of *degree* centrality on firm's financial constraint. The coefficient of *degree* is -0.006450. This result implies that being in bottom quantile of *degree* increase the probability of facing financial constraint by about 1.935 % (0.006450*(4-1)), all else equal. *degree* measures the firm's direct links with other firms by independent directors. The negative relation suggest that firm's better information environment remove the possibility of financial constraint.

In column (4), the second individual quantile ranking centrality is *betweenness*. The estimate implies that one level increase in *betweenness* centrality leads to a decrease in the possibility of financial constraint by 7.404%, holding constant control variables. *Betweenness* measure considers the how frequent a firm is an intermediary between other firms.

In column (5), I present the results of quantile ranking centrality of *closeness*. The interpretation is that, all else equal, the estimated reduction in possibility of financial constraint due to being in the top quantile of *closeness* is 5.4195% (0.018065*(4-1)), compared with the bottom quantile. Closeness centrality includes the effect of information spread speed.

In column (6), the final measure is *eigenvector*. The coefficient is -0.000877, which indicates that one level increase in *eigenvector* centrality leads to a loss of 0.0877% in possibility of financial constraint. However, the result is not significant or economically meaningful.

The findings of this study suggest a negative relationship between board interlocks and financial constraints, indicating that firms with higher levels of board interlocks tend to experience fewer financial constraints. This result supports the hypothesis that board interlocks can alleviate financial constraints through enhanced information dissemination and improved monitoring, although the exact mechanisms may be more nuanced than initially anticipated. However, there is not significant results when using accounting-based measures of financial constraint. The regression results are in Appendix B.

Board interlocks facilitate the transfer of private information between insiders and outsiders, potentially reducing information asymmetry between firms and their potential capital providers.

Lower information asymmetry can decrease the cost of external funds, as capital providers are better informed about the firm's operations and prospects, leading to more favorable financing conditions. This study's results align with this view, suggesting that the information shared through board interlocks indeed helps firms to secure external funding more effectively, thereby reducing financial constraints. On the other side, the concern that board interlocks could enhance information asymmetry, as directors might spread sensitive information within a small group for personal benefits, does not appear to be supported by our findings. While Akbas et al. (2016) and others have highlighted the potential for increased information asymmetry among general investors, the overall effect observed in this study indicates that the benefits of reduced information asymmetry for capital providers outweigh the potential drawbacks. This suggests that the information flow facilitated by board interlocks primarily aids in decreasing financial constraints rather than exacerbating them.

Effective monitoring is another critical mechanism through which board interlocks can influence financial constraints. By sharing knowledge of managerial practices and enhancing monitoring capabilities, board interlocks can help reduce agency costs. Independent directors with more connections can gain insights into better monitoring practices and avoid critical mistakes, thereby enhancing the overall governance of the firm. Current study suggests that the positive effects of enhanced monitoring through board interlocks prevail over the potential negative impacts. Previous studies have shown that directors sitting on multiple boards might become less effective due to busyness (Beasley, 1996; Klein, 1998; Core et al., 1999; Fich and Shivdasani, 2006; Ahmed and Duellman, 2007). However, the results of this study indicate that the enhanced monitoring capabilities and the spread of value-enhancing corporate practices through board interlocks (Palmer et al., 1986; Palmer et al., 1989; Haunschild, 1993; Gulati and Westphal, 1999) outweigh the potential downsides of director busyness. Moreover, while Hann et al. (2019) point out that directors might misuse information obtained through interlocks, leading to impaired monitoring, the overall evidence from this study suggests that the beneficial aspects of information sharing and improved monitoring practices dominate, resulting in reduced financial constraints.

The findings are also consistent with Hu and Liu (2015) which indicating that firms with managers' social connections are less constrained by limited capital. These connections reduce information

asymmetry and improve access to external funding. Their findings shows that firms led by CEOs with diverse career experiences have lower investment-cash flow sensitivity and utilize more external funds, including bank loans and trade credit.

The significant relationship between board interlock and financial constraints has important implications for corporate governance and management practices. Firms experiencing financial constraints might benefit from strategically enhancing their board interlocks. By doing so, they can leverage the diverse expertise, networks, and resources that interlocked directors bring. This strategic approach could improve firms' access to financing. For policymakers and regulators, the findings underscore the importance of considering the role of board interlocks in corporate governance frameworks. Policies that encourage transparency and accountability in board interlocks can help ensure that firms leverage these relationships more effectively.

Table 2-4 Baseline results

Table 2-4 reports the baseline results of board centrality on financial constraint using an OLS regression. The sample is from U.S. listed firms (excluding the financial firms) from 2008 to 2019. The dependent variables are all financial constraint score, which is calculated by the author. The main independent variable of interest is centrality. Centrality is the average of degree, betweenness, closeness and eigenvector. The detailed measurements of those variables can be found in section 3. The definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include year fixed effects and firm fixed effects. All variables are winsorized at both the 1% and 99% levels. Standard errors appear in parentheses.

	Dependent variable:					
	fc					
	(1)	(2)	(3)	(4)	(5)	(6)
centrality	-0.013143***					
	(0.004543)					
other_centrality		-0.013208***				
		(0.004835)				
degree			-0.006450**			
			(0.002751)			

betweenness				-0.007404***		
				(0.002836)		
closeness					-0.018065***	
					(0.005178)	
eigenvector						-0.000877
						(0.002950)
firm_age	0.000275	0.000327	0.000200	0.000390	0.000560	0.000261
	(0.002198)	(0.002198)	(0.002199)	(0.002199)	(0.002199)	(0.002200)
firm_size	-0.004587	-0.004608	-0.004613	-0.004818	-0.004605	-0.004672
	(0.005511)	(0.005512)	(0.005512)	(0.005512)	(0.005510)	(0.005515)
sales_growth	0.001192	0.001223	0.001111	0.001100	0.001344	0.001133
	(0.003332)	(0.003333)	(0.003333)	(0.003332)	(0.003332)	(0.003334)
Q	0.005560***	0.005569***	0.005581***	0.005577***	0.005560***	0.005627***
	(0.002095)	(0.002095)	(0.002095)	(0.002095)	(0.002094)	(0.002096)
ceo_chairman_duality	-0.003177	-0.003062	-0.003111	-0.003215	-0.002567	-0.002728
	(0.005668)	(0.005667)	(0.005669)	(0.005669)	(0.005664)	(0.005668)
ceo_founder_duality	0.023040	0.021641	0.021851	0.020653	0.020156	0.016941
	(0.159645)	(0.159649)	(0.159673)	(0.159652)	(0.159596)	(0.159713)
board_size	0.003545**	0.003451**	0.003482**	0.003541**	0.003190*	0.003158*
	(0.001745)	(0.001744)	(0.001746)	(0.001747)	(0.001740)	(0.001741)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,829	10,829	10,829	10,829	10,829	10,829
R^2	0.2528%	0.2419%	0.2182%	0.2341%	0.2985%	0.1531%
F Statistic (df = 8; 8284)	2.624373***	2.510696**	2.264379**	2.429801**	3.100576***	1.587536
Note:	*p**p***p<0.01					

2.6 Endogeneity concerns

The results imply a negative relation between board centrality and financial constraint. However, the coefficient may suffer from endogeneity problems, including omitted variable bias and reverse

causality issues. Omitted variables could cause the estimates biased. In addition, the direction of causality between financial constraint and board centrality may be reversed. It is possible that firms facing financial constraint tend to recruit independent directors with more connections for their advantage of information accessing. To test the robustness to endogeneity problems, I employ instrumental variable approach and difference-in-difference approach.

2.6.1 Instrumental variable approach

Suitable instrumental variables should satisfy the relevance and exclusion conditions. Relevance condition states that the instruments are correlated with the suspected endogenous variable. Exclusions condition states that the instruments do not affect the dependent variable. In this study, proper instruments should only affect the board centrality but have no effects on financial decisions.

Motivated by Amin et al. (2020), Faleye et al. (2014), and Intintoli et al. (2018), the first instrument is the fraction of independent directors who have elite MBA degree (*fraction_indep_mba*). Independent directors with elite MBA are linked with other alumni. Due to the elite program, it is arguable that they could have more opportunity to be invited as board members. From the perspective of firm boards, more fraction of independent directors with elite MBA implies more board connectedness. In addition, it is reasonable to argue that whether firm choose independent directors with elite program is unrelated with the future specific financial status. The second instrument is *sector_indep*, which is the average number of Fama-French 48 industries the independent directors in a board have worked for in the past. Board members worked in more industries are likely to establish more links with other board members. Moreover, factors influencing the previous work experience among independent directors are least likely to be related to the firm's future financial decisions.

Table 2-5 reports the regression results with *fraction_indep_mba* and *sector_indep* as instrumental variables. The regression included the same control variables in baseline analysis and industry, year fixed effects. Industries are defined by two-digit Standard Industrial Classification (SIC) codes.

Column (1) presents the first-stage regression results of *fraction_indep_mba* and *sector_indep* as instruments for board centrality. The dependent variable is board *centrality* and the independent variables include *sector_indep*, *fraction_indep_mba*, and the abovementioned controls. The estimates are 0.55 and 0.41 and both are significant at 1% level. The interpretation is that if all the independent directors have elite institute degree, the board centrality level is predicted to be higher by 0.55 quantile than the board with no elite-graduated independent directors. The estimate for *sector_indep* suggests that if there is an increase of average independent director's prior sector experience by one, the board centrality level increase by 0.41 quantile.

Column (2) presents the results of the second-stage regression. The estimates suggests that an increase in board centrality by one level reduces the possibility of financial constraint by 6%. The negative relation is significant at 1% level. This result is consistent with the results in baseline analysis, which support the hypothesis that board centrality influence negatively on firm's status of financial constraint. The instrumental estimation implies that the effect of board centrality cannot be explained by endogeneity problems.

Table 2-5 Instrumental variables regression results

Table 2-5 reports the results of two-stage least squares regressions using two instruments. The sample are from U.S. listed firms (excluding financial firms) from 2008 to 2019. The firm instrument is the fraction of independent directors who hold MBA degree from elite institution. The second instrument is the average number of Fama-French industries that the independent directors have worked for in the past. Column 1 shows the first-stage regression and Column 2 shows the second-stage regression. The independent variable of interest is centrality. Detailed definitions can be found in Appendix A. All the independent variables are lagged by 1 year. All regressions include year fixed effects and industry fixed effects. All variables are winsorized at both the 1% and 99% levels. Standard errors appear in parentheses. $***p < 0.01$; $**p < 0.05$; $*p < 0.1$.

	Dependent variable:	
	centrality	*fc*
fraction_indep_mba	0.55***	
	(0.12)	
sector_indep	0.41***	

	(0.01)	
centrality		-0.06***
		(0.01)
firm_age	-0.002***	-0.001***
	(0.0003)	(0.0002)
firm_size	0.08***	-0.01**
	(0.003)	(0.002)
sales_growth	0.01	0.03***
	(0.01)	(0.005)
Q	0.03***	0.03***
	(0.003)	(0.002)
ceo_chairman_duality	-0.07***	-0.01**
	(0.01)	(0.01)
ceo_founder_duality	0.65***	0.39***
	(0.17)	(0.09)
board_size	0.07***	0.01***
	(0.003)	(0.002)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Observations	15,537	10,829
R^2	0.39	0.41
Adjusted R^2	0.39	0.40
F Statistic	148.54*** (df = 66; 15459)	7,729.21***
Note:	*p**p***p<0.01	

2.6.2 Difference-in-differences analysis using independent directors' deaths

Board centrality may alter due to the death of independent directors, which could be used to test the direction of causality between board centrality and financial constraint. In this sector, I use independent director's death as an exogeneous shock to address the endogeneity problems. I first use propensity score to match the treatment sample, then I use difference-in-difference (DiD) approach to test the endogeneity concerns.

The independent director's death data is from BoardEx. DiD analysis requires the treatment group and control group to follow parallel trends. I use propensity score matching to find firms with parallel trends. Propensity score matching is a method to construct an artificial control group by matching each treated unit with a non-treated unit of similar characteristics, which tries to replicate a randomized controlled trail for experiments that is not ethically or logistically feasible to randomize.

Motivated by Intintoli et al. (2018) and Amin et al. (2020), I first identify the year when an independent director in a firm died. Then I categorize firms seeing independent directors' death as treatment group and firms with similar characteristics but not seeing the death as control group. For propensity score matching, I use the same variables in baseline analysis to find the control firms with similar characteristics, which include centrality, firm age, firm size, Tobin's Q, sales growth, CEO chairman duality, CEO founder duality, board size, year, and industry. Matching control group to treatment group in the year when the firm sees independent directors' death may lead to endogenous selection problem, so I match the control group and treatment group based on firm data one year prior to the death. The treatment and matched control firms are required to be in the same industry and year. Firms having the same first two digits of SIC are identified as in the same industry. Then all the firms in control group are given a propensity score based on abovementioned matching criteria using probit model. Those paired firms within a calliper of 0.01 according to nearest neighbour matching are treatment group and control group for DiD test. I find 295 firms seeing directors' death and all have matched control firms. Table 2-5 reports the balancing table prior the shock of independent directors' death for the 295 pairs of firms.

Table 2-6 balancing table for propensity score matching

Table 2-6 shows the balancing table of 295 pairs of firms prior the shock of independent directors' death. Using propensity score matching, control group consists of firms with similar characteristics but no shock. Standardized mean difference (SMD) is used to indicate the goodness of balance between treatment group and control group. A threshold of less than 0.1 for SMD is acceptable for the matched sample.

variables	Treatment group	Control group	SMD
centrality	2.66 (0.80)	2.64 (0.82)	0.025

firm_age	27.90 (14.96)	28.62 (15.29)	0.048
firm_size	7.68 (1.89)	7.72 (1.90)	0.021
sales_growth	0.04 (0.25)	0.07 (0.36)	0.079
Q	1.83 (1.06)	1.87 (1.29)	0.032
ceo_chairman_duality	0.42 (0.49)	0.45 (0.50)	0.062
ceo_founder_duality	0.00 (0.00)	0.00 (0.06)	0.082
board_size	9.20 (2.14)	9.39 (2.10)	0.091

SMD is the abbreviation of standardized mean difference, the difference in the means between treatment group and control group standardized by standard deviation of the covariate. SMDs close to zero indicate a good balance and that there are not major differences between the treatment and control groups. A threshold of less than 0.1 for SMD is acceptable for the matched sample. Table 2-5 demonstrates that all the covariates pass the threshold, which implies that the firms matched are in the parallel trend with the treatment group.

The matched pairs of treatment group and control group are further used in DiD test. Table 2-6 presents the regression results of the DiD test. Treat is a dummy variable, which equals 1 for treatment group, 0 for control group. Post is a dummy variable, which equals 1 for firms seeing independent director's death at any time, 0 for otherwise.

Table 2-7 Difference-in-differences analysis

Table 2-7 reports the results of Difference-in-differences regression. The shock is the death of independent director. The sample is the 295 pairs of firms, which are from propensity score matching. The dependent variable is financial constraint. The independent variable of interest is treat*post. Detailed definitions can be found in Appendix A. The regression includes year fixed effects and industry fixed effects. All variables are winsorized at both the 1% and 99% levels. Standard errors appear in parentheses. $***p < 0.01$; $**p < 0.05$; $*p < 0.1$.

	Dependent variable:
	fc
treat	0.040***
	(0.010)
post	-0.114***
	(0.039)
centrality	0.032***
	(0.008)
firm_age	-0.001***
	(0.0004)
firm_size	-0.014***
	(0.003)
sales_growth	0.040***
	(0.010)
Q	0.026***
	(0.004)
ceo_chairman_duality	-0.013
	(0.009)
ceo_founder_duality	0.499***
	(0.090)
board_size	-0.001
	(0.003)
	(0.066)
*treat*post*	0.096**
	(0.041)
Industry FE	Yes
Year FE	Yes
Observations	3,309
R^2	0.338
Adjusted R^2	0.324
F Statistic	27.606*** (df = 60; 3238)
Note:	*p**p***p<0.01

treat*post is the DiD indicator and indicates the effects from death of independent directors. The coefficient is significantly positive, implying that due to the death of independent directors, possibility of facing financial constraint increases. Overall, the findings suggest that the causality direction is from board interlock to financial constraint.

However, the endogenous factors cannot be completely ruled out, because only when including industry fixed effects in the model, the instrumental variables method and DiD analysis are significant. The significance does not appear when considering firm fixed effects. Therefore, the interpretation of causal direction between board interlocks and financial constraints needs caution.

2.7 Conclusion

This study delves into the relationship between board centrality and firms' financial constraints, employing an innovative text-based analysis to gauge financial constraint information. This method provides a nuanced measure of financial constraints, capturing the characteristics that firms traditionally exhibit when facing financial limitations. The analysis is based on an unbalanced panel of 15,537 firm-year observations from 3,125 unique firms spanning from 2008 to 2019. The findings reveal that firms with high board centrality tend to face fewer financial constraints, supporting the hypothesis that increased board interlocks mitigate financial constraints through enhanced information dissemination.

Board centrality refers to the extent to which a firm's board members are interlocked with other boards, creating a network of interconnected directors. This interconnectedness can facilitate the flow of information, resources, and strategic insights across firms. The study hypothesizes that higher board centrality should alleviate financial constraints, as firms can leverage the broader network to access critical financial resources and strategic guidance. The results of the study affirm this hypothesis. Firms with more central boards—those with directors who sit on multiple boards—experience lower levels of financial constraint. This finding is significant as it highlights the practical benefits of board interlocks, suggesting that such networks can provide firms with valuable opportunities to secure financing and manage financial challenges more effectively.

One of the key innovations of this study is the use of text-based analysis to measure financial constraints. Traditional measures often rely on financial ratios that may not fully capture the nuanced characteristics of financial constraints. The text-based analysis, however, extracts relevant information from firms' financial reports, offering a more comprehensive view of their financial status. This method enhances the accuracy of the financial constraint measure, providing deeper insights into the factors influencing a firm's financial health.

A significant concern in studies examining the relationship between board characteristics and firm outcomes is endogeneity—where causality between variables may be bidirectional or influenced by unobserved factors. To address this, the study employs two robust approaches: the instrumental variable approach and Difference-in-Differences analysis. The consistent results from these two analyses reinforce the conclusion that board centrality reduces financial constraints.

3. Board expertise and financial constraints

3.1 Introduction

There has been a growing recognition that manager-specific attributes can affect the firm's actions. One of the attributes is directors' previous experience, i.e. board expertise. A survey highlights that 47% of directors consider industry experience to be the most desired characteristic for board's success (Society of Corporate Secretaries and Governance Professionals and Deloitte Development LLC, 2012). Many firms also affirm the importance of industry experience for board recruitment (Coca-Cola Co., 2011; Hewlett-Packard, 2011; PricewaterhouseCoopers LLP, 2012; Society of Corporate Secretaries and Governance Professionals and Deloitte Development LLC, 2014; NYSE, 2016). In academics, previous literature mainly focuses on the effect of board industry experience on governance and firm value. For example, directors with previous industry experience are reported to have broaden knowledge, decision-making capacity, and information sources, which further improves the information environment and enhances firm value (Masulis et al., 2012; Faleye et al., 2014; Von Meyerinck et al., 2016). A strand of studies focuses on the effect of industry experts on corporate governance. Work experience in upstream and downstream industry helps directors shrink information gap between managements and boards and further improve the ability of monitoring (Dass et al., 2014). In addition, board expertise exerts positive effects on advising (Cohen et al., 2014; Wang et al., 2015; Bradley et al.,2017; Wang, 2017; Meng and Tian, 2020). However, less attention has been paid to the financial effect of board expertise. This study extends the literature by investigating the role of board expertise on financial constraints.

In a perfect market, there is no financial constraints, since the costs of external funds and internal funds are equal (Modigliani and Miller, 1958). However, due to the imperfection in financial market, firms practically face higher cost of external funds (Fazzari and Athey, 1987; Kaplan and Zingales, 1997) and are therefore unable to invest their desired projects (Bodnaruk et al., 2015; Hoberg and Maksimovic, 2015; Buehlmaier and Whited, 2018). When dealing with financial constraints effective boards play pivotal role, because boards bear the ultimate responsibility of channelling the information between the outside and the inside for collecting funds. Industry experts can reduce the cost of this channelling through providing deeper understanding of the

environment uncertainty and industry trends, due to accumulation of previous work experience and knowledge (Oehmichen et al., 2017). In addition, the social connections built upon previous work experience increase information exchange between firms and investors and therefore can reduce information asymmetry and financial constraints (Bradley et al., 2017). Furthermore, the combination of better information environments and social connectedness bring boards more chances of learning industry-specific governance experience and improve the boards' ability of monitoring and advising, which can increase the confidence among investors and therefore lower the cost of lending (Wang et al., 2015). Thus, firms could become less financially constrained and invest scheduled projects.

Nevertheless, more industry expertise can also exacerbate the status of financial constraints. First, due to previous work experience, industry experts in boards may show excessive tolerance for monitoring (Faleye et al., 2018), which could increase the cost of supervising for investors. Firms thus cost more on external finance and face more risk of financial constraints. Second, high proportion of industry experts in boards may decrease diversity and further negatively impact governance (Dass et al., 2014). Second market may negatively react to the appointments of industry experts and raise the cost of external funds. Firms could then fall into financial constraints and be unable to fund the wished-for investments.

To empirically investigate the effect of board expertise on financial constraints, I use a sample of U.S. listed firms, including 11,638 firm-year observations for 2,389 listed firms in U.S. between 2008 and 2019. I collect the data of director's employment history from BoardEx. Industry experts are independent directors who have previously worked in the same industry. Firms share the firms two digits of standard industrial classification (SIC) are defined in the same industry. Then I construct three measures of board expertise, including board_industry_expertise_number (the number of industry experts in board), board_industry_expertise_percent (the fraction of industry experts to independent directors) and board_industry_expertise (a dummy variable which equals 1 if there is any industry expert in board, 0 otherwise).

Motivated by Bodnaruk et al. (2015), Hoberg and Maksimovic (2015) and Buehlmaier and Whited (2018), I construct a financial constraint index based on the related information in financial reports.

I crawled 10-k reports from Edgar Database during the period between 2008 to 2019. The fundamental assumption is that financially constrained firms have obligation to report its difficulty of collecting funds and delay of investing projects. Related text information can be further transformed into index of financial constraints.

I start the baseline analysis with a fixed effects model on an unbalanced panel. I control for the firm-specific, board-specific, CEO-specific characteristics, industry fixed effects, and year fixed effects. The results show that the coefficients of the three measures of board expertise are positively significant, suggesting that with more industry experts in board, firms are more financially constrained. The results seem to support the hypothesis that board expertise increase the cost of assessing and supervising for investors. However, a possible explanation is that firms may perceive the approaching financial constraints and hire industry experts ahead to relieve it. In other words, causality may be the reverse, and the anticipation of future financial constraints may determine the choice of board recruitments. To address this concern, I regress financial constraints on the third lag of board expertise and controls. The coefficients of board_industry_expertise_number and board_industry_expertise_percent remain significantly positive, implying that the results may not involve reverse causality problems. In addition of reverse causality test, I use alternative measures of financial constraints for robustness test. The results basically support the hypothesis that board expertise increase financial constraints.

The results seem to have practical implication that board expertise causes more risk of financial constraints, but this is kind of against instinct, since industry expertise is regarded an important component for the business success among firms and studies (Coca-Cola Co., 2011; Hewlett-Packard, 2011; PricewaterhouseCoopers LLP, 2012; Society of Corporate Secretaries and Governance Professionals and Deloitte Development LLC, 2014; Cohen et al., 2014; Wang et al., 2015; NYSE, 2016; Drobetza et al., 2018; Falaye et al., 2018; Chen, 2020). One explanation for the positive effect could be that firms with ambition of extending may hire more industry experts for their industry-specific knowledge and social connectedness. in the meantime, the ambition of extending creates urgent capital demands, which further increases its cost of borrowing. As required by shareholders, the focal firms then reveal its capital demands and possible project delays in financial reports, which finally manifests itself in being more financially constrained. However,

if the focal firms are able to assess the business environment and project feasibility reasonably, they may not have such ambition and avoid capital constraints. In other word, ambition could be a key point for financial constraints. Some empirical studies support this conjecture. R&D investment could be a signal for firm ambition, since firms with ambition tend to invest more on R&D nowadays for future success. Drobetza et al. (2018) and Faleye et al. (2018) both find that firms with more industry expertise tend to invest more in R&D, and as indicated by Santos and Cincera (2021), being an innovative firm increases the risk of financial constraints. However, I leave the question whether ambition causes more industry expertise and financial constraints to future research.

This paper contributes to the strand of literature investigating the effects of boards expertise and corporate financial decisions and governance. For instance, Masulisa et al. (2012) demonstrate a positive correlation between board expertise and firm performance. Firms with more industry experts tend to have less earnings restatements and more cash holdings. They also find that stock market value industry experts appointments at a premium. Faleye et al. (2018) finds with more industry expertise, firms tend to use less R&D-based real earnings management and invest more in R&D, which further enhances firm value. Von Meyerinck et al. (2016) finds a positive market reaction to the announcement of a new industry expert appointment. Chen (2020) shows that financial industry expertise in bank improves performance and reduces risk-taking after forced CEO turnovers, possibly due to being more effective on monitoring and advising. Drobetza et al. (2018) shows that with more industry expertise, firms are valued higher, and this result passes a quasi-experience based on director death. They further document that the positive relation is more pronounced for firms with larger R&D investment, larger cash reserves, and facing more difficult decisions when facing shocks, while less pronounced for firms with high sales growth.

This paper differs from previous literature in two aspects. Firstly, I study the relationship between board expertise and financial constraints, which is the first one to my best knowledge. I find that there is a significantly negative correlation between board expertise and financial constraints, which passes several robustness tests. Secondly, I use text-based measure of financial constraints, which may be more precise compared with accounting-ratio based measures.

The rest of the paper is organized as follows. Section 3.2 is literature review and development of hypothesis. Section 3.3 describes the construction of variables and research design. Section 3.4 provides the baseline results. Section 3.5 deals with endogeneity problems. Section 3.6 concludes.

3.2 Literature review

3.2.1 Theoretical backgrounds of boards

There are several theories of explaining the impact of boards on firm governance, mainly including agency theory, stewardship theory, resources dependence theory. Although some recent researchers appeal to integrate these theories (Hillman and Dalziel, 2003; Hoskisson et al., 2013), for the sake of clearness, this section reviews these three perspectives respectively.

3.2.1.1 Agency theory

Agency theory concentrates on the costs of conflict between management and ownership, which fundamentally assumes that agents are self-serving. According to Jensen and Meckling (1976), agent is the one who represents the principals to perform day-to-day transactions. In agency relationship, the principals transfer part of the decision-making authority to the agents. In corporate governance, the managers are agents and owners are principals. Agency theory highlight the pursuit of self-interests in managements at the expense of shareholders, which thus increases the transaction costs within firms, including costs of monitoring, contracts designment, sub-optimal decisions (Fama and Jensen, 1983). Agency problem can also arise between large shareholders and small shareholders, since large shareholders usually have more resources of controlling firm governance and may further make use of the advantage to exploit small shareholders.

Due to the mechanism of agent relationship, although it is not theoretically possible to eliminate all the cost of agency problem, there are several ways to mitigate it and align the interest to greater extent between agents and principals, including board structure and incentive scheme (Jensen and Meckling, 1976). The perspective of board structure usually emphasizes the importance of board

size, insiders versus outsiders (also known as executive and non-executive directors), gender ratio etc. Incentive scheme highlights the usage of contracts to align the interests between different entities to the greatest extent.

3.2.1.2 Stewardship theory

Stewardship theory focuses on the cooperation between managements and ownership. The theory posits that managers chase recognition from society and can act as good stewards to owners to maximize shareholders' utilities. As managers, the motivations of being good stewards could be "a need to achieve, to gain intrinsic satisfaction through successfully performing inherently challenging work, to exercise responsibility and authority "(Donaldson and Davis, 1991). Steward theory emphasize that driven by non-financial pursuit, managers are trustworthy and therefore could act in line with the profit of shareholders.

The proponents of stewardship theory further bring forward several inferences about firm governance. For example, they argue that the majorities of insiders are related to better firm performance, because insiders have more experience and knowledge about the firm and industry than outsiders, so they could thus make better decisions (Donaldson, 1990). In addition, due to similar reasons, stewardship theory also supports more power should be delegated to professional managers for maximizing the profits and improving decision-making process. Moreover, unification of chairman and CEO can be theoretically favoured due to the less interference in the concentration of power (Davis et al., 1997).

3.2.1.3 Resource dependence theory

Resource dependence theory concentrates on the interaction between firms and their environments. As stated in Pfeffer and Salancik (2003), "to understand the behaviour of an organization you must understand the context of that behaviour—that is, the ecology of the organization." Form perspective of resource dependence theory, the environments are continuously and ultimately uncertain and firms must utilize all the resources to overcome the uncertainty. In this process,

boards serve as links to essential resources for better firm performance, which include but not limited to information, knowledge, capabilities, capital, social capital etc.

Empirically, there is ample evidence documents the role of boards as resources providers. For example, directors with more social connections are found to be better monitors (Pugliese et al., 2014), because relying on their human capital, they can access more information about the vulnerabilities in governance. In addition, Faleye et al. (2018) find the directors' previous work experience affects firm' innovation input. The number of directors having prior experience in the same industry (i.e., experts) is positively related to R&D investment and further to firm value. A reason could be that their previous work experience enhances the ability to distinguish the risk and reward in the focal industry. They also find that firms in industry in which non-experts find difficulties in monitoring and advising tend to hire more experts. Moreover, depending on the firms' relative resources, power imbalance, ownership concentration, and CEO ownership, the connections to outside boards (i.e. board interlocks) are related to firm future performance (Zona et al., 2018).

3.2.2 Impacts of Board expertise

Board Industry experts are the independent directors who have worked for another firm in the same industry as the focal firm. Several reports highlight the prominent position of industry expertise in board member recruitment (Coca-Cola Co., 2011; Hewlett-Packard, 2011; PricewaterhouseCoopers LLP, 2012; Society of Corporate Secretaries and Governance Professionals and Deloitte Development LLC, 2014; NYSE, 2016). Due to their superior knowledge and experience than non-expertise, board industry expertise is seen as valuable resource in the process of evaluating investment opportunities and uncertain environments. Board industry expertise may have several impacts on firm, including information superiority, corporate governance, and value-enhancing. What worth mentioning is that these three aspects are not fundamentally exclusive. For example, Information superiority may increase the directors' ability of governance and thus increase focal firm value. However, for detailedness, the remains of this section review them respectively.

3.2.2.1 Information superiority

Several studies report the information superiority of independent directors of industry expertise (Masulis et al., 2012; Dass et al., 2014; Faleye et al., 2014; Oehmichen et al., 2017). As agency theory stated, there is an intrinsic conflict between monitoring and being monitored. Due to the pursuit of self-interests, the managers have a propensity to not fully reveal the information to the independent directors. However, the board's main functions are to monitor and advise managements. With better access to information, boards could be more effective on these functions (Adams and Ferreira, 2007; Harris and Raviv,2008). Independent directors with more industry experience are expected to have more information, since their experience in relevant firms could lower information cost and improve information quality, which can further provide greater recognition about overcoming potential uncertainty, anticipating industry opportunities, and preparing for demand or supply shock (Wang, 2017; Drobetz et al., 2018; Faleye et al., 2018). In addition, except the information superiority from self-experience, industry expertise may acquire information from their social connections from previous experience. The excessive exposure to industry dynamics enables industry experts to obtain information faster. Moreover, according to Faleye et al. (2018), source credibility theory implies that advice from perceived experts is more likely to be accepted in board. As a result, more industry expertise in board may increase the information exchange between outside directors and the executives, which additionally enhance the informational advantage of industry expertise. From the perspective of empirical study, Dass et al. (2013) report that industry experts bridge the information gap between boards and managers. They also find for firms facing severe information problem, industry experts are more preferred and exerts significantly positive impacts on firm performance and firm value. Similarly, Nanda and Onal (2016) find a director expertise has informational advantage on product-market prospects. Using abnormal returns earned from focal firm's trade by independent directors as proxy for information they retain, they find industry expertise have significantly more information than non-expertise.

Nevertheless, studies simultaneously hint that industry expertise may not be necessarily equipped with informational superiority (Dass et al., 2014; Drobetza et al., 2018; Faleye et al., 2018). Being superfluously familiar with the industry norms, expert directors may therefore be less acutely

sensitive to industry dynamics and subtle investment opportunities in intensively innovative and ground-breaking fields, compared with non-experts. In other word, the informational advantage does not necessarily translate into informational superiority in all aspects. In addition, Faleye et al. (2018) further points that having high proportion of industry experts in board may relate to this narrow vision. One of underlying reason is the lack of diversity. The similarity shared among the industry experts could impede the generation of alternative opinions. Moreover, the independent directors primarily bear responsibility of monitoring and advising, while the top executives bear that of strategy-forming and execution. Compared with the top executives, the industry experts of independent directors may lack of specific business operations and thus not be able to provide extra help in information mining.

3.2.2.2 Corporate governance

Many researchers summarize that in the system of corporate governance, the board of independent directors mainly performs two roles, monitor and advisor (Adams and Ferreira, 2007; Harris and Raviv, 2008; Adams et al., 2010). In general, industry expertise in boards can influence the functioning of boards, but the evidence of effectiveness is mixed.

Industry experts are expected to be more capable in monitoring and advising, because their previous industry experience enables them to better forecast the industry-specific uncertainty, analyse highly relevant information and evaluate the decision-making process (Cohen et al., 2014; Wang et al., 2015; Bradley et al., 2017; Oehmichen et al., 2017). Previous industry experience helps the experts build industry network ties, which enables focal boards to retrieve trustworthy, industry-specific information (Kor and Sundaramurthy, 2009). In practice, practitioners confirm the importance of industry experience. For example, Wang et al. (2015) document that Citigroup announced adding directors with expertise in finance and investment after a significant loss. Similarly, Coca-Cola Co. (2011) highlight board members should have “Extensive knowledge of the Company’s business, industry or manufacturing”. Empirically, Cohen et al. (2014) find more industry expertise is related to higher financial report quality, which suggests improvements of monitoring the financial reporting process. Wang et al. (2015) find evidence that having industry expertise in boards increases the ability of monitoring. Faleye et al. (2018) implies that industry

experts are more needed in firms that are difficult to monitor and advise for non-experts. In financial department, Chen (2020) finds that financial industry expertise on boards increases the possibility of CEO turnover and outsider succession in banks, which later enhances bank performance and decrease risk-taking behaviours. The author gives the credit to industry expertise for better monitoring and advising.

Nevertheless, some studies imply that the previous working experience may hinder the effectiveness of board monitoring (Wang et al., 2015; Ellis et al. 2018; Chen, 2020). Industry experts are in the social cycle within the industry due to the previous working experience, which could negatively impact the separation between independent directors and managers. The separation is arguably necessary for effective monitoring and advising, according to agency theory. In addition, with the similar experience, industry experts may show more sympathy to managers and therefore become more tolerant in monitoring. Moreover, according to Faleye et al. (2018), the similarity of industry backgrounds may hinder the quality of group decision-making process, due to the pressure of conformity. Industry experts in boards may thus be unable to provide effective advice. Empirically, Ellis et al. (2018) infers that in diversified firms, industry experts are not impartial advisor, because they lack effective monitoring in their familiar industry, or lack effective advising in their unfamiliar industry.

3.2.2.3 Firm value

Theoretically, the impact of board industry expertise on firm value is mixed. On one hand, the effect could be positive. it is arguable that the board directors ultimately assume the responsibility for the firm performance and thereof firm value through advising and monitoring. Previous literature shows that for effective governance and stronger firm performance, directors should retrieve more relevant information about focal firm and focal industry (Harris and Raviv, 2008; Adams and Ferreira, 2007). Benefiting from previous industry experience, board industry experts are expected to be equipped with more information conduits and ability of related decision-making, which further enhances the board effectiveness and thus firm value. In addition, the secondary market may react positively to the appointments of industry expertise based on abovementioned rationale and thus enhance firm market value as well. According to this rationale, firms with more

fraction of industry experts are supposed to be valued at a premium compared with those less. Several empirical studies support the positive effect of industry expertise. Drobetza et al. (2018) find, for example, that there is a significantly positive association between board industry expertise and firm value. The positivity is more pronounced for firms with larger investment programs, larger cash reserves, and during crises, and less for firms with high sales growth, R&D expenditures, merger activities, competitive threat, and product market changes. Faleye et al. (2018) find board industry expertise increases R&D investments, lower volatility of future earnings, and firm value. Von Meyerinck et al. (2016) find that the market reacts positively to the appointments with industry expert directors. The firms appointing expert directors enjoy an average of 0.4% more announce returns.

On the other hand, theoretically there could be negative effect of industry expertise on firm value. Due to deeply intimate familiarity with the industry, industry experts may be unable to distinguish some cutting-edge and ground-breaking investment opportunities, which may be detrimental to the development of the firms and thus firm value. Furthermore, having more industry experts do not necessarily exert positive effects on corporate daily governance and firm value. It is suggested that the top executives are responsible to daily company management, while industry experts do not, which implies that industry experts may not provide additional help for the governance. Moreover, with too high fraction of industry experts, the board could be unable to maintain essential diversity and thus hinder the alternatives of decision-making. What worth pointing here is that the disadvantages of having industry experts may disappoint the second market and lead to lower firm market value. However, to the best of my knowledge, there is no empirical study reporting clear negative impact of industry experts on firm value.

3.2.3 Hypothesis development

In this section, I first briefly review the causes of financial constraints, and then specify how to develop the hypothesis between industry expertise and financial constraints.

According to the literature in chapter 1, there are several theoretical causes of financial constraints, including information asymmetry, agency problems and market imperfection. The first factor is

information asymmetry. Information asymmetry occurs when one party has more information than another. In corporate finance, information asymmetry can lead to financial constraints if investors do not have access to sufficient information about a company's financial condition. This can make it difficult for the company to access capital, as investors may be wary of investing without complete information. Secondly, agency problems occur when the interests of managers and owners are not aligned. In the context of financial constraints, agency problems can arise if managers use company resources for their own benefit, rather than to generate returns for shareholders. This can lead to financial constraints if the company's financial performance suffers, reducing its ability to access capital. Another factor is market imperfections. Market imperfections, such as barriers to entry or informational inefficiencies, can lead to financial constraints. For example, if a company operates in an industry with high barriers to entry, it may be difficult for the company to access capital, as potential investors may be wary of entering a market that is difficult to compete in.

I develop two competing hypotheses based on the related literature. The first hypothesis predicts that board industry expertise could mitigate financial constraints. Firstly, industry experts could lower agency problem. According to the assumption of agency problem, the pursuit of self-interests in managements lead to strong incentives to conduct opportunistic behaviours, including sub-optimal decisions-makings, financial frauds, and earning's managements (Sarto and Saggese, 2022). Industry experts are equipped with information superiority due to their previous work experience, which enable them to make more informed decisions based on their understanding of the trends, challenges, and opportunities that non-experts do not have (Faleye et al., 2018). The boards with more industry experts are thus more effective on monitoring above-mentioned misconducts and involve in less agency problem between shareholders and managers. According to Gertler (1992), reducing agency problems could lower the costs of investors' supervision. Firms with more industry experts can therefore collect external capital in lower price and promote desired investment. They face less risk of financial constraints.

Secondly, the increase of industry expertise improves information asymmetry. Relying on previous work experience, experts build up their industry network ties, which enables them to increase the exchange of information with outside (Faleye et al., 2018). In addition, industry experts are

expected to have deeper understanding of the risk and trends, which helps firms improve information environments (Meng and Tian, 2020). According to Myers and Majluf (1984), lowering information asymmetry can decrease the cost of assessments for investors and thus the cost of capital for firms. The external financing cost of capital decrease for firms with more industry experts, and the risk of financial constraints is reduced.

H1: Higher board industry expertise relieves financial constraints.

The second hypothesis conjectures that with higher board industry expertise, financial constraints become more stringent. Experts' previous industry experience could negatively impact the separation between independent directors and managers, since the social connections built upon which can cause industry experts show excessive sympathy to managers and become more tolerant in monitoring, which may lead to higher cost of supervising for outside investors and thus higher cost of capital for firms (Faleye et al., 2018). Accordingly, board industry expertise may cause more risk of financial constraints. In addition, hiring more industry experts in boards could lead to the lack of diversity. Board members with similar backgrounds may exhibit "groupthink", that is to think in similar way and be unable to generate alternatives decisions (Ellis et al., 2018). Therefore, stock market may react negatively to the appointment of industry experts and raise the cost of capital for focal firms. The increased financing cost could deter focal firms from desired projects and leads to financial constraints.

H2: Higher board industry expertise aggravates financial constraints.

3.3 Empirical design

3.3.1 Measure of board industry expertise

The concept of board industry expertise is closely related to industry experts. Industry experts is so called because the director previously worked in the same industry. Having more industry experts means gaining greater expertise in board. To construct board industry expertise, I follow the steps in Hoitash et al. (2009) and Faleye et al. (2018). I first record the employment history of

all the independent directors based on BoardEx database. Then I match the standard industrial classification (SIC) code with each director's current and previous employers based on Compustat database. In my study, an independent director is defined as industry expert if the current employer shares the same two-digit SIC code with any previous employers. Then I create three measures of board industry expertise: *board_industry_expertise_number* (the number of industry experts), *board_industry_expertise_percent* (the proportion of industry experts in independent directors), and *board_industry_expertise* (a dummy variable equals 1 if there is any industry expert in board, 0 otherwise).

3.3.2 Control variables

I control for three groups of variables, including firm-specific, board-specific, and CEO-specific. For firm-specific controls, according to previous research (Masulisa et al., 2012; Faleye et al., 2018), smaller and younger firms may face difficulty when collecting external funds compared to those larger and more established firms, since their business models are not accepted in the market. Therefore, I control for *firm size* and *firm age*. In addition, firms having more investment opportunities are in high demand of external capital, which may lead to higher cost of external capital and thus higher risk of financial constraints (Denis and Sibilkov, 2010). I control for investment opportunity using Tobin's Q (*Q*) and *sales growth* as proxies. Research also reports there are mixed relationships between the following variables and financial constraints, including return on asset (*ROA*), book leverage (*leverage*), research and development intensity (*rd_intensity*), and *market capitalization* (Ding et al., 2013; Kim and Sohn, 2013; Cheng et al., 2014; Erel et al., 2015; Chan et al., 2017; Campbell et al., 2021).

In terms of board-specific controls, since U.S. laws prohibit directors working for competing firms after their current service, there is concern that industry expert directors are older, more experienced. Following Faleye et al. (2018), I add two control variables to mitigate this concern, the average age of board members (*board_age*) and the average board tenure of independent directors (*board_tenure*). In addition, I control for several variables affecting board effectiveness, including *board_size* (the number of board members), *board_independence* (the proportion of independent directors to board members). It is worth noting that the number of industry expertise

is a subset of the total board size. As the total number of directors increases, the number of independent directors is likely to increase as well. This may raise concerns about multicollinearity between these two variables, highlighting the importance of including both industry expertise dummy variables and industry expertise percentages in baseline analysis.

For CEO-specific controls, I control for *CEO-chairman duality* and *CEO-founder duality*, because the founders and chairmen have privileged position and unique influence on firms' financial decisions.

3.3.3 Empirical specification

Based on following regression specification, I examine the impact of board industry expertise on financial constraints:

$$Financial\ Constraints_{\ it} = \beta_0 + \beta_1 Board\ Industry\ Expertise_{\ it-1} + \boldsymbol{\beta} Controls_{it-1} + \varepsilon$$

Where Financial Constraints is the score calculated from the naïve Bayes algorithm for each firm-year in chapter 2.3.2, *Board Industry Expertise* is given by three measures, including the proportion of industry experts in independent directors, the number of industry experts, and a dummy variable equals 1 if there is any industry expert in board, 0 otherwise, Controls includes *Q*, *sales growth*, *firm size*, *firm age*, *board size*, *board independence*, *board age*, *board tenure*, *CEO-founder duality*, *CEO-chairman duality*. An industry dummy based on two-digits SIC code is added in the regression. All the explanatory variables are lagged by 1 year to mitigate endogeneity concerns. The dependent variable is financial constraints, and the main independent variable of interest is board interlock. The detailed definitions of these variables are presented in the Appendix A.

3.4 Sample and data

I collect information of board members from BoardEx, including age, tenure, previous work experience, and board position. Financial constraints scores are calculated based on the financial reports crawled from Edgar Database. Accounting information is from Compustat. Stock information is from the Center for Research in Security Prices (CRSP). Data related to board industry expertise are from 1920 to 2019, other data from 2008 to 2019.

Following Whited and Wu (2006) and previous chapter, I use several exclusion criteria. Regulated firms with SIC between 4900 and 4999 are omitted. Financial firms with SIC between 6000 and 6999 are excluded. For eliminating coding errors, firms reporting smaller total debt than short-term debt are deleted, and firms undergoing a merger accounting for more than 15% book value of assets are deleted as well. Firms with negative total assets, book equity and sales are deleted. Then I match firms from the four databases according to Central Index Key (CIK). The final sample consists of 11,638 firm-year observations with 2,389 unique firms. All the continuous variables are winsorized at 99%.

Table 3-1 reports the descriptive statistics for the variables used in model. The mean of *board_industry_expertise_number* is 2.11, which means on average, each firm has 2.11 industry experts in board. The median is 2 for industry experts that each firm has. The range of the number of industry experts is from 0 to 12. The mean of *board_industry_expertise_percent* is 0.31, which implies that firms have averagely 31% industry experts in board. The median of *board_industry_expertise_percent* is 0.27. The mean of *board_industry_expertise* is 0.86, which infers that 86% of firms have industry experts in board. For independent variables, the mean of fc is 0.14, which suggests that 14% of all the observations are classified as financial constraint.

In terms of firm-specific controls, averagely log of total assets (*firm_size*) is 6.45; *firm age* is 20.98; Tobin's *Q* is 2.40; *sales growth* is 0.2; return on assets (*ROA*) is 0.02; book *leverage* is 0.22; *market capitalization* is 4,447.42. What worth mentioning is the difference between the mean and median of research and development intensity (*rd_intesnsity*), accounting for (1.37-0.05=) 1.32, which is due to several outliers that are as large as 60.91. For board-specific and CEO-specific controls, the average age of boards (*board_age*) is 62.35; average board tenure (*board_tenure*) is 5.94; the number of board member (*board_size*) is 8.26 averagely; the independence of boards

(*board_independence*) is averagely 83%. In 0.1% of all observations, CEOs is also founder (*CEO-founder duality*), and *CEO-chairman duality* is 40%. For alternative measures of financial constraints, the average score of *kz* index is 0.85, *ww* is -0.31, *sa* is -3.49, and *tangibility* 0.52.

Table 3-1 Summary statistics

The sample consists of 11,638 firm-year observations for 2,389 firms. The observation period is from 2008 to 2019. An independent director is a board member who have no material relationship with a company and is not involved in the day-to-day operation of the company. An independent director is defined as industry expert if the current employer shares the same two-digit SIC code with any previous employers. *board_industry_expertise_number* is the number of industry experts in board. *board_industry_expertise_percent* is the fraction of industry experts to independent directors. *board_industry_expertise* is a dummy variable which equals 1 if there is any industry expert in board, 0 otherwise. *fc* is the score of financial constraint, as stated in Empirical Design. All variables are winsorized at both the 1% and 99% levels.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
board_industry_expertise_number	11,638	2.11	1.61	0	1	2	3	12
board_industry_expertise_percent	11,638	0.31	0.23	0.00	0.14	0.27	0.43	1.00
board_industry_expertise	11,638	0.86	0.35	0	1	1	1	1
fc	11,638	0.14	0.34	0.00	0.00	0.00	0.00	1.00
firm_size	11,638	6.45	2.10	-2.62	4.96	6.43	7.95	10.94
firm_age	11,638	20.98	14.29	1	9	18	29	47
Q	11,638	2.40	2.59	0.42	1.27	1.76	2.73	92.41
sales_growth	11,638	0.20	1.02	-0.83	-0.03	0.05	0.16	10.05
ROA	11,638	0.02	0.33	-7.97	0.01	0.10	0.15	0.42
leverage	11,638	0.22	0.26	0.00	0.00	0.17	0.33	6.14
rd_intensity	11,638	1.37	7.28	0.00	0.01	0.05	0.17	60.91
market_capitalization	11,638	4,447.42	9,332.53	0.45	194.55	865.48	3,405.21	45,199.62
board_age	11,638	62.35	4.59	42.50	59.45	62.50	65.23	83.36
board_tenure	11,638	5.94	3.39	0.00	3.46	5.62	7.86	25.30
board_size	11,638	8.26	2.16	2	7	8	10	19
board_independence	11,638	0.83	0.08	0.33	0.80	0.86	0.89	0.94
ceo_founder_duality	11,638	0.001	0.02	0	0	0	0	1

ceo_chairman_duality	11,638	0.40	0.49	0	0	0	1	1
kz	11,638	0.85	2.05	-10.48	0.07	0.77	1.61	24.20
ww	11,638	-0.31	0.13	-0.57	-0.39	-0.31	-0.23	0.48
sa	11,638	-3.49	0.74	-4.58	-4.04	-3.50	-3.00	0.11
tangibility	11,638	0.52	0.20	0.01	0.37	0.51	0.64	0.98

3.5 Baseline results

Table 3-2 reports the baseline regression results of impact of board industry expertise on financial constraints. There are three independent variables, which are the number of industry experts, the fraction of industry experts to independent directors and a dummy indicating the existence of industry experts. The dependent variable of interest is score of financial constraints. Control variables include firm age, firm size, sales growth, Tobin's *Q*, ROA, book leverage, research and development intensity, market capitalization, CEO-chairman duality, CEO-founder duality, board size, average age of board members, average tenure of board members, and board independence. All regressions include industry fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code.

Before delving into respective results of each column, it is worth reporting some similarities that shared among those three baseline regressions. Firstly, all the firm age and firm size are negatively related to financial constraints. The possible rationale behind is that as the company become larger, the business model is more accepted, and the difficulty of raising capital become less. The coefficients are all significant at the 1% level. Secondly, the coefficients of sales growth and Tobin's Q in three regressions are all positive and significant at the 1% level, which supports the understanding that companies with more investment opportunities show higher demand for external capital and thus have higher risk of facing financial constraints. Thirdly, ROA and book leverage are negatively correlated with financial constraints at 1% significance level. The possible reason is that for companies with higher ROA and book leverage, the second market have more confidence in the business model and thus tend to lend them money, which means the companies face less risk of financial constraints. Fourthly, the coefficients of research and development

intensity adversely relate to financial constraints at 1% significance level. According to previous study (Ding et al., 2013; Kim and Sohn, 2013; Cheng et al., 2014), it is possibly because higher research and development input increases the cost of assessing for outside investors, which leads to reluctance of lending capital. The financial constraints of focal firms could thus become more stringent. Fifthly, the coefficients of CEO-founder duality are positively correlated to financial constraints in 1% significance level. A possible explanation could be that CEO being founder have more power on the operation of firms and are influenced less by the others. Investors are concerned with the arbitrary power and tend to not lend. As a result, focal firms face more difficulty of collecting external funds and have higher risk of financial constraints. Sixthly, an unexpected result is that all the coefficients of board average tenure are negatively and significantly related to financial constraints, which is opposite with the assumption that with more experience, board are more capable of collecting capital and faces less risk of financial constraints. A possible underlying reason could be that investors consider experienced directors to be sophisticated players who can maneuver the dissemination of negative information and therefore have less confidence of assessing the value of focal firms. To avert risk, outside investors choose to lend at higher cost. Thus, it become harder for focal firms to raise external funds. The other coefficients are not statistically or economically significant.

The coefficients of all the three measures of board industry expertise are positively related to financial constraints at 1% significance level, implying the support for H2 that enhancement of board expertise may cause more agency issues and higher risk of financial constraints. In the first column, the independent variable is the number of industry experts. The number of industry experts and financial constraints have positive correlation at 1% significance level. The coefficient is 0.021585, indicating that all else being equal, with one more industry expert in board, firms have 2.1585% more possibility of falling into financial constraints. The second column shows a positive relation between the proportion of industry experts and financial constraints. The coefficient of *board_industry_expertise_percent* is 0.149350, which suggests that every percent increase of the proportion, firms face 0.14% more risk of financial constraints. In the third column, I examine the effect of existence of industry experts on financial constraints. The coefficient is 0.029743, implying that the possibility of facing financial constraints for firms with industry experts is 2.9% greater than those without. Overall, the findings support H2 but not H1.

The results indicate a counterintuitive relationship between board industry expertise and financial constraints, suggesting that firms with boards possessing significant industry expertise tend to experience higher financial constraints. This finding challenges the conventional wisdom that industry-specific knowledge and skills on the board would naturally alleviate financial difficulties. Instead, it appears that extensive industry expertise may increase the risk of financial constraints for these firms.

The results of the current study diverge from much of the existing literature, which generally highlights the positive impacts of board expertise on firm performance and resource acquisition (Drobetza et al., 2018; Faleye et al., 2018; Von Meyerinck et al., 2016). Drobetza et al. (2018) argue that directors with relevant industry expertise provide valuable insights and guidance, improving strategic decisions and resource access. Similarly, Von Meyerinck et al. (2016) suggest that industry-specific knowledge helps board members identify and exploit opportunities, thereby reducing financial constraints.

The findings, however, align with a more nuanced perspective offered by some researchers, who suggest that the informational advantage of industry expertise does not always translate to superiority in all aspects (Dass et al., 2013; Wang et al., 2015; Ellis et al., 2018). Faleye et al. (2018) suggest that a high proportion of industry experts on a board may lead to a narrow vision due to a lack of diversity. The shared similarities among industry experts can hinder the generation of alternative opinions. Additionally, while independent directors are responsible for monitoring and advising, top executives handle strategy formation and execution. Consequently, independent directors with industry expertise may lack specific business operation insights and fail to provide additional help in information mining (Wang et al., 2015). Ellis et al. (2018) finds that in diversified firms, industry experts are not impartial advisors as they either fail to monitor effectively in familiar industries or to advise effectively in unfamiliar ones.

The positive relationship between board industry expertise and financial constraints has several important implications for corporate governance and management practices. Firms should be cautious about the potential risks associated with having highly industry-expert boards. While

expertise can undoubtedly provide valuable insights, it may also lead to less diversification and riskier decision-making, which can exacerbate financial constraints. Companies might benefit from balancing industry expertise with diverse perspectives on the board. Including members with financial acumen, risk management experience, and broader business insights can help counterbalance the potential overconfidence of industry experts. This diversified approach can lead to more prudent and balanced strategic decisions, mitigating the risk of financial constraints. For policymakers and corporate governance practitioners, the findings highlight the need for guidelines that encourage a balanced board composition. Policies that promote diversity in board skills and experiences can help firms avoid the pitfalls associated with over-reliance on industry expertise.

Table 3-2 Baseline results

Table 3-2 reports the regression results of board industry expertise on financial constraint. The sample is from U.S. listed firms (excluding the financial firms) from 2008 to 2019. The dependent variable is financial constraint score, which is calculated by the author. The main independent variables of interest are *board_industry_expertise_number*, *board_industry_expertise_percent*, and *board_industry_expertise*. *board_industry_expertise_numb*er is the number of industry experts; *board_industry_expertise_percent* is the proportion of industry experts in independent directors; *board_industry_expertise* is a dummy variable equals 1 if there is any industry expert in board, 0 otherwise. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include industry fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable:		
	fc		
board_industry_expertise_number	0.021585***		
	(0.002070)		
board_industry_expertise_percent		0.149350***	
		(0.013886)	
board_industry_expertise			0.029743***
			(0.008793)
firm_age	-0.002737***	-0.002761***	-0.002821***
	(0.000254)	(0.000253)	(0.000255)
firm_size	-0.006258**	-0.006411**	-0.005290**
	(0.002564)	(0.002563)	(0.002581)

sales_growth	0.029718***	0.029499***	0.030492***
	(0.002813)	(0.002812)	(0.002828)
Q	0.007979***	0.008184***	0.008197***
	(0.001382)	(0.001381)	(0.001390)
ROA	-0.153701***	-0.153259***	-0.154073***
	(0.012734)	(0.012728)	(0.012814)
rd_intensity	0.006245***	0.006166***	0.006343***
	(0.000466)	(0.000466)	(0.000469)
market_capitalization	0.000001***	0.000001***	0.000001**
	(0.0000004)	(0.0000004)	(0.0000004)
ceo_chairman_duality	-0.006711	-0.005989	-0.011821*
	(0.006003)	(0.006006)	(0.006041)
ceo_founder_duality	0.314143***	0.314435***	0.290110***
	(0.102545)	(0.102500)	(0.103147)
board_size	-0.003236*	0.001737	-0.000485
	(0.001937)	(0.001919)	(0.001929)
board_age	-0.001120	-0.001191	-0.000457
	(0.000767)	(0.000767)	(0.000769)
board_tenure	0.007337***	0.007717***	0.005945***
	(0.001098)	(0.001102)	(0.001097)
board_independence	0.043744	0.084953**	0.107049***
	(0.039247)	(0.038524)	(0.039369)
Industry FE	Yes		
Year FE	Yes		
Observations	8,081	8,081	8,081
R^2	0.470933	0.471386	0.464514
Adjusted R^2	0.466110	0.466567	0.459632
F Statistic (df = 64; 8007)	111.362500***	111.565200***	108.527800***
Note:	*p<0.1; **p<0.05; ***p<0.01		

3.6 Robustness test

3.6.1 Alternative measures of financial constraints

Text-based measure of financial constraints is used in baseline model. In this section, several other alternative measures of financial constraints are introduced for robustness test, including KZ index, SA index, WW index, and tangibility.

The following equation is used for testing the impact of board industry expertise on financial constraints based on alternative measures. I also add Industry fixed effects and year fixed effects in the model.

$$Alternative\ measures_{\ it} = \beta_0 + \beta_1 Board\ Industry\ Expertise_{\ it-1} + \boldsymbol{\beta} Controls_{it-1} + \varepsilon$$

The results are presented in Appendix B. Consistent with the findings in baseline regression, the coefficients of board industry expertise in regressions based on WW index and tangibility are positive and significant. However, the results are not statistically significant in KZ index. In addition, there are negative and significant correlations in SA index regression.

3.6.2 Test of reverse causality

In previous sections, I show the positive and significant coefficients between financial constraints and board industry expertise. The following analyses test whether there is reverse causality.

Following Faleye et al. (2014), I assume that lagged financial constraints with three periods makes it more challenging to establish reverse causality. The equation is as follows:

$$Financial\ Constraints_{\ it} = \beta_0 + \beta_1 Board\ Industry\ Expertise_{\ it-3} + \boldsymbol{\beta} Controls_{it-3} + \varepsilon$$

As demonstrated in Table 3-3, the positive and significant correlations are consistent in the regression of the number and the proportion of industry experts, which implies that it is unlikely that there are reverse causality problems. The results support hypothesis that with more industry experts, firms face more risk of financial constraints. However, the coefficient in the existence of industry experts is insignificant. I tend to believe that this finding does not have much interpretive

power on reverse causality, because the existence of industry experts is too common among firms (86% observations have industry experts in their boards).

Table 3-3 Test of reverse causality

Table 3-3 reports the findings of reverse causality test. The sample is from U.S. listed firms (excluding the financial firms) from 2008 to 2019. The dependent variable is financial constraint score, which is calculated by the author. The main independent variables of interest are *board_industry_expertise_number*, *board_industry_expertise_percent*, and *board_industry_expertise*. *board_industry_expertise_number* is the number of industry experts; *board_industry_expertise_percent* is the proportion of industry experts in independent directors; *board_industry_expertise* is a dummy variable equals 1 if there is any industry expert in board, 0 otherwise. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 3 year. All regressions include year fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable:		
	fc		
board_industry_expertise_number	0.021195***		
	(0.002564)		
board_industry_expertise_percent		0.145488***	
		(0.017397)	
board_industry_expertise			0.012517
			(0.012235)
firm_age	-0.002834***	-0.002853***	-0.002947***
	(0.000302)	(0.000302)	(0.000303)
firm_size	-0.002466	-0.002518	-0.001318
	(0.003184)	(0.003183)	(0.003207)
sales_growth	0.042850***	0.042783***	0.043210***
	(0.004041)	(0.004040)	(0.004067)
Q	0.011611***	0.011755***	0.012358***
	(0.001764)	(0.001763)	(0.001774)
ROA	-0.181943***	-0.180450***	-0.179354***
	(0.015377)	(0.015371)	(0.015489)
leverage	-0.031293**	-0.031020**	-0.030911**
	(0.015159)	(0.015156)	(0.015257)

rd_intensity	0.004242***	0.004173***	0.004371***
	(0.000711)	(0.000711)	(0.000716)
market_capitalization	0.000001*	0.000001	0.000001
	(0.0000005)	(0.0000005)	(0.0000005)
ceo_chairman_duality	-0.013858*	-0.012913*	-0.019601***
	(0.007304)	(0.007315)	(0.007365)
ceo_founder_duality	0.368645***	0.367685***	0.344739**
	(0.141618)	(0.141594)	(0.142506)
board_size	-0.004467*	0.000533	-0.002106
	(0.002347)	(0.002346)	(0.002347)
board_age	-0.000854	-0.000905	-0.000087
	(0.000979)	(0.000979)	(0.000982)
board_tenure	0.008454***	0.008742***	0.006583***
	(0.001365)	(0.001371)	(0.001368)
board_independence	0.012451	0.057295	0.096702*
	(0.049681)	(0.048718)	(0.049515)
Industry FE		Yes	
Year FE		Yes	
Observations	5,294	5,294	5,294
R^2	0.432263	0.432435	0.424950
Adjusted R^2	0.424654	0.424828	0.417243
F Statistic (df = 63; 5223)	63.121830***	63.166130***	61.264910***
Note:	*p<0.1; **p<0.05; ***p<0.01		

3.7 Conclusion

The relationship between board expertise and financial constraints is a critical area of investigation in corporate governance and financial management. This study explores this relationship using a sample of listed industrial companies in the U.S. from 2018 to 2019. The findings reveal a significantly positive correlation between board expertise and financial constraints, a result that stands in contrast to the conventional wisdom suggesting that industry expertise should alleviate financial difficulties. Several robustness tests, including alternative measures of financial constraints and regressions using the third lag of board expertise, reinforce this positive effect.

These unexpected results raise important questions about the role of board expertise and the potential trade-offs firms face in their governance structures.

The central finding of this study is the significantly positive correlation between board expertise and financial constraints. This suggests that firms with boards possessing extensive industry expertise tend to experience higher levels of financial constraints. Initially, this appears counterintuitive, as it is generally believed that industry expertise should enhance a firm's strategic decision-making and resource acquisition, thereby reducing financial constraints. To ensure the robustness of these findings, various tests were conducted. Alternative measures of financial constraints were employed, and regressions using the third lag of board expertise were performed. Consistently, the results supported the positive relationship, indicating that the association is not an artifact of the specific measures or models used.

These findings have significant implications for corporate governance and financial strategy. They suggest that firms might need to reconsider the composition of their boards, particularly regarding the inclusion of industry experts. One potential implication is that to avoid financial constraints, firms might consider hiring fewer industry experts on their boards. This runs counter to the prevalent practice of prioritizing industry-specific knowledge in board appointments. However, this recommendation should be approached with caution. The value of industry expertise is well-documented in enhancing strategic insights and providing valuable networks. Therefore, the suggestion to hire fewer industry experts is not straightforward and underscores the need for further research to understand the nuances of this relationship. One possible explanation for the positive correlation between board expertise and financial constraints could be the ambition of firms. Ambitious firms, aiming for growth and competitive advantage, may deliberately hire more industry experts to leverage their knowledge and connections. These firms might also engage in substantial investments, driving up their demand for capital and, consequently, their cost of capital.

Given the counterintuitive nature of these findings, further research is essential to unravel the complexities of the relationship between board expertise and financial constraints. Future studies should explore the specific mechanisms through which board expertise influences financial outcomes. This could involve examining the role of board dynamics, decision-making processes,

and the strategic choices that firms make under the guidance of industry experts. Additionally, research should consider the context in which these firms operate, including industry characteristics, market conditions, and regulatory environments. Such factors could moderate the relationship between board expertise and financial constraints, providing a more nuanced understanding of when and how industry expertise impacts financial health.

While the study provides insights into the relationship between board industry expertise and financial constraints, several limitations should be acknowledged. Firstly, this measure of financial constraints relies on the availability and quality of textual data, which may not be uniformly available across all firms, potentially leading to a biased or incomplete sample. Additionally, the focus on publicly traded firms may limit the generalizability of the findings to privately held companies or firms in different regulatory environments. Future studies could explore these relationships across various contexts to enhance the robustness and applicability of the findings. Moreover, despite using sophisticated measures to capture industry expertise and financial constraints, unobserved factors may still influence these variables. Incorporating additional controls or employing alternative methodologies, such as instrumental variables, could address potential endogeneity concerns.

4. CEO overconfidence and financial constraints

4.1 Introduction

Corporate governance and decision-making are profoundly influenced by the psychological and behavioural attributes. Among the myriad of attributes that Chief Executive Officers (CEOs) overconfidence has emerged as a focal point of academic and industry discussions, given its potential to significantly shape a firm's strategic trajectory (Malmendier and Tate, 2005). Overconfident CEOs, often recognized by their heightened belief in their own capabilities and an optimistic outlook on the outcomes of their decisions, can influence a investment patterns, risk-taking, innovation, cash holdings, and financial strategies (Malmendier and Tate, 2005; Malmendier and Tate,2008; Malmendier et al., 2011; Hirshleifer et al., 2012; Deshmukh et al., 2013; Hribar and Jenkins, 2004; Phua et al.,2018; Aktas et al., 2019; Chen et al., 2020).

Other than the abovementioned about the effects of CEO overconfidence on various business aspects, its relationship with financial constraints is also explored. Financial constraints encapsulate the challenges when firms attempt to secure external financing for projects or operations, which is a critical determinant of a firm's growth prospects, competitive positioning, and overall financial stability (Fazzari et al., 1988). Previous studies investigating relation between CEO overconfidence and financial constraints mainly adopt proxy of investment-cash flow sensitivity (Malmendier and Tate,2005; Lin, 2007; Glaser et al., 2008; Huang et al., 2011; Mohamed et al., 2014; Maditinos et al., 2015; Koo and Yang, 2018). The fundamental idea is that overconfident CEOs tend to overestimate the firm's future cash flows and thus believe the market undervalues their firm. The misperception of cost of capital further influences external financing provided to the firm and lead to a higher sensitivity of investment-cash flow, which implies the firm have difficulty of collecting capital. The firms with overconfident CEOs therefore tend to be financially constrained. However, there remain several challenges for this rationale. Firstly, previous literature using investment sensitivity shows that overconfident CEOs are sensitive to cash flow, which is not equivalent to the difficulty of raising funds. Investment decisions are influenced by a myriad of factors, not just financial constraints. This makes it challenging to isolate the effect of financial constraints from other determinants of investment (Whited, 1992). For

instance, the sensitivity could be the result of managerial strategy but not the capability of collecting capital, which is the main facet of financial constraints. Secondly, there are several proxies for financial constraints, but previous research of relation between financial constraints and CEO overconfident mainly focus on measure of investment sensitivity. Adopting various proxies could provide a more comprehensive or nuanced understanding of financial constraints (Kaplan and Zingales, 1997; Hadlock and Pierce, 2010). Thirdly, overconfident CEOs may exert conflicting effects on financial constraints. For example, Overconfident CEOs usually have strong belief in their strategies which further aligns with shareholder interests, potentially boosting performance and reducing agency conflicts, which could relieve difficulty of raising capital (Malmendier and Tate, 2005). However, according to Jensen and Meckling (1976), overconfident CEOs might occasionally undertake initiatives that don't align with shareholder priorities, exacerbating agency disputes and financial constraints. These challenges present the importance of reviewing the relation between financial constraints and CEO overconfidence.

The empirical analysis covers a sample of 15,661 firm-year observations between 2006 and 2019. To measure CEO overconfidence, I first calculate the average moneyness percentage of options using ExecuComp data, which is the ratio of the per-option realizable value to the average anticipated exercise price. CEOs are labelled as overconfidence from the moment they hold onto stock options that are more than 67% in the money (Malmendier and Tate, 2005). A binary variable, ceo_overconfidence67, is set to 1 for firms led by overconfident CEOs and 0 otherwise. Also motivated by Campbell et al. (2011), firms are categorized as high_optimism if their CEOs once held options with moneyness above 100%, low_optimism if below 30%, and mid_optimism if between 30% and 100%. In terms of measure of financial constraints, I source 10-k reports from the Edgar Database and create a text-based financial constraint index. The underlying premise is that firms facing financial constraints are compelled to disclose challenges in securing funds and any resultant project delays. The textual information in financial statements can be converted into a financial constraints index.

After accounting for various known determinants of financial constraints, the baseline analysis finds a significantly positive relation between low CEO overconfidence and the risk of financial constraints. It seems that the perk from low overconfidence exceeds the downsides on the facet of

financial constraints. Although baseline analysis is not in line with previous literature which supports that CEO overconfidence increases risk of financial constraints, the results are robust after controlling for year fixed effects and industry fixed effects. To be more comprehensive, I regress on alternative measures of financial constraints. The results are robust when using tangibility as the alternative. To further test the robustness, motivated by Aktas et al. (2019), I construct a parallel sample through propensity score matching (PSM) process. Propensity score matching ensures that the impact of CEO overconfidence isn't merely attributed to observable variations, like firm or CEO attributes, between companies led by overconfident CEOs compared to those led by rational ones. The results are consistent with the baseline analysis.

The study contributes the literature regarding to the relation between financial constraints and managerial characteristics. For example, Hu and Liu (2015) found that firms with CEOs who have more industry experience tend to face less risk of financial constraints, suggesting that experienced managers might be better at securing other forms of financing or managing resources more efficiently. Especially, Malmendier and Tate (2005) find positive effect of CEO overconfidence on investment-cash flow sensitivity. They highlight that the overconfident CEOs are also hesitant to secure new bank loans, believing that banks undervalue their investment projects. Similarly, Glaser et al. (2008) found that companies led by optimistic managers tend to invest more and exhibit greater sensitivity between investment and cash flow.

The study is also related to the managerial overconfidence literature. For example, Hirshleifer et al. (2012) delve into the connection between CEO overconfidence and innovation, uncovering that overconfident CEOs tend to be more involved in innovative endeavours. Their propensity for risk-taking, driven by their overconfidence, can lead them to engage in potentially high-reward innovative projects. In a related paper, Hribar and Jenkins (2004) explore the influence of CEO overconfidence on management forecasting, revealing that such CEOs often lean towards providing optimistic forecasts, which can shape stakeholder decisions. Malmendier et al. (2011) take a unique approach by examining the interplay between early-life experiences and CEO overconfidence, suggesting that challenging early-life experiences might mould CEOs to make distinct financial decisions influenced by their heightened confidence. Deshmukh et al. (2013) focus their research on the nexus between CEO overconfidence and dividend policies, concluding

that overconfident CEOs exhibit a reduced likelihood to distribute dividends, possibly stemming from their belief in the higher returns of internal reinvestments. Adding another dimension to the discourse, Phua et al. (2018) investigated the leadership efficacy of overconfident CEOs by gauging stakeholder commitments. Their findings indicate that these CEOs, possibly perceived as more competent or trustworthy, often foster stronger stakeholder relationships.

The rest of the paper proceeds as follows. Section 4.2 reviews past literature. Section 4.3 describes the sample. Section 4.4 examines the baseline regression. Section 4.5 addresses the robustness test. Section 4.6 concludes the paper.

4.2 Literature review

4.2.1 Types of overconfidence

Overconfidence basically refers to an excessive faith in one's own abilities, judgments, or cognitive biases, often leading to miscalculations and inaccurate decisions. According to Ackert and Deaves (2010), overconfidence is "Overconfidence is the tendency for people to overestimate their knowledge, abilities, and the precision of their information, or to be overly sanguine of the future and their ability to control it". Moore and Schatz (2017) further summarize three types of overconfidence, including overestimation, overplacement and overprecision. Focusing on these three types, this part reviews the multifaceted nature of overconfidence.

Overestimation is characterized as a tendency where an individual's self-assessment exceeds an objective or empirically determined standard of accuracy (Hoffrage, 2016). This form of overconfidence is widely documented in various domains. Svenson's (1981) seminal study on American drivers revealed that a majority considered themselves to be above average, signifying a universal pattern of overestimation in self-evaluation. Similarly, Kruger and Dunning's (1999) research showed that individuals with lower abilities often overestimate their competence, which may reflect a disconnect between perceived and actual abilities. This trend extends to predictive behaviours as well, as illustrated by Fischhoff et al. (1977), where people consistently overestimate their accuracy in forecasting uncertain events. In the healthcare context, overestimation manifests

when patients overvalue the benefits of treatments, potentially leading to dissatisfaction with medical outcomes (Zikmund-Fisher et al., 2010). In understanding complex environmental phenomena, individuals have been found to overrate their comprehension, indicating the pervasive nature of overestimation across diverse aspects of human cognition and behaviours (Tobler et al., 2012).

Overplacement, also known as the better-than-average effect, is characterized by an individual's inclination to overvalue their performance in comparison to others. This widespread phenomenon, as defined by Alicke et al. (1995), is underpinned by the common belief among individuals that they surpass the average person across various domains. Gender differences in overplacement have been observed, with men frequently exhibiting higher levels of overvaluation in self-assessment than women (Hedges and Nowell, 1995). In the context of professional environments, overplacement can manifest in leadership overreach and poor teamwork, which can subsequently erode organizational performance (Goethals, 2003). The sports arena provides a notable example of overplacement, where athletes are often found to overestimate their chances of winning (Price et al., 2012). Furthermore, in the economic sphere, overplacement has been linked to irrational exuberance and excessive risk-taking, particularly in competitive markets (Kyle and Wang, 1997). The multifaceted implications of overplacement extend across diverse fields, highlighting its significance and complexity.

Overprecision is a phenomenon that is defined by an unwarranted degree of certainty in one's beliefs or judgments, despite evidence not substantiating such confidence. This concept was empirically detailed by Moore and Healy (2008), who discovered that individuals often constrain their confidence intervals too narrowly, thereby illustrating a pattern of overprecision in their assessments. This trend manifests across a variety of fields. In financial markets, for instance, overprecision in analysts' earnings predictions can induce market inefficiencies, leading to potential economic imbalances (Hirst et al., 2008). In healthcare, medical professionals might exhibit overprecision in diagnosing ailments, a factor that could have consequences for patient care by leading to less-than-optimal treatment decisions (Christensen-Szalanski and Bushyhead, 1981). The scientific community is not exempt from this bias, as researchers may present overprecision in formulating hypotheses and predicting experimental outcomes, thereby affecting

the integrity and interpretation of research findings (Klayman et al., 1999). Within organizational management, overprecision in forecasting has been linked to inadequate strategic planning and resource allocation, which can undermine the effectiveness of managerial decisions (Buehler et al., 2010). In the realm of negotiations, overprecision can inhibit the negotiation process, obstructing the pathway to mutually beneficial resolutions (Neale and Bazerman, 1985). Moreover, cognitive biases, such as the illusion of control, further compound this issue by reinforcing overprecision in judgments (Langer, 1975). Collectively, these instances paint a comprehensive picture of overprecision as a pervasive cognitive bias with wide-ranging implications, transcending sectors and influencing various aspects of human decision-making and interaction.

Overconfidence is a complex and multifaceted bias with far-reaching implications in various domains, including business, education, healthcare, and environmental policy. Its manifestations, overestimation, overplacement, and overprecision, have been extensively studied, shedding light on human judgment and decision-making processes.

4.2.2 Measures of CEO overconfidence

Previous section reviews the multifaceted types of CEO overconfidence, this part examines the literature measuring CEO overconfidence. Given its implications for corporate governance, investment decisions, and shareholder value, accurately measuring CEO overconfidence is crucial. Over the years, researchers have developed various proxies and methodologies to capture this trait, each with its own set of advantages and limitations. According to the types of data source, there can be three types of measures for CEO overconfidence, including text-based measures, accounting-ratio based measures, option-holding measures, survey-based measures.

4.2.2.1 Option-holding measures

Option-Holding Measures analyse CEO overconfidence through the lens of stock option exercises. According to Malmendier and Tate (2005), overconfident CEOs are more likely to overestimate the value they can create. This belief is reflected in their option-holding behaviour, which is beyond the rational thresholds. CEOs are granted stock options as a part of their compensation.

Once these options are vested (the CEO has the right to exercise them), CEOs can either exercise the options and sell the shares to realize gains or they can hold on to the options. If a CEO holds on to vested options (especially when they are deeply in the money) rather than exercising them, he or she is essentially betting that the company's stock price will rise even further. In practice, stock option grants are often the majority of CEO compensation scheme. Excessively holding on to vested options indicates being exposed to under-diversified risks and overestimating the value, which thus implies the overconfidence about the future stock performance. Two measures related to option-holding are reviewed in this section, including holder67, longholder.

The first measure is holder67, introduced by Malmendier and Tate (2005). The fundamental idea is that overconfident CEOs believe their company's stock price will continue to rise, even when their stock options are significantly in-the-money. Consequently, they might delay exercising these options, anticipating even higher future stock prices. In contrast, a rational CEO would exercise these options earlier to diversify their portfolio and realize the gains. Holder67 is based on the model by Hall and Murphy (2002), which is used to calibrate a range of rational benchmarks for option exercise, considering various levels of risk aversion and diversification needs.

The second measure is longholder, also proposed by Malmendier and Tate (2005). A CEO is considered a longholder if failing to exercise options that are at least 40% in-the-money in a given year and also have at least half of their total vested, in-the-money options unexercised until the expiration date or until the last year before the expiration date. Once a CEO is classified as a longholder, they retain this classification, which means overconfidence, as a personal characterisitic, is not time-varying. The idea behind is similar to holder67, CEOs who retain their stock options for extended periods, even when it might make more financial sense to exercise and sell them, could be acting on an overconfident belief in their company's future stock performance.

While option-holding measures are instrumental in understanding the overconfidence of corporate leaders, they are not without limitations. One of the criticisms is option-holding behaviours could also be influenced by personal financial considerations, strategic signalling to stakeholders, pressures from boards or investors, and broader economic conditions. Such behaviours, although fiscally prudent on a personal level, might be misread as indications of overconfidence in the

company's prospects (Malmendier and Tate, 2015). Additionally, the varied structures of option grants across firms and potential misclassifications due to metrics like holder67 or longholder further complicate interpretations (Brown and Sarma, 2007). Moreover, the method's CEO-centric focus may overlook the significant influence of other corporate leaders. Thus, although option-holding offers insights, it needs to be viewed critically.

4.2.2.2 Text-Based Measures

One emerging area of interest is the use of text-based measures to gauge CEO overconfidence. Text-based measures use computational linguistic analysis to gauge CEO overconfidence. These methods primarily draw on CEO speeches, interviews, and written communications, and they typically assume that the frequency and tone of words are associated with confidence and certainty.

Malmendier and Tate (2008) provide an additional measure of CEO overconfidence through press coverage. They conduct a search of major newspapers for articles about the CEO. Focusing on articles from large-circulation publications like The New York Times, The Wall Street Journal, and BusinessWeek, they further identify articles that label the CEO with specific keywords that suggest overconfidence. Specifically, they look for terms like "confident" or "optimistic". CEOs who are described as "confident" or "optimistic" more frequently than the median CEO in their sample are classified as overconfident based on press coverage. It's worth noting that while this press-based measure offers a unique lens through which to view CEO overconfidence, it also comes with its own set of challenges. For instance, media portrayals might not always accurately reflect a CEO's true personality or beliefs, and the measure might be influenced by factors like the CEO's relationship with the press or the broader media narrative at the time.

Relying on trait theory, Brown and Sarma (2007) measure CEO overconfidence through a psychological approach. They construct a media coverage proxy, aiming to capture the portrayal of a CEO in various media outlets, such as newspapers, magazines, and online platforms. By analysing the tone, sentiment, and content of media coverage, researchers can gauge how a CEO is perceived and whether this perception aligns with overconfidence. However, the authors

acknowledge potential limitations of this measure, such as managers projecting false confidence to mislead investors or attempting to hype major corporate events.

Park et al. (2019) utilize a unique approach to gauge CEO overconfidence by analysing the Management Discussion and Analysis sections of 10-K documents from the US Securities and Exchange Commission's EDGAR database. Leveraging the Diction program, they extract levels of "optimism" from the text, using it as a surrogate for overconfidence. This method is grounded in the idea that the language and sentiment in the Management Discussion and Analysis can offer insights into a CEO's confidence and perspective on the company's future.

Text-based measures offer a unique and objective lens to assess CEO overconfidence by analysing naturally occurring data, such as earnings calls or annual reports. This method is advantageous as it bypasses potential biases inherent in surveys and interviews, captures the evolution of CEO sentiment over time, and benefits from the scalability offered by modern natural language processing techniques (Li, 2010; Tetlock et al., 2008). However, challenges arise in interpreting the nuances of language, accounting for cultural and industry-specific variations, and ensuring the availability of relevant textual data. Additionally, advanced textual analysis, especially when reliant on machine learning, may risk overfitting, capturing noise rather than genuine patterns of overconfidence (Loughran and McDonald, 2011; Huang et al., 2014).

4.2.2.3 Accounting-ratio-based measures

Accounting ratios, derived from financial statements, have been used to infer CEO overconfidence indirectly. Accounting-ratio measures offer a quantitative perspective on CEO overconfidence by examining financial decisions and strategies. The fundamental idea is that overconfident CEOs are associated with specific pattern of firms' financial performance, and hence could be reflected through related accounting reports.

Lin et al. (2005) delves into the relationship between managerial optimism and corporate investment decisions by examining a sample of listed companies in Taiwan. Their primary method for gauging managerial optimism is derived from management earnings forecasts. The rationale

behind this approach is that a CEO's optimism in assessing future outcomes might lead to upwardly biased forecasts. To construct a measure of managerial optimism on a personal basis, they weigh each forecaster equally. If a CEO consistently provides forecasts that are overly positive, they are classified as optimistic. This method is rooted in the idea that optimistic managers might perceive their firm's future performance more favourably than the broader market's outlook. The study's findings suggest that in firms with more financing constraints, optimistic managers display a higher sensitivity between investment and cash flow compared to their non-optimistic counterparts.

In Hayward and Hambrick (1997), recent stock price performance of a firm is utilized as an indicator of CEO hubris. The premise is grounded in behavioural feedback theory. Witnessing their firm's stock outperform industry benchmarks, CEOs might attribute this success to their own leadership prowess rather than external factors. This self-attribution can inflate their confidence, leading them to believe they have superior insights or capabilities. As a result, such CEOs, buoyed by recent stock successes, may overestimate their ability to derive value from acquisitions, making them prone to paying higher premiums. This mechanism highlights the intricate interplay between stock performance and CEO decision-making, emphasizing the potential pitfalls of unchecked confidence in strategic decisions.

Campbell et al. (2011) employ a method where they track a company's investment rates over a span of two years and juxtapose it against the average investment rates of similar companies in the industry. If a CEO's company consistently outpaces its peers in investments, it's an indication that the CEO is overconfident, likely perceiving more opportunities or having a bullish outlook on the company's future. Conversely, CEOs whose companies lag in investments compared to industry standards are categorized as diffident or having low confidence, possibly due to a more cautious or pessimistic view of the future.

In Glaser et al. (2008), the authors gauge CEO optimism by examining their stock transaction behaviours. They focus on the stock trades made by members of a company's Executive and Supervisory Boards each year. Two main measures are used: one counts the number of stock transactions, and the other measures the volume of these transactions. Additionally, they use "dummy" indicators to flag optimism: if there's a positive trend in the number or volume of stock

purchases, it's seen as a sign of optimism. In essence, if CEOs or board members buy more company stock than they sell, it suggests they're optimistic about the company's future.

Doukas and Petmezas (2007) measure managerial overconfidence by examining their acquisition habits. They pinpoint overconfidence in managers who make five or more acquisitions within a three-year span, a criterion also used by Fuller, Netter, and Stegemoller (2002) to label firms as "frequent" acquirers. The idea behind this measure is that when managers frequently make acquisitions in a short period, it likely indicates their overconfidence. Such behaviour implies that these managers are eager to capitalize on opportunities, trusting their capability to extract value from their acquisitions. This perspective resonates with Heaton's (2002) view that overconfident managers embark on more projects, suggesting they might be overly optimistic about the results of their ventures.

There are several advantages of using accounting-ratio based methods to measure CEO overconfidence. Firstly, standardized financial data makes them reliable and applicable across different firms and industries (Heaton, 2002; Richardson, 2006). Plus, by tracking these ratios over time, it can be seen how CEO confidence shifts and affects business decisions (Hackbarth, 2009). However, there are some drawbacks. These ratios don't directly measure overconfidence and can be influenced by other business factors, potentially leading to wrong conclusions (Ben-David et al., 2013). They also might miss the deeper psychological aspects of overconfidence that other methods, like surveys, can capture (Huang et al., 2014). So, although these methods are useful, they may not fully reflect the understanding of CEO overconfidence.

4.2.2.4 Survey

Another prominent approach is using surveys. One pioneering approach is conducted by Ben-David et al. (2013), who utilize a decade-long quarterly survey by Duke University (spanning 2001 to 2011) to analyse projections made by U.S. chief financial officers. They find a significant miscalibration among executives. Specifically, executives' predictions are too constrained, with realized market returns falling within their 80% confidence intervals only 36% of the time. They

reveal that firms led by these miscalibrated executives tend to adopt more aggressive corporate policies, characterized by increased investment and greater reliance on debt financing.

Building upon this foundation, Graham et al. (2020) undertakes an innovative methodology to directly gauge the psychological traits and attitudes of senior executives. Designing an anonymous psychometric personality test, they assess various personality traits including risk-aversion, optimism, time preferences, and loss aversion. Their survey includes CEOs and CFOs who were engaged with publications like Chief Executive and CFO magazines, as well as attendees of the World Economic Forum in Davos. Most of these surveys were administered online, supplemented by a few conducted through fax. Their findings demonstrate a connection between CEOs' behavioural characteristics, such as optimism and managerial risk-aversion, and the corporate financial policies.

Utilizing surveys to measure CEO overconfidence presents distinct advantages but is not without its challenges. On the positive side, surveys allow for a direct examination of executives' psychological constructs, offering insights into complex dimensions such as overconfidence. The flexibility in question design and the capacity to reach a wide spectrum of respondents further enhance the adaptability and broad applicability of this method (Cain et al., 2015). Surveys also facilitate cross-disciplinary collaboration, enabling researchers to leverage expertise across varied academic domains. Despite these merits, the approach is marred by several shortcomings. The risk of response bias, arising from social desirability or other influences, may skew the results. There's also the challenge of isolating overconfidence from other intertwined psychological variables, which can complicate analysis and interpretation. Furthermore, practical concerns related to administration, including the potentially significant time and financial commitments required to engage high-level executives, present additional obstacles Graham et al. (2020).

4.2.3 Impacts of CEO overconfidence

CEO overconfidence, characterized by an exaggerated belief in one's own abilities and the underestimation of risks, is a focal point in corporate finance literature. This section synthesizes key findings on how CEO overconfidence impacts various facets of corporate finance.

Overconfident CEOs influence a firm's investment decisions, often leaning towards riskier or unconventional projects due to an inflated belief in their own capabilities (Malmendier and Tate, 2005). Such CEOs might channel more resources into research and development, hoping for ground-breaking innovations, but this can also lead to significant sunk costs if projects don't materialize as expected (Hirshleifer et al., 2012). They are also prone to ramping up capital expenditures, expanding operations, or venturing into new markets based on optimistic projections. However, even when market feedback suggests caution, these CEOs might persist or even escalate their commitment, potentially exacerbating investment misjudgements (Camerer and Lovallo, 1999). While their boldness can sometimes yield innovative breakthroughs, it also introduces heightened risks, underscoring the double-edged nature of CEO overconfidence in shaping investment decisions.

Overconfident CEOs also shape a firm's financing strategies, often driven by their unwavering belief in their own abilities and their firm's potential (Malmendier and Tate, 2008). Overconfident CEOs tend to favour internal financing, like retained earnings, over external sources, feeling that the external markets might undervalue their firms. In addition, when seeking for external funds, they lean towards debt, aiming to avoid diluting ownership and maintain control (Hackbarth, 2009). In the realm of mergers and acquisitions, these CEOs might opt for all-stock deals, capitalizing on what they perceive as their stock's undervaluation (Roll, 1986). However, their confidence can sometimes blind them to emerging financial distress, potentially delaying crucial financial decisions (Ben-David et al., 2013). In essence, while their bold financing choices can be innovative, they also come with heightened risks, reflecting the intricate balance of CEO overconfidence in financial decision-making.

In the arena of Mergers and Acquisitions, CEO overconfidence plays a pivotal role, often leading to bold and aggressive acquisition strategies (Roll, 1986). Overconfident CEOs tend to initiate more acquisitions, driven by their belief in spotting undervalued targets and realizing synergies others might overlook. This confidence, however, can result in them paying higher acquisition premiums, potentially overestimating the target's value (Hayward and Hambrick, 1997). After acquisition, they might be overly optimistic about integration, and underestimate the complexities

of merging operations, cultures, and systems (Malmendier and Tate, 2008). Additionally, such CEOs might lean towards diversifying acquisitions, expanding into varied industries with the belief they can manage diverse sectors effectively, though this can lead to overextension (Morck et al., 1990). While some overconfident CEOs indeed drive post-acquisition growth, many face challenges when their optimistic projections clash with on-ground realities (Andrade et al., 2001). In sum, CEO overconfidence in merge and acquisition could lead to transformative decisions, but it also brings about heightened risks.

CEO overconfidence impacts a firm's dividend policy. Overconfident CEOs, trusting in their ability to generate higher internal returns, often lean towards retaining earnings rather than distributing them as dividends (Deshmukh et al., 2013). This inclination can be amplified by self-attribution bias, where such CEOs credit past successes to their personal prowess and believe in replicating these successes with more internal resources (Daniel et al., 1998). While traditional finance views dividends as a signal of firm health, overconfident CEOs might downplay this, expecting the market to recognize the firm's value in due course (Baker and Wurgler, 2004). Instead of regular dividends, they might favour share repurchases, seeing them as a way to both return value to shareholders and signal confidence in the firm's future (Dittmar, 2000). Generally, though overconfident CEOs' dividend policies might reflect their optimism, they also highlight the behavioural nuances influencing corporate financial decisions.

CEO overconfidence influences a firm's approach to risk management. Overconfident CEOs often view risks more as navigable challenges or untapped opportunities rather than threats, leading them to potentially underestimate their impact (Malmendier and Tate, 2005). Such CEOs might shy away from traditional hedging, believing they can adeptly handle adverse market shifts without such safeguards (Tversky and Kahneman, 1992). They may also be more comfortable with higher leverage, confident in their firm's prospects and their ability to manage debt, even in fluctuating markets (Hackbarth, 2009). Additionally, though diversification is typically a risk-mitigating strategy, overconfident CEOs might pursue it with an ambition to manage and extract value from varied business areas (Morck et al., 1990). However, during crises, their unwavering self-belief might delay essential interventions, potentially intensifying the firm's challenges (Ben-David et al.,

2013). In sum, while CEO overconfidence can spur bold risk-taking, it also brings about potential vulnerabilities that firms need to navigate carefully.

4.2.4 CEO overconfidence and financial constraints

Previous literature indicate that CEO overconfidence is positively related to financial constraints. Malmendier and Tate (2005), Malmendier and Tate (2008) and Malmendier and Tate (2005) investigate the relation between financial constraints and CEO overconfidence. Fundamentally, they assume that CEO overconfidence is characterized by their tendency to overestimate the value they believe they can create. This overestimation appears in two ways: believing that the market undervalues the company's current assets and overvaluing potential future investments they might choose. CEOs, in this context, make decisions on investment levels, encompassing both internal (like capital expenditure) and external investments (like mergers). CEOs also decide on the financing method, choosing between internal cash flow or external equity capital. An overconfident CEO trusts the market price for riskless debt financing but disagrees with potential shareholders on the worth of an equity stake in the firm, leading to a difference in perceived value of newly issued shares. While rational CEOs see all capital sources as equal and believe market prices are set appropriately, overconfident CEOs avoid risky external equity capital. They believe the market undervalues their firm's equity, leading them to prioritize internal financing to prevent perceived dilution. Consequently, their investment decisions are more influenced by the availability of internal cash flow, thus facing more financial constraints.

Empirically, several studies explore the relationship between managerial optimism or overconfidence and investment-cash flow sensitivity across different countries and contexts. Lin et al. (2005) find a positive correlation between investment and internal cash flow among Taiwanese companies. Similarly, Glaser et al. (2008) observe that firms with optimistic managers invest more and exhibit higher investment-cash flow sensitivity. Huang et al. (2011) note this relationship in Chinese companies, but it is significant only for state-controlled firms due to their higher agency costs. Mohamed et al. (2014) find that optimistic managers in American firms significantly influence corporate investment, especially when internal financing is available, leading to potential investment distortions. Maditinos et al. (2015) confirm in their study on Greek

companies that optimistic managers make investments more sensitive to cash flow. Lastly, Koo and Yang (2018) report that overconfident managers in Korean firms tend to commit more to investments, suggesting a propensity for excessive investment decisions. In summary, across various studies and regions, managerial optimism or overconfidence consistently appears to heighten investment-cash flow sensitivity.

However, although previous literature show consistence in the relation between financial constraints and CEO overconfidence, it comes with drawbacks of over-reliance on investment sensitivity as the measure of financial constraints. This method might oversimplify the multifaceted nature of financial constraints, failing to capture the nuances of constraints arising from diverse reasons such as market conditions or internal policies (Kaplan and Zingales, 1997). Additionally, endogeneity issues arise as investment decisions are influenced by various factors, making it difficult to single out the impact of financial constraints (Whited, 1992). Furthermore, the heterogeneity of firms in terms of investment opportunities and risk profiles suggests that a singular approach might not be universally applicable (Gomes, 2001). Potential measurement errors, especially when relying on accounting data, can also skew results (Erickson and Whited, 2000). It is crucial to consider these limitations and potentially integrate other proxies or qualitative insights for a more comprehensive understanding of financial constraints.

4.2.5 Hypothesis development

According to afore mentioned literature, I develop two competing hypotheses. The first hypothesis conjectures that overconfident CEO is associated with less risk of financial constraints. The rationale is that overconfident CEOs often adopt strategic communication through their investment and financing decisions, conveying a sense of optimism about the company's future to stakeholders, which can further bridge the information gap, attracting more investments and alleviating financial pressures, since the market might interpret such decisions as signals of private positive information (Daniel et al., 1998). Furthermore, overconfident CEOs' inclination to support high-risk, innovative ventures is seen as a strategic move, narrowing the knowledge divide between leadership and investors, which in turn could reduce agency problem and further financial constraints (Hirshleifer et al., 2012). Additionally, their preference for internal financing or debt,

aimed at preventing equity dilution, aligns their stake with shareholders (Phua et al., 2018), curtailing agency-related expenses and subsequently easing financial constraints (Malmendier and Tate, 2005).

H1. With an overconfidence CEO, firm faces less risk of financial constraints.

The second hypothesis predicts the opposite result. Overconfident CEOs, in their tendency to overestimate returns, can inadvertently lead to mispricing and the misallocation of resources. Such actions can intensify information asymmetry, making it challenging for the market to accurately gauge the firm's true value, thereby amplifying financial constraints (Malmendier and Tate, 2005). CEO overconfidence can also manifest in the realm of risk management. A miscalculated risk assessment might result in inadequate hedging or risk strategies, further widening the information alienation between shareholders and managers, leading to higher risk of financial constraints (Gervais et al., 2011). Additionally, such CEOs may sometimes pursue projects that diverge from shareholder interests, intensifying agency conflicts and financial pressures (Jensen and Meckling, 1976). This risk-taking propensity can also be at odds with the preferences of debt holders, escalating agency costs and further straining the firm's financial position (Myers, 1977).

H2. With an overconfidence CEO, firm faces more risk of financial constraints.

4.3 Empirical design

4.3.1 Measure of CEO overconfidence

Following Malmendier and Tate (2005), the stock option proxy is adopted to measure CEO overconfidence. This measure assumes that overconfident CEOs prefer not to exercise in-the-money stock option timely, due to their overestimation of the stock price, compared to rational CEOs. I utilize ExecuComp variables to determine the average percentage moneyness of stock options, defined as the per-option average estimated profit divided by the average estimated exercise price. Three specific variables are obtained from ExecuComp: *OPT_UNEX_EXER_EST_VAL* (estimated value of the exercisable unexercised options),

OPT_UNEX_EXER_NUM (number of exercisable unexercised options), and *PRCCF* (year-end stock price).

First, I calculate the average estimated profit per option by dividing *OPT_UNEX_EXER_EST_VAL* by *OPT_UNEX_EXER_NUM*. Subsequently, I estimate the average estimated exercise price price by subtracting the average profit per option from *PRCCF*. The moneyness is then determined by dividing the average profit by the average exercise price.

CEOs are classified as overconfident from the first instance they retain stock options that are more than 67% in the money. Variable *ceo_overconfidence67* is created as an indicator variable that equals 1 if a firm is managed by an overconfident CEO and 0 otherwise. Furthermore, motivated by Campbell et al. (2011), I classify firms with CEOs who once holding option that have moneyness higher than 100% as *high_optimism*, and low than 30% *low_optimism*, between 30% to 100% *mid_optimism*.

4.3.2 Control variables

Drawing from prior research (Masulisa et al., 2012; Faleye et al., 2018), there is evidence that smaller and younger firms often encounter challenges in securing external funds compared to their larger, well-established counterparts, primarily because their business models might not yet be recognized in the market. Thus, I control for firm size and age. Moreover, firms with abundant investment opportunities often seek external capital, potentially incurring a higher cost for this capital and increasing the risk of financial constraints (Denis and Sibilkov, 2010). I account for this by using Tobin's Q and sales growth as proxies for investment opportunities. Additionally, various studies have presented mixed findings on the relationship between financial constraints and factors like return on assets (ROA), research and development intensity, and market capitalization (Ding et al., 2013; Kim and Sohn, 2013; Cheng et al., 2014; Erel et al., 2015; Chan et al., 2017; Campbell et al., 2021).

For board and CEO controls, I incorporate controls for the average age of board members and the average tenure of independent directors. Additionally, I adjust for factors influencing board

efficacy, such as board size (number of members) and board independence (ratio of independent directors to total board members). Lastly, I account for the roles of CEO-chairman duality and CEO-founder duality, recognizing that founders and chairpersons often hold a distinct position and exert a unique influence on a firm's financial decisions.

4.3.3 Empirical specification

Through the following model, the relation between financial constraints and CEO overconfidence is examined.

$$Financial\ Constraints_{\ it} = \beta_0 + \beta_1 CEO\ overconfidence_{it-1} + \boldsymbol{\beta} Controls_{it-1} + \varepsilon$$

Where Financial Constraints is the score calculated from the naïve Bayes algorithm for each firm-year in chapter 2.3.2, CEO overconfidence is given by the stock option proxy. Controls includes Tobin's Q, sales growth, firm size, firm age, board size, board independence, average board age, average board tenure, CEO-founder duality, CEO-chairman duality. Year fixed effects and industry fixed effects based on two-digits SIC code are added in the regression. All the explanatory variables are lagged by 1 year to mitigate endogeneity concerns. The dependent variable is financial constraints, and the main independent variable of interest is CEO overconfidence. The detailed definitions of these variables are presented in the Appendix A.

4.4 Sample and data

To construct the sample, I use Compustat for accounting information, ExecuComp for CEO-related information, and SEC Edgar Database for financial reports, BoardEx for board-related information. In line with the criteria outlined in Whited and Wu (2006), I apply several exclusionary rules. Firms regulated under SIC codes 4900-4999 are removed, as are financial firms falling under SIC codes 6000-6999. To account for potential coding errors, firms that report total debt less than their short-term debt are excluded. Additionally, firms involved in mergers that account for over 15% of their book value of assets are also omitted. Firms with negative values for total assets, book equity, and sales are removed. Subsequently, firms from the four databases are aligned based on their Central Index Key (CIK). To avoid the lack of CEO-related information

before 2006 in Execucomp, the observations span from 2006 to 2019.This results in a sample of 15,661 firm-year observations, representing 3,219 distinct firms. All continuous variables in this dataset are winsorized at the 99th percentile.

Table 4-1 Summary statistics

The sample consists of 15,661 firm-year observations for 3,219 firms. The observation period is from 2006 to 2019. The variable *overconfident_coe67* is a binary indicator, set to one if the CEO is deemed overconfident and zero otherwise. Following Malmendier and Tate (2005), CEOs are labelled overconfident in the initial fiscal year when they retain exercisable executive options with a moneyness exceeding 67%. Motivated by Campbell et al. (2011), *high_optimisn* is a binary indicator that takes the value of one if a CEO holds executive options with moneyness surpassing 100% on at least one occasion during their tenure, *low_optimism* if lower 30%, and *mid_optimism* for others. fc is the score of financial constraint, as stated in Empirical Design. All variables are winsorized at both the 1% and 99% levels.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
overconfident_ceo67	15,661	0.21	0.41	0	0	0	0	1
high_optimism	15,661	0.01	0.10	0	0	0	0	1
mid_optimism	15,661	0.61	0.49	0	0	1	1	1
low_optimism	15,661	0.66	0.48	0	0	1	1	1
fc	15,661	0.07	0.26	0.00	0.00	0.00	0.00	1.00
firm_size	15,661	7.51	1.68	2.30	6.27	7.47	8.63	10.94
firm_age	15,661	25.77	14.74	1	14	23	43	47
Q	15,661	2.14	1.42	0.42	1.29	1.73	2.49	19.55
sales_growth	15,661	0.10	0.48	-0.83	-0.01	0.05	0.13	10.05
ROA	15,661	0.12	0.12	-1.96	0.08	0.13	0.17	0.42
rd_intensity	15,661	0.26	2.89	0.00	0.01	0.03	0.10	60.91
market_capitalization	15,661	6,905.45	11,279.49	3.97	697.07	2,029.04	6,912.41	45,199.62
board_age	15,661	62.60	3.98	44.91	60.19	62.79	65.16	78.60
board_tenure	15,661	6.45	2.95	0.00	4.49	6.20	8.13	23.58
board_size	15,661	9.07	2.14	4	8	9	11	18
board_independence	15,661	0.85	0.07	0.38	0.83	0.88	0.90	0.94
ceo_founder_duality	15,661	0.0002	0.01	0	0	0	0	1
ceo_chairman_duality	15,661	0.45	0.50	0	0	0	1	1
kz	15,661	0.71	1.60	-18.2	0.03	0.69	1.46	10.27
ww	15,661	-0.36	0.10	-0.57	-0.43	-0.36	-0.30	0.19
sa	15,661	-3.87	0.57	-4.58	-4.50	-3.86	-3.45	-1.88

tangibility	15,661	0.46	0.16	0.05	0.34	0.45	0.56	0.98

Table 4-1 provides summary statistics for the sample. The mean for fc is 0.07, indicating 7% of the observations are in the status of financial constraints. *overconfident_ceo67* is 0.21 averagely, meaning the 21% of the observations are run by overconfident CEOs. Due to the deletion of observations with missing data, the sum of the means of *high_optimism*, *mid_optimism*, and *low_optimism* does not equal 1.

For firm-specific controls, averagely log of total assets (*firm_size*) is 7.51; firm age is 25.77; Tobin's Q is 2.14; sales growth is 0.10; return on assets is 0.12; market capitalization is 6,905.45, *rd_intensity* is 0.26. For board-specific and CEO-specific controls, the average age of boards is 62.60; average board tenure is 6.45; the number of board member is 9.07 averagely; the independence of boards is averagely 85%. In 0.02% of all observations, CEO is also founder and in 45%, CEO is also board chair. For alternative measures of financial constraints, the average score of KZ index is 0.71, WW is -0.36, SA is -3.87, and tangibility 0.46.

4.5 Baseline results

Table 4-2 reports the baseline results. Column (1) reports the regression results of overconfident_ceo67 and financial constraints score, column (2) for *high_optimism*, column (3) for *mid_optimism*, and column (4) for *low_optimism*. The coefficients for *overconfident_ceo67*, *high_optimism*, and *mid_optimism* are negative, but there is no significance, indicating that being an overconfident CEO may not exert impacts on firm's financial status. *low_optimism* shows positive and significant relation to financial constraints, indicating that CEOs with less overconfidence tend to face higher risk of financial constraints, based on the stock option proxy as CEO overconfidence measure.

The findings of this study reveal that there is no significant relationship between CEO overconfidence and financial constraints. Contrary to the common assumption that overconfident CEOs might exacerbate financial constraints through overly aggressive investment decisions and

risk-taking (Malmendier and Tate,2008; Malmendier and Tate,2015; Lin, 2007; Glaser et al., 2008; Huang et al., 2011; Mohamed et al., 2014; Maditinos et al., 2015)., the results do not support this hypothesis. Instead, the data suggest that CEO overconfidence does not play a significant role in determining a firm's financial constraints. Interestingly, the study finds that CEOs with low confidence are associated with a higher risk of financial constraints. This result indicates that the lack of confidence in CEOs might lead to more conservative decision-making, which in turn could limit a firm's financial flexibility and access to capital. Low-confidence CEOs may be overly cautious, avoiding necessary investments or strategic moves that could enhance the firm's financial standing (Ye and Yuan, 2008).

These findings diverge from much of the existing literature that highlights the potential risks posed by overconfident CEOs. Previous research often suggests that overconfident CEOs, driven by their belief in their ability to generate superior returns, might undertake excessive risk, leading to financial distress (Malmendier and Tate,2008; Malmendier and Tate,2015; Lin, 2007; Glaser et al., 2008; Huang et al., 2011; Mohamed et al., 2014; Maditinos et al., 2015). However, the results do not find a significant correlation between overconfidence and financial constraints, suggesting that the impact of CEO overconfidence might be more nuanced or context-dependent than previously thought. On the other hand, the finding that low-confidence CEOs are linked to higher financial constraints aligns with some strands of the literature emphasizing the drawbacks of excessive risk aversion. For instance, Opper et al. (2013) argue that risk-averse CEOs may underinvest in profitable projects, leading to suboptimal firm performance and further influence the ability of capital collection.

The implications of these findings are twofold. Firstly, they suggest that the presence of an overconfident CEO may not necessarily lead to heightened financial constraints. This could imply that firms might not need to be as wary of overconfidence in their top executives as previously thought, provided that adequate governance mechanisms are in place to check any potential excesses. Secondly, the association between low-confidence CEOs and higher financial constraints highlights the potential risks of excessive conservatism in executive decision-making. Firms with risk-averse leaders may face greater financial difficulties due to missed opportunities and insufficient strategic investments. This suggests that boards should consider the confidence levels

of their CEOs and encourage a balanced approach to risk-taking, ensuring that their leaders are neither too reckless nor overly cautious.

In terms of control variables, there are several finding worth reporting. Coefficients of *firm_age* are all negative and significant at 1% for the four regressions, which are in line with most previous studies (Masulisa et al., 2012). The business models of older firms usually enjoy greater acceptance in capital market, lowering their cost of raising capital. Additionally, the two proxies for investment opportunities, *sales_growth* and *Q* are both positive and significant for the four regressions, which is in line with the prevalent perception that firms with more investment opportunities demand more capital and therefore face higher risk of financial constraints. Moreover, the coefficients of *ROA* are significantly negative, indicating that firms with higher *ROA* faces less risk of financial constraints. According to Kim and Sohn (2013), investors tend to invest firms with higher ROA for higher return, which lowers the cost of money collection for the firms. Lastly, the coefficients of *rd_intensity* are positive and significant, which is in line with the idea that high R&D investment increases the uncertainty and the cost of assessment, further increasing the cost of capital.

Table 4-2 Baseline results

This table reports the regression results of CEO overconfidence on financial constraint. The sample is from U.S. listed firms (excluding the financial firms) from 2006 to 2019, including 15,661 firm-year observations. The dependent variable is financial constraint score, which is calculated by the author. The main independent variables of interest are *overconfident_ceo67*, *high_optimism*, *mid_optimism*, and *low_optimism*. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include industry fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	(1)	(2)	(3)	(4)
overconfident_ceo67	-0.006438			
	(0.007917)			
high_optimism		-0.043391		
		(0.031449)		
mid_optimism			-0.005552	
			(0.006657)	

low_optimism				0.018318***
				(0.006665)
firm_age	-0.001704***	-0.001675***	-0.001690***	-0.001723***
	(0.000264)	(0.000261)	(0.000262)	(0.000261)
firm_size	0.004467	0.004353	0.004645	0.004945
	(0.003775)	(0.003775)	(0.003782)	(0.003777)
sales_growth	0.052647***	0.052453***	0.052602***	0.052659***
	(0.006518)	(0.006515)	(0.006517)	(0.006512)
Q	0.026712***	0.026508***	0.026821***	0.027154***
	(0.002565)	(0.002553)	(0.002580)	(0.002562)
ROA	-0.439116***	-0.439299***	-0.438737***	-0.435627***
	(0.028913)	(0.028887)	(0.028936)	(0.028913)
rd_intensity	0.004945***	0.004950***	0.004973***	0.004934***
	(0.001120)	(0.001120)	(0.001120)	(0.001119)
market_capitalization	0.000001*	0.000001*	0.000001*	0.000001*
	(0.0000005)	(0.0000005)	(0.0000005)	(0.0000005)
ceo_chairman_duality	-0.013643**	-0.013915**	-0.013392**	-0.015354**
	(0.006451)	(0.006407)	(0.006492)	(0.006409)
ceo_founder_duality	-0.008275	-0.006889	-0.010233	-0.015351
	(0.224294)	(0.224257)	(0.224330)	(0.224167)
board_size	-0.001301	-0.001125	-0.001285	-0.001307
	(0.002069)	(0.002063)	(0.002067)	(0.002063)
board_age	0.000891	0.000933	0.000913	0.000782
	(0.000930)	(0.000930)	(0.000930)	(0.000930)
board_tenure	0.005346***	0.005218***	0.005401***	0.004954***
	(0.001262)	(0.001255)	(0.001270)	(0.001258)
board_independence	0.077246	0.077587	0.077867	0.070285
	(0.048986)	(0.048977)	(0.048983)	(0.049027)
Industry FE		Yes		
Year FE		Yes		
Observations	15,661	15,661	15,661	15,661
R^2	0.251500	0.251667	0.251505	0.252423
Adjusted R^2	0.241990	0.242159	0.241995	0.242924
F Statistic (df = 60; 5588)	31.293380***	31.321040***	31.294140***	31.446850***
Note:	*p<0.1; **p<0.05; ***p<0.01			

4.6 Robustness test

4.6.1 Alternative measure of financial constraints

Previous section uses text-based measure of financial constraints in model. In this section, several common alternative measures of financial constraints are used for robustness test, including KZ index, SA index, WW index, and tangibility.

Following model is adopted for the test.

$$Alternative\ measures_{\ it} = \beta_0 + \beta_1 CEO\ overconfidence_{\ it-1} + \boldsymbol{\beta} Controls_{it-1} + \varepsilon$$

To save space, the results are in Appendix B. The results of using tangibility as measure of financial constraints are consistent with the baseline analysis in that low confident CEOs exaggerate risk of financial constraints. The results also find negative and significant coefficient in high_optimism and mid_optimism, implying that firms with overconfident CEOs faces less possibility of financial constraints. However, results in model with KZ index, SA index, and WW index do not present significance.

4.6.2 Propensity score matching

Another challenge that the baseline model face is the assumption of linear relationship, which may lead to biases, if the relation is fundamentally non-linear. Motivated by Aktas et al. (2019), I use propensity score matching (PSM) process to generate two datasets, control group and treatment group, with parallel trends to address the concern. To find parallel trends, I use the same control variables in baseline analysis, including firm age, firm size, Tobin's Q, sales growth, ROA, rd_intensity, market_capitalization, CEO chairman duality, CEO founder duality, board size, board age, board tenure, board independence. The two datasets are comparable in terms of all control variables but differ only on the CEO's overconfidence.

I first divide firms into two categories, with overconfident CEOs and without overconfident CEOs. Then all the observations without overconfident CEOs are given a propensity score based on the matching criteria using probit model. Based on the nearest neighbour matching method, those pairs of firm-years within calliper of 0.01 are treatment group and control group. Matching a control group based on the year a firm with overconfident CEO could introduce endogeneity issues. To mitigate this, I match the control and treatment groups using firm data from one year before. I find 168 pairs of firms for treatment group and control group.

Table 4-3 reports the balance summary between the two groups. SMD stands for standardized mean difference, which represents the difference between the means of the treatment and control groups, adjusted by the covariate's standard deviation. An SMD near zero suggests a well-balanced match, indicating minimal differences between the two groups. An SMD value below 0.1 is generally deemed acceptable for matched samples. As shown in Table 4-3, all covariates meet this criterion, suggesting that the matched firms follow a trend parallel to the treatment group. I then rerun the model in baseline analysis using the matched datasets, which is shown in table 4-4. The results are consistent with baseline results.

Table 4-3 balance summary for propensity score matching

Table 4-3 shows the balancing table of 168 pairs of firms between treatment group and control group. Standardized mean difference (SMD) is used to indicate the goodness of balance between treatment group and control group. A threshold of less than 0.1 for SMD is usually acceptable for the matched sample.

variables	Treatment	control	SMD
firm_size	7.21 (1.37)	7.27 (1.64)	0.037
firm_age	19.25 (13.88)	20.52 (14.75)	0.089
Q	2.93 (1.77)	3.20 (1.82)	0.107
sales_growth	0.16 (0.33)	0.26 (0.39)	0.068
ROA	0.16 (0.08)	0.17 (0.10)	0.067
rd_intensity	0.07 (0.09)	0.08 (0.15)	0.006
market_capitalization	5319.87 (8446.38)	6928.17 (10688.54)	0.097
board_age	62.23 (4.06)	62.06 (4.85)	0.036
board_tenure	5.78 (3.00)	5.94 (3.06)	0.051

board_size	8.62 (2.14)	8.57 (1.82)	0.024
board_independence	0.82 (0.09)	0.82 (0.09)	0.012
ceo_founder_duality	0.00 (0.00)	0.00 (0.00)	<0.001
ceo_chairman_duality	0.38 (0.49)	0.38 (0.49)	<0.001

Table 4-4 baseline regression on the matched sample

Table 4-4 reports the coefficient estimates of baseline model using the matched sample. The dependent variable is financial constraint. The independent variables of interest are *high_optimism*, *mid_optimism*, *low_optimism*, and *overconfident_ceo67*. All the independent variables are lagged by 1 year. Detailed definitions can be found in Appendix A. The regression includes year fixed effects and industry fixed effects. All variables are winsorized at both the 1% and 99% levels. Standard errors appear in parentheses.

	(1)	(2)	(3)	(4)
overconfident_ceo67	-0.0514			
	(0.0555)			
high_optimism		-0.0489		
		(0.2920)		
mid_optimism			0.0049	
			(0.0530)	
low_optimism				0.0719***
				(0.0218)
firm_age	-0.0019	-0.0013	-0.0012	-0.0007
	(0.0022)	(0.0021)	(0.0021)	(0.0021)
firm_size	-0.0099	-0.0069	-0.0059	-0.0070
	(0.0284)	(0.0285)	(0.0283)	(0.0279)
sales_growth	-0.0904	-0.0908	-0.0903	-0.0943
	(0.0695)	(0.0698)	(0.0697)	(0.0692)
Q	-0.0239	-0.0232	-0.0233	-0.0270
	(0.0167)	(0.0167)	(0.0168)	(0.0168)
ROA	0.0128	0.0028	-0.0002	0.0695
	(0.2953)	(0.2962)	(0.2966)	(0.2973)
rd_intensity	0.3813*	0.3891*	0.3925*	0.4454**
	(0.2144)	(0.2150)	(0.2171)	(0.2166)

market_capitalization	0.000002	0.000002	0.000002	0.000002
	(0.000004)	(0.000004)	(0.000004)	(0.000004)
ceo_chairman_duality	0.0151	0.0101	0.0104	0.0133
	(0.0448)	(0.0450)	(0.0450)	(0.0444)
board_size	-0.0159	-0.0167	-0.0166	-0.0187
	(0.0138)	(0.0139)	(0.0139)	(0.0138)
board_age	-0.0001	-0.0004	-0.0005	-0.0018
	(0.0059)	(0.0059)	(0.0059)	(0.0059)
board_tenure	0.0216**	0.0214**	0.0213**	0.0257***
	(0.0094)	(0.0094)	(0.0094)	(0.0098)
board_independence	0.3637	0.3664	0.3627	0.4214*
	(0.2333)	(0.2342)	(0.2355)	(0.2353)
Industry FE		Yes		
Year FE		Yes		
Observations	336	336	336	336
R^2	0.2384	0.2331	0.2330	0.2461
F Statistic (df = 45; 120)	0.8347	0.8106	0.8101	0.8703
Note:	*p<0.1; **p<0.05; ***p<0.01			

4.7 Conclusion

Understanding the factors that influence financial constraints within firms is a crucial aspect of corporate finance and governance. This paper delves into the impact of CEO overconfidence on the risk of financial constraints, employing a text-based financial constraints index. The findings challenge conventional assumptions about the role of CEO confidence in managing a firm's financial health, presenting a nuanced perspective on how executive behavior can influence financial outcomes.

The primary finding of this study is that low CEO confidence is associated with a higher risk of financial constraints. This relationship persists even after integrating various variables that determine financial constraints, along with industry and year fixed effects. Interestingly, the study finds no evidence that overconfident CEOs contribute to financial constraints, contradicting the

widely held belief that overconfident CEOs, through their aggressive and risky decision-making, might exacerbate financial challenges within firms.

The association between low CEO confidence and heightened financial constraints suggests that CEOs who lack confidence may adopt overly conservative approaches to decision-making. Such conservatism can lead to missed opportunities and a reluctance to pursue necessary investments, ultimately restricting the firm's growth and financial flexibility. Low-confidence CEOs might avoid taking calculated risks that could diminish the firm's capital structure or strategic positioning, thereby increasing the likelihood of financial constraints.

To ensure the reliability of these findings, several robustness tests were conducted. These included using alternative measures of financial constraints and constructing a sample through a propensity score matching process. The consistency of the results across these various tests reinforces the validity of the primary findings and underscores the complex relationship between CEO confidence and financial constraints.

The findings of this study have important implications for both corporate practice and policymaking. Boards of directors and corporate governance bodies should be aware of the potential risks associated with low CEO confidence. While it is crucial to avoid reckless risk-taking, excessive conservatism can also be detrimental to a firm's financial health. Boards should strive to strike a balance, encouraging a level of confidence in CEOs that supports strategic risk-taking and innovation without leading to undue financial strain.

While this study provides new insights into the relationship between CEO confidence and financial constraints, one of the limitations must be acknowledged. The measures of CEO confidence used in this study may not capture all dimensions of confidence, potentially overlooking other relevant aspects such as situational confidence or confidence in specific areas of management. Future studies could refine these measures to provide a more comprehensive understanding of CEO confidence.

5. Conclusion

Chapter 2 examines how board interlocks affects a firm's financial constraint status. I adopt a novel measure of financial constraints using text-based analysis to discern information. This measure captures traits that financially constrained firms are conventionally thought to possess. With an unbalanced-panel sample comprising 15,537 firm-year observations from 3,125 distinct firms between 2008 and 2019, the data reveals that firms with greater board centrality typically experience fewer financial constraints. This observation aligns with the theory that increased board interconnections can mitigate financial constraints by facilitating information dissemination. Regarding potential endogeneity issues, the findings hold up under both the instrument variable approach and DiD analysis. For the instrument variable method, I employ two instruments to address board centrality. As for the DiD analysis, I first establish a control group using propensity score matching process and then leverage the death of an independent director as an external shock for the DiD test. These outcomes echo the primary analysis, implying a causal link from board centrality to financial constraints.

Chapter 3 probes into the influence of board expertise on financial constraints. Using data from U.S. industrial companies listed between 2018 and 2019, I find a significant negative relationship between board expertise and financial constraints. This negative impact is further supported by multiple robustness tests, including alternative financial constraint measures and examining the third lag of board expertise. While the data suggests that hiring fewer industry experts may help firms evade financial constraints, many previous literatures underscore the significance of board expertise, indicating a need for further studies. One potential explanation for this unforeseen negative effect might be ambition. Ambitious firms might be inclined to recruit more industry specialists and simultaneously pursue substantial investments, potentially amplifying their capital needs and consequently, capital costs. Nevertheless, I reserve this hypothesis for future exploration.

Chapter 4 delves into the relationship between CEO overconfidence and the risk of financial constraints. Utilizing a text-based financial constraints index, I observe that low CEO confidence can potentially heighten a firm's risk of financial constraints, even after accounting for various determinants of financial constraints, alongside industry and year fixed effects. Interestingly,

there's no substantial evidence linking high overconfident CEOs to financial constraints. To reinforce these findings, I performed multiple robustness tests, employing alternative financial constraint measures and regressing on a sample derived from a propensity score matching method. These tests corroborate the initial findings. Nonetheless, these outcomes diverge from earlier research addressing the link between CEO overconfidence and financial constraints. This disparity might arise from differing proxies for financial constraints used in various studies. Given the discrepancy, prudence is urged in policy recommendations, and more in-depth research is needed.

6. Appendix A. Variable definition

Variable definition for chapter 2

Dependent variables	
fc	score of financial constraint, as stated in Empirical Design.
Explanatory variables	
degree	quantile ranking of degree centrality, as stated in Empirical Design.
closeness	quantile ranking of closeness centrality, as stated in Empirical Design.
betweenness	quantile ranking of betweenness centrality, as stated in Empirical Design.
eigen_centrality	quantile ranking of eigenvector centrality, as stated in Empirical Design.
centrality	quantile ranking of all the four centralities.
other_centrality	quantile ranking of the average of closeness, betweenness, and eigenvector.
Board variables	
ceo_chairman_duality	1, if CEO is chairman; 0, otherwise
ceo_founder_duality	1, if CEO is founder; 0, otherwise
board size	the number of board members for a specific firm in a year
fraction_indep_mba	the number of independent directors who has elite MBA degree divided by the number of all board members for a firm in a year.
Sector_indep	the average number of Fama-French 48 industries the independent directors in a board have worked for in the past.
Firm-specific variables	
Q	*((csho*prcc_f+at-(ceq+txdb))/at)*
firm_size	the natural logarithm of the book value of assets (*at*).
firm_age	the number of years the firm is listed with a non-missing stock price on Compustat.
cash_holding	The ratio of cash and short-term investments (*che*) to total assets (*at*)

cash_flow	Operating income before depreciation (*oancf*) scaled by lagged total assets (*at*)
rd_to_sales	research and development expenditure (*xrd*) divided by sale (*sale*)
capital_expenditure	Capital Expenditures/ total assets *(capx/at)*
dividend	the sum of Dividends Common/Ordinary (*dvc*) and Dividends - Preferred/Preference(*dvp*) divided by total assets(*at*)
Alternative measures of financial constraints	
kz	Following Baker et al. (2003), *–1.002[(ib + dp)/lagged asset] + 0.283[(at + prcc_ f × csho - ceq - txdb)/at] + 3.139 [(dltt + dlc)/(dltt + dlc + seq)] – 39.368 [(dvc + dvp)/lagged ppent] – 1.315[che/lagged ppent]*
ww	Following Whited and Wu (2006), *–0.091 [(ib + dp)/at] – 0.062DIVPOS + 0.021[dltt/at] – 0.044[log(at)] + 0.102ISG – 0.035[sales growth]*, *DIVPOS* is an indicator that takes 1 if *dvc + dvp* is positive, *ISG* is industry sales growth according to first three digits of SIC for each year.
sa	Following Hadlock and Pierce (2010), $-0.737Size + 0.043Size^2 - 0.040Age$, where *Size* is log of inflation-adjusted (to 2004) assets, *Age* is the number of years a firm is listed with non-missing stock price on Compustat. Size is winsorized at 4.5 billion dollars and Age at 37 years.
tangibility	Folloing Hu and Liu (2015), *(che+0.715*rect+0.547*invt+0.535*ppent)/at)*

Variable definition for chapter 3

Dependent variables	
fc	score of financial constraint, as stated in Empirical Design.
Explanatory variables	
Board_industry_expertise_number	quantile ranking of degree centrality, as stated in Empirical Design.
Board_industry_expertise_percent	quantile ranking of closeness centrality, as stated in Empirical Design.
Board_industry_expertise	quantile ranking of betweenness centrality, as stated in Empirical Design.
CEO-specific controls	
ceo_chairman_duality	1, if CEO is chairman; 0, otherwise
ceo_founder_duality	1, if CEO is founder; 0, otherwise
Board-specific controls	
board size	the number of board members for a specific firm in a year
board_age	The average age in board members
board_tenure	The average tenure in board members
board_independence	The proportion of independent directors to board members
Firm-specific variables	
Q	*((csho*prcc_f+at-(ceq+txdb))/at)*
firm_size	the natural logarithm of the book value of assets (*at*).
firm_age	the number of years the firm is listed with a non-missing stock price on Compustat.
sales_growth	Percentage changes of sales between previous year and current year.
ROA	*(oibdp/at)*
leverage	*((dltt+dlc)/at)*
market_capitalization	*(csho*prcc_f)*
rd_intensity	research and development expenditure (*xrd*) divided by sale (*sale*)

Alternative measures of financial constraints	
kz	Following Baker et al. (2003), *–1.002[(ib + dp)/lagged asset] + 0.283[(at + prcc_ f × csho - ceq - txdb)/at] + 3.139 [(dltt + dlc)/(dltt + dlc + seq)] – 39.368 [(dvc + dvp)/lagged ppent] – 1.315[che/lagged ppent]*
ww	Following Whited and Wu (2006), *–0.091 [(ib + dp)/at] – 0.062DIVPOS + 0.021[dltt/at] – 0.044[log(at)] + 0.102ISG – 0.035[sales growth], DIVPOS* is an indicator that takes 1 if *dvc + dvp* is positive, *ISG* is industry sales growth according to first three digits of SIC for each year.
sa	Following Hadlock and Pierce (2010), *–0.737Size + 0.043Size^2 – 0.040Age*, where *Size* is log of inflation-adjusted (to 2004) assets, *Age* is the number of years a firm is listed with non-missing stock price on Compustat. *Size* is winsorized at 4.5 billion dollars and Age at 37 years.
tangibility	Folloing Hu and Liu (2015), *(che+0.715*rect+0.547*invt+0.535*ppent)/at)*

Variable definition for chapter 4

Dependent variable	
fc	score of financial constraint, as stated in Empirical Design.
Explanatory variables	
overconfident_ceo67	an indicator variable equals 1, if the firm is run by overconfident CEO, otherwise 0. Following Hirshleifer et al. (2012), A CEO is labeled overconfident since the first time they retain stock options that exceed 67% in the money.
high_optimism	An indicator variable equals 1, if the firm is run by a CEO with high optimism. A CEO is labeled high optimism, since the first time holding executive options that have moneyness greater than 100%.
mid_optimism	An indicator variable equals 1, if the firm is run by a CEO with mid optimism. A CEO is labeled mid optimism, if holding executive options that have moneyness between 30% and 100% during the tenure.
low_optimism	An indicator variable equals 1, if the firm is run by a CEO with low optimism. A CEO is labeled low optimism, if holding executive options that have moneyness less than 30% sduring the tenure.
CEO-specific controls	
ceo_chairman_duality	1, if CEO is chairman; 0, otherwise
ceo_founder_duality	1, if CEO is founder; 0, otherwise
Board-specific controls	
board size	the number of board members for a specific firm in a year
board_age	The average age in board members
board_tenure	The average tenure in board members
board_independence	The proportion of independent directors to board members
Firm-specific variables	
Q	*((csho*prcc_f+at-(ceq+txdb))/at)*
firm_size	the natural logarithm of the book value of assets (*at*).
firm_age	the number of years the firm is listed with a non-missing stock price on Compustat.
sales_growth	Percentage changes of sales between previous year and current year.
ROA	*(oibdp/at)*
market_capitalization	*(csho*prcc_f)*
rd_intensity	research and development expenditure (*xrd*) divided by sale (*sale*)
Alternative measures of financial constraints	

kz	Following Baker et al. (2003), *–1.002[(ib + dp)/lagged asset] + 0.283[(at + prcc_ f × csho - ceq - txdb)/at] + 3.139 [(dltt + dlc)/(dltt + dlc + seq)] – 39.368 [(dvc + dvp)/lagged ppent] – 1.315[che/lagged ppent]*
ww	Following Whited and Wu (2006), *–0.091 [(ib + dp)/at] – 0.062DIVPOS + 0.021[dltt/at] – 0.044[log(at)] + 0.102ISG – 0.035[sales growth]*, *DIVPOS* is an indicator that takes 1 if *dvc + dvp* is positive, *ISG* is industry sales growth according to first three digits of SIC for each year.
sa	Following Hadlock and Pierce (2010), *–0.737Size + 0.043Size^2 – 0.040Age*, where *Size* is log of inflation-adjusted (to 2004) assets, *Age* is the number of years a firm is listed with non-missing stock price on Compustat. *Size* is winsorized at 4.5 billion dollars and Age at 37 years.
tangibility	Folloing Hu and Liu (2015), *(che+0.715*rect+0.547*invt+0.535*ppent)/at)*

7. Appendix B. Alternative tests

Table 7-1: Board interlocks and alternative measures of financial constraints

This table reports the regression results of board centrality on alternative measures of financial constraint using an OLS regression. The sample is from U.S. listed firms (excluding the financial firms) from 2008 to 2019. The dependent variables are *kz*, *ww*, *sa*, and *tangibility*. The main independent variable of interest is centrality. *Centrality* is the average of *degree*, *betweenness*, *closeness* and *eigenvector*. The detailed measurements of those variables can be found in section 3 and Appendix A. All the independent variables are lagged by 1 year. All regressions include year fixed effects and firm fixed effects. All variables are winsorized at both the 1% and 99% levels. Standard errors appear in parentheses. $***p < 0.01$; $**p < 0.05$; $*p < 0.1$.

	Dependent variable:			
	kz	*ww*	*sa*	*tangibility*
centrality	0.002	0.0001	0.004*	-0.0002
	(0.028)	(0.001)	(0.002)	(0.002)
firm_age	-0.002	-0.001**	-0.042***	-0.001
	(0.012)	(0.0005)	(0.001)	(0.001)
firm_size	-0.057*	-0.046***	-0.121***	-0.038***
	(0.034)	(0.001)	(0.002)	(0.002)
sales_growth	0.099***	0.022***	0.022***	0.005***
	(0.022)	(0.001)	(0.002)	(0.002)
Q	-0.002	0.001	0.006***	0.007***
	(0.013)	(0.001)	(0.001)	(0.001)
ceo_chairman_duality	0.019	-0.001	-0.004	-0.004
	(0.035)	(0.001)	(0.003)	(0.002)
ceo_founder_duality	-0.097	0.081**	-0.066	0.009
	(0.943)	(0.039)	(0.070)	(0.066)
board_size	0.003	-0.001	-0.0005	0.0005
	(0.011)	(0.0004)	(0.001)	(0.001)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	10,829	10,829	10,829	10,829
R^2	0.003	0.172	0.406	0.049
Adjusted R^2	-0.304	-0.082	0.223	-0.244
F Statistic (df = 8; 8284)	2.783***	215.456***	706.595***	52.943***
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 7-2: Board expertise and KZ index

This table reports the regression results of board industry expertise on financial constraint. The sample is from U.S. listed firms (excluding the financial firms) from 2008 to 2019. The dependent variable is KZ index. The main independent variables of interest are *board_industry_expertise_number*, *board_industry_expertise_percent*, and *board_industry_expertise*. *board_industry_expertise_number* is the number of industry experts; *board_industry_expertise_percent* is the proportion of industry experts in independent directors; *board_industry_expertise* is a dummy variable equals 1 if there is any industry expert in board, 0 otherwise. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include year fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable:		
	kz		
board_industry_expertise	0.079474		
	(0.062685)		
board_industry_expertise_number		0.015909	
		(0.013992)	
board_industry_expertise_percent			0.089488
			(0.094339)
firm_age	-0.008894***	-0.008752***	-0.008775***
	(0.001705)	(0.001704)	(0.001704)
firm_size	0.205341***	0.205637***	0.205844***
	(0.017675)	(0.017667)	(0.017668)
sales_growth	0.090502***	0.090015***	0.089935***
	(0.021480)	(0.021487)	(0.021492)
Q	0.087591***	0.087185***	0.087321***
	(0.009554)	(0.009557)	(0.009555)
ROA	-1.135036***	-1.132898***	-1.132231***
	(0.083615)	(0.083585)	(0.083583)
leverage	2.643018***	2.642489***	2.642881***
	(0.078077)	(0.078075)	(0.078084)
rd_intensity	-0.016756***	-0.016791***	-0.016808***
	(0.003135)	(0.003136)	(0.003138)
market_capitalization	-0.000016***	-0.000016***	-0.000016***
	(0.000003)	(0.000003)	(0.000003)

ceo_chairman_duality	0.070321*	0.069066*	0.068391*
	(0.040907)	(0.040847)	(0.040877)
ceo_founder_duality	-0.691722	-0.665193	-0.668949
	(0.760253)	(0.760440)	(0.760446)
board_size	0.008319	0.007119	0.010596
	(0.013074)	(0.013199)	(0.013110)
board_age	-0.013029**	-0.013268**	-0.013206**
	(0.005276)	(0.005294)	(0.005298)
board_tenure	-0.033068***	-0.032800***	-0.032861***
	(0.007524)	(0.007574)	(0.007607)
board_independence	-0.067937	-0.068874	-0.030563
	(0.269858)	(0.271252)	(0.266523)
Industry FE		Yes	
Year FE		Yes	
Observations	8,081	8,081	8,081
R^2	0.257138	0.257109	0.257073
Adjusted R^2	0.250366	0.250336	0.250299
F Statistic (df = 64; 8007)	43.306040***	43.299430***	43.291160***
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 7-3: Board expertise and SA index

This table reports the regression results of board industry expertise on financial constraint. The sample is from U.S. listed firms (excluding the financial firms) from 2008 to 2019. The dependent variable is SA index. The main independent variables of interest are *board_industry_expertise_number*, *board_industry_expertise_percent*, and *board_industry_expertise*. *board_industry_expertise_number* is the number of industry experts; *board_industry_expertise*_percent is the proportion of industry experts in independent directors; *board_industry_expertise* is a dummy variable equals 1 if there is any industry expert in board, 0 otherwise. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include year fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable:		
	sa		
board_industry_expertise	-0.057434***		
	(0.006400)		
board_industry_expertise_number		-0.012076***	
		(0.001429)	
board_industry_expertise_percent			-0.084695***
			(0.009634)
firm_age	-0.030591***	-0.030694***	-0.030681***
	(0.000174)	(0.000174)	(0.000174)
firm_size	-0.233635***	-0.233804***	-0.233769***
	(0.001805)	(0.001805)	(0.001804)
sales_growth	0.016058***	0.016432***	0.016615***
	(0.002193)	(0.002195)	(0.002195)
Q	-0.006586***	-0.006281***	-0.006352***
	(0.000975)	(0.000976)	(0.000976)
ROA	-0.170679***	-0.172187***	-0.172631***
	(0.008537)	(0.008539)	(0.008535)
leverage	0.067950***	0.068303***	0.067785***
	(0.007972)	(0.007976)	(0.007974)
rd_intensity	-0.000308	-0.000279	-0.000241
	(0.000320)	(0.000320)	(0.000320)
market_capitalization	0.000016***	0.000016***	0.000016***
	(0.0000003)	(0.0000003)	(0.0000003)
ceo_chairman_duality	0.025452***	0.026161***	0.025776***

	(0.004177)	(0.004173)	(0.004174)
ceo_founder_duality	-0.099068	-0.118949	-0.119039
	(0.077624)	(0.077685)	(0.077655)
board_size	0.007777***	0.008727***	0.005861***
	(0.001335)	(0.001348)	(0.001339)
board_age	0.000153	0.000346	0.000395
	(0.000539)	(0.000541)	(0.000541)
board_tenure	-0.010764***	-0.011009***	-0.011221***
	(0.000768)	(0.000774)	(0.000777)
board_independence	-0.160422***	-0.157314***	-0.181074***
	(0.027553)	(0.027711)	(0.027217)
Industry FE		Yes	
Year FE		Yes	
Observations	8,081	8,081	8,081
R^2	0.944058	0.943994	0.944035
Adjusted R^2	0.943548	0.943484	0.943525
F Statistic (df = 64; 8007)	2,111.291000***	2,108.761000***	2,110.396000***
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 7-4: Board expertise and WW index

This table reports the regression results of board industry expertise on financial constraint. The sample is from U.S. listed firms (excluding the financial firms) from 2008 to 2019. The dependent variable is WW index. The main independent variables of interest are *board_industry_expertise_number*, *board_industry_expertise_percent*, and *board_industry_expertise*. *board_industry_expertise_number* is the number of industry experts; *board_industry_expertise_percent* is the proportion of industry experts in independent directors; *board_industry_expertise* is a dummy variable equals 1 if there is any industry expert in board, 0 otherwise. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include year fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable:		
	ww		
board_industry_expertise	0.000561		
	(0.001923)		
board_industry_expertise_number		0.001267***	
		(0.000429)	
board_industry_expertise_percent			0.007711***
			(0.002893)
firm_age	-0.000550***	-0.000546***	-0.000548***
	(0.000052)	(0.000052)	(0.000052)
firm_size	-0.047146***	-0.047234***	-0.047224***
	(0.000542)	(0.000542)	(0.000542)
sales_growth	0.008887***	0.008841***	0.008831***
	(0.000659)	(0.000659)	(0.000659)
Q	0.000855***	0.000830***	0.000840***
	(0.000293)	(0.000293)	(0.000293)
ROA	-0.031099***	-0.031156***	-0.031105***
	(0.002565)	(0.002563)	(0.002563)
leverage	0.023243***	0.023297***	0.023335***
	(0.002396)	(0.002394)	(0.002395)
rd_intensity	0.000459***	0.000450***	0.000448***
	(0.000096)	(0.000096)	(0.000096)
market_capitalization	-0.0000003***	-0.0000003***	-0.0000003***
	(0.0000001)	(0.0000001)	(0.0000001)
ceo_chairman_duality	-0.000689	-0.000301	-0.000324

	(0.001255)	(0.001253)	(0.001254)
ceo_founder_duality	-0.042472*	-0.040872*	-0.041069*
	(0.023326)	(0.023319)	(0.023321)
board_size	-0.000516	-0.000689*	-0.000404
	(0.000401)	(0.000405)	(0.000402)
board_age	-0.000228	-0.000271*	-0.000269*
	(0.000162)	(0.000162)	(0.000162)
board_tenure	-0.000774***	-0.000668***	-0.000664***
	(0.000231)	(0.000232)	(0.000233)
board_independence	0.007481	0.002633	0.005497
	(0.008280)	(0.008318)	(0.008173)
Industry FE		Yes	
Year FE		Yes	
Observations	8,081	8,081	8,081
R^2	0.825667	0.825854	0.825819
Adjusted R^2	0.824077	0.824267	0.824231
F Statistic (df = 64; 8007)	592.535800***	593.309300***	593.164900***
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 7-5: Board expertise and tangibility as proxy for financial constraints

This table reports the regression results of board industry expertise on financial constraint. The sample is from U.S. listed firms (excluding the financial firms) from 2008 to 2019. The dependent variable is tangibility. The main independent variables of interest are *board_industry_expertise_number*, *board_industry_expertise_percent*, and *board_industry_expertise*. *board_industry_expertise_number* is the number of industry experts; *board_industry_expertise_percent* is the proportion of industry experts in independent directors; *board_industry_expertise* is a dummy variable equals 1 if there is any industry expert in board, 0 otherwise. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include year fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable:		
	tangibility		
board_industry_expertise	0.029516***		
	(0.005424)		
board_industry_expertise_number		0.009408***	
		(0.001208)	
board_industry_expertise_percent			0.078027***
			(0.008131)
firm_age	-0.001607***	-0.001545***	-0.001553***
	(0.000148)	(0.000147)	(0.000147)
firm_size	-0.033188***	-0.033349***	-0.033514***
	(0.001529)	(0.001526)	(0.001523)
sales_growth	0.017514***	0.017206***	0.016975***
	(0.001859)	(0.001856)	(0.001852)
Q	0.014971***	0.014753***	0.014785***
	(0.000827)	(0.000825)	(0.000824)
ROA	-0.059401***	-0.058826***	-0.058525***
	(0.007235)	(0.007219)	(0.007204)
leverage	-0.112620***	-0.112643***	-0.112080***
	(0.006756)	(0.006743)	(0.006730)
rd_intensity	0.002609***	0.002571***	0.002523***
	(0.000271)	(0.000271)	(0.000270)
market_capitalization	-0.0000001	-0.0000001	-0.0000001
	(0.0000002)	(0.0000002)	(0.0000002)
ceo_chairman_duality	-0.005170	-0.004436	-0.003493

	(0.003540)	(0.003528)	(0.003523)
ceo_founder_duality	0.093851	0.107985	0.110169*
	(0.065784)	(0.065673)	(0.065544)
board_size	0.000441	-0.000502	0.001893*
	(0.001131)	(0.001140)	(0.001130)
board_age	-0.001130**	-0.001344***	-0.001451***
	(0.000457)	(0.000457)	(0.000457)
board_tenure	0.002789***	0.003205***	0.003554***
	(0.000651)	(0.000654)	(0.000656)
board_independence	-0.059161**	-0.074190***	-0.059502***
	(0.023351)	(0.023426)	(0.022972)
Industry FE		Yes	
Year FE		Yes	
Observations	8,081	8,081	8,081
R^2	0.461580	0.463649	0.465733
Adjusted R^2	0.456671	0.458760	0.460862
F Statistic (df = 64; 8007)	107.254400***	108.151100***	109.060700***
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 7-6: CEO overconfidence and KZ index

This table reports the regression results of CEO overconfidence on financial constraint measures through *kz* index. The sample is from U.S. listed firms (excluding the financial firms) from 2006 to 2019. The dependent variable is financial constraint score, which is calculated by the author. The main independent variables of interest are *overconfident_ceo67*, *high_optimism*, *mid_optimism*, and *low_optimism*. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include industry fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable: kz			
	(1)	(2)	(3)	(4)
overconfident_ceo67	-0.002304			
	(0.050694)			
high_optimism		-0.028209		
		(0.201393)		
mid_optimism			0.022897	
			(0.042625)	
low_optimism				0.021795
				(0.042700)
firm_age	-0.010417***	-0.010408***	-0.010323***	-0.010468***
	(0.001690)	(0.001670)	(0.001676)	(0.001674)
firm_size	0.184761***	0.184690***	0.183968***	0.185340***
	(0.024170)	(0.024174)	(0.024213)	(0.024196)
sales_growth	0.064304	0.064218	0.063880	0.064431
	(0.041735)	(0.041722)	(0.041726)	(0.041721)
Q	-0.040947**	-0.041021**	-0.042303**	-0.040253**
	(0.016425)	(0.016348)	(0.016521)	(0.016416)
ROA	-1.329551***	-1.329353***	-1.335975***	-1.324498***
	(0.185134)	(0.184984)	(0.185273)	(0.185239)
rd_intensity	-0.007595	-0.007594	-0.007668	-0.007615
	(0.007170)	(0.007169)	(0.007171)	(0.007169)
market_capitalization	-0.000012***	-0.000012***	-0.000012***	-0.000012***
	(0.000003)	(0.000003)	(0.000003)	(0.000003)
ceo_chairman_duality	0.016190	0.016204	0.012236	0.014696
	(0.041308)	(0.041026)	(0.041569)	(0.041062)
ceo_founder_duality	-0.105325	-0.104992	-0.088528	-0.115362

	(1.436178)	(1.436096)	(1.436372)	(1.436217)
board_size	-0.009172	-0.009094	-0.008681	-0.009283
	(0.013248)	(0.013213)	(0.013237)	(0.013214)
board_age	-0.019194***	-0.019173***	-0.019188***	-0.019341***
	(0.005954)	(0.005952)	(0.005952)	(0.005959)
board_tenure	0.003881	0.003829	0.003166	0.003505
	(0.008081)	(0.008035)	(0.008132)	(0.008062)
board_independence	1.709819***	1.709909***	1.709280***	1.701161***
	(0.313661)	(0.313641)	(0.313636)	(0.314110)
Industry FE			Yes	
Year FE			Yes	
Observations	15,661	15,661	15,661	15,661
R^2	0.193311	0.193314	0.193353	0.193349
Adjusted R^2	0.183062	0.183064	0.183104	0.183099
F Statistic (df = 60; 5588)	22.318060***	22.318420***	22.323980***	22.323400***
Note:	*p<0.1; **p<0.05; ***p<0.01			

7-7: CEO overconfidence and SA index

This table reports the regression results of CEO overconfidence on financial constraint measures through *sa* index. The sample is from U.S. listed firms (excluding the financial firms) from 2006 to 2019. The dependent variable is financial constraint score, which is calculated by the author. The main independent variables of interest are *overconfident_ceo67*, *high_optimism*, *mid_optimism*, and *low_optimism*. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include industry fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable: sa			
	(1)	(2)	(3)	(4)
overconfident_ceo67	0.012428			
	(0.009167)			
high_optimism		-0.071095*		
		(0.036413)		
mid_optimism			0.008223	
			(0.007709)	
low_optimism				-0.003581
				(0.007723)
firm_age	-0.028566***	-0.028638***	-0.028601***	-0.028620***
	(0.000306)	(0.000302)	(0.000303)	(0.000303)
firm_size	-0.124251***	-0.124393***	-0.124510***	-0.124323***
	(0.004371)	(0.004371)	(0.004379)	(0.004376)
sales_growth	0.020653***	0.020820***	0.020780***	0.020886***
	(0.007547)	(0.007543)	(0.007546)	(0.007546)
Q	-0.015862***	-0.015475***	-0.015933***	-0.015598***
	(0.002970)	(0.002956)	(0.002988)	(0.002969)
ROA	-0.315912***	-0.312341***	-0.315986***	-0.314712***
	(0.033479)	(0.033446)	(0.033507)	(0.033504)
rd_intensity	-0.000863	-0.000887	-0.000909	-0.000877
	(0.001297)	(0.001296)	(0.001297)	(0.001297)
market_capitalization	0.000009***	0.000009***	0.000009***	0.000009***
	(0.000001)	(0.000001)	(0.000001)	(0.000001)
ceo_chairman_duality	0.008956	0.010835	0.008876	0.010420
	(0.007470)	(0.007418)	(0.007518)	(0.007427)
ceo_founder_duality	-0.107035	-0.111708	-0.105009	-0.109028

	(0.259713)	(0.259653)	(0.259771)	(0.259764)
board_size	0.003999*	0.003843	0.003918	0.003783
	(0.002396)	(0.002389)	(0.002394)	(0.002390)
board_age	-0.001260	-0.001267	-0.001302	-0.001276
	(0.001077)	(0.001076)	(0.001076)	(0.001078)
board_tenure	-0.004911***	-0.004731***	-0.004943***	-0.004645***
	(0.001461)	(0.001453)	(0.001471)	(0.001458)
board_independence	-0.179297***	-0.180348***	-0.180419***	-0.178718***
	(0.056721)	(0.056708)	(0.056722)	(0.056812)
Industry FE		Yes		
Year FE		Yes		
Observations	15,661	15,661	15,661	15,661
R^2	0.794134	0.794206	0.794108	0.794074
Adjusted R^2	0.791518	0.791592	0.791492	0.791457
F Statistic (df = 60; 5588)	359.263900***	359.423600***	359.207200***	359.132500***
Note:	*p<0.1; **p<0.05; ***p<0.01			

7-8: CEO overconfidence and tangibility as proxy for financial constraints

This table reports the regression results of CEO overconfidence on financial constraint measures through *tangibility*. The sample is from U.S. listed firms (excluding the financial firms) from 2006 to 2019. The dependent variable is financial constraint score, which is calculated by the author. The main independent variables of interest are *overconfident_ceo67*, *high_optimism*, *mid_optimism*, and *low_optimism*. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include industry fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable: tangibility			
	(1)	(2)	(3)	(4)
overconfident_ceo67	-0.005000			
	(0.004825)			
high_optimism		-0.045333**		
		(0.019160)		
mid_optimism			-0.008145**	
			(0.004056)	
low_optimism				0.011540***
				(0.004062)
firm_age	-0.000516***	-0.000495***	-0.000519***	-0.000523***
	(0.000161)	(0.000159)	(0.000160)	(0.000159)
firm_size	-0.029671***	-0.029786***	-0.029400***	-0.029372***
	(0.002300)	(0.002300)	(0.002304)	(0.002301)
sales_growth	0.013170***	0.013003***	0.013198***	0.013157***
	(0.003972)	(0.003969)	(0.003970)	(0.003968)
Q	0.020265***	0.020106***	0.020564***	0.020513***
	(0.001563)	(0.001555)	(0.001572)	(0.001561)
ROA	-0.146505***	-0.146405***	-0.145200***	-0.144466***
	(0.017620)	(0.017599)	(0.017629)	(0.017620)
rd_intensity	0.002064***	0.002067***	0.002099***	0.002059***
	(0.000682)	(0.000682)	(0.000682)	(0.000682)
market_capitalization	-0.0000001	-0.00000002	-0.0000001	-0.0000001
	(0.0000003)	(0.0000003)	(0.0000003)	(0.0000003)
ceo_chairman_duality	-0.009974**	-0.010082***	-0.009155**	-0.011147***
	(0.003932)	(0.003903)	(0.003955)	(0.003906)
ceo_founder_duality	-0.092074	-0.091146	-0.096289	-0.096245

	(0.136690)	(0.136627)	(0.136676)	(0.136611)
board_size	0.000605	0.000757	0.000543	0.000620
	(0.001261)	(0.001257)	(0.001260)	(0.001257)
board_age	-0.000825	-0.000787	-0.000807	-0.000890
	(0.000567)	(0.000566)	(0.000566)	(0.000567)
board_tenure	0.004340***	0.004235***	0.004495***	0.004077***
	(0.000769)	(0.000764)	(0.000774)	(0.000767)
board_independence	-0.121643***	-0.121408***	-0.121044***	-0.125963***
	(0.029853)	(0.029839)	(0.029844)	(0.029878)
Industry FE			Yes	
Year FE			Yes	
Observations	15,661	15,661	15,661	15,661
R^2	0.312882	0.313437	0.313245	0.313741
Adjusted R^2	0.304151	0.304714	0.304519	0.305022
F Statistic (df = 60; 5588)	42.408580***	42.518290***	42.480340***	42.57830***
Note:	*p<0.1; **p<0.05; ***p<0.01			

7-9: CEO overconfidence and WW index

This table reports the regression results of CEO overconfidence on financial constraint measures through *ww* index. The sample is from U.S. listed firms (excluding the financial firms) from 2006 to 2019. The dependent variable is financial constraint score, which is calculated by the author. The main independent variables of interest are *overconfident_ceo67*, *high_optimism*, *mid_optimism*, and *low_optimism*. The detailed definitions of the other variables are in Appendix A. All the independent variables are lagged by 1 year. All regressions include industry fixed effects and year fixed effects. The industries are classified based on the first two digits of SIC code. All variables are winsorized at both the 1% and 99% levels. Standard Errors are reported in parentheses.

	Dependent variable: ww			
	(1)	(2)	(3)	(4)
overconfident_ceo67	0.001547			
	(0.002088)			
high_optimism		-0.004551		
		(0.008297)		
mid_optimism			0.000965	
			(0.001756)	
low_optimism				0.002155
				(0.001759)
firm_age	-0.000794***	-0.000803***	-0.000799***	-0.000808***
	(0.000070)	(0.000069)	(0.000069)	(0.000069)
firm_size	-0.040003***	-0.040010***	-0.040033***	-0.039942***
	(0.000996)	(0.000996)	(0.000998)	(0.000997)
sales_growth	0.008854***	0.008880***	0.008871***	0.008904***
	(0.001719)	(0.001719)	(0.001719)	(0.001719)
Q	-0.004546***	-0.004498***	-0.004552***	-0.004422***
	(0.000677)	(0.000673)	(0.000681)	(0.000676)
ROA	-0.027057***	-0.026702***	-0.027051***	-0.026258***
	(0.007627)	(0.007621)	(0.007633)	(0.007631)
rd_intensity	0.000150	0.000147	0.000144	0.000145
	(0.000295)	(0.000295)	(0.000295)	(0.000295)
market_capitalization	-0.0000001	-0.0000001	-0.0000001	-0.0000001
	(0.0000001)	(0.0000001)	(0.0000001)	(0.0000001)
ceo_chairman_duality	-0.002750	-0.002554	-0.002750	-0.002718
	(0.001702)	(0.001690)	(0.001713)	(0.001692)
ceo_founder_duality	0.017728	0.017202	0.017939	0.016199

	(0.059166)	(0.059164)	(0.059177)	(0.059164)
board_size	-0.000880	-0.000905*	-0.000891	-0.000925*
	(0.000546)	(0.000544)	(0.000545)	(0.000544)
board_age	-0.000534**	-0.000537**	-0.000539**	-0.000554**
	(0.000245)	(0.000245)	(0.000245)	(0.000245)
board_tenure	0.000754**	0.000779**	0.000752**	0.000747**
	(0.000333)	(0.000331)	(0.000335)	(0.000332)
board_independence	-0.005946	-0.006066	-0.006084	-0.006927
	(0.012922)	(0.012921)	(0.012922)	(0.012940)
Industry FE			Yes	
Year FE			Yes	
Observations	15,661	15,661	15,661	15,661
R^2	0.622676	0.622659	0.622659	0.622740
Adjusted R^2	0.617882	0.617865	0.617865	0.617947
F Statistic (df = 60; 5588)	153.692500***	153.681600***	153.681600***	153.73460***
Note:	*p<0.1; **p<0.05; ***p<0.01			

8. Reference

Abzug, R., & Galaskiewicz, J. (2001). Nonprofit boards: Crucibles of expertise or symbols of local identities? *Nonprofit and Voluntary Sector Quarterly*, *30*(1), 51–73.

Acharya, V. V., Almeida, H., & Campello, M. (2007). Is cash negative debt? A hedging perspective on corporate financial policies. *Journal of Financial Intermediation*, *16*(4), 515–554.

Ackert, L. F., & Deaves, R. (2010). Behavioral Finance: Psychology. *Decision-making, and Markets*, *97*, 99.

Adams, R. B., & Ferreira, D. (2007). A theory of friendly boards. *The journal of finance*, *62*(1), 217-250.

Adams, R. B., Hermalin, B. E., & Weisbach, M. S. (2010). The role of boards of directors in corporate governance: A conceptual framework and survey. *Journal of economic literature*, *48*(1), 58-107.

Adizes, I. (2004). *Managing corporate lifecycles*. The adizes institute publishing.

Adler, P. S., & Kwon, S.-W. (2002). Social capital: Prospects for a new concept. *Academy of Management Review*, *27*(1), 17–40.

Ahmed, A. S., & Duellman, S. (2007). Accounting conservatism and board of director characteristics: An empirical analysis. *Journal of accounting and economics*, *43*(2-3), 411-437.

Ahn, S., Jiraporn, P., & Kim, Y. S. (2010). Multiple directorships and acquirer returns. *Journal of Banking & Finance*, *34*(9), 2011–2026.

Akbas, F., Meschke, F., & Wintoki, M. B. (2016). Director networks and informed traders. *Journal of Accounting and Economics*, *62*(1), 1–23.

Aktas, N., Louca, C., & Petmezas, D. (2019). CEO overconfidence and the value of corporate cash holdings. *Journal of Corporate Finance*, *54*, 85-106.

Alicke, M. D., Klotz, M. L., Breitenbecher, D. L., Yurak, T. J., & Vredenburg, D. S. (1995). Personal contact, individuation, and the better-than-average effect. *Journal of Personality and Social Psychology*, *68*(5), 804-825.

Almeida, H. V., & Wolfenzon, D. (2006). A theory of pyramidal ownership and family business groups. *The Journal of Finance*, *61*(6), 2637–2680.

Almeida, H., & Campello, M. (2001). Financial constraints and investment-cash flow sensitivities: New research directions. *Twelfth Annual Utah Winter Finance Conference*.

Almeida, H., & Campello, M. (2002). The Demand for Corporate Liquidity: A Theory and Some Evidence," working paper.

Almeida, H., & Campello, M. (2007). Financial constraints, asset tangibility, and corporate investment. *The Review of Financial Studies*, *20*(5), 1429–1460.

Almeida, H., Campello, M., & Weisbach, M. S. (2004). The cash flow sensitivity of cash. *The Journal of Finance*, *59*(4), 1777–1804.

Alti, A. (2003). How sensitive is investment to cash flow when financing is frictionless? *The Journal of Finance*, *58*(2), 707–722.

Álvarez, R., & Bertin, M. J. (2016). Banking competition and firm-level financial constraints in Latin America. *Emerging Markets Review*, *28*, 89–104.

Amin, A., Chourou, L., Kamal, S., Malik, M., & Zhao, Y. (2020). It's who you know that counts: Board connectedness and CSR performance. Journal of Corporate Finance, 64, 101662.

Amin, A., Chourou, L., Kamal, S., Malik, M., & Zhao, Y. (2020). It's who you know that counts: Board connectedness and CSR performance. *Journal of Corporate Finance*, *64*, 101662.

Andrade, G., Mitchell, M., & Stafford, E. (2001). New evidence and perspectives on mergers. *Journal of Economic Perspectives*, 15(2), 103-120.

Andrén, N., & Cociorva, A. (2019). Do credit ratings measure financial constraints?

Antweiler, W., & Frank, M. Z. (2004). Is all that talk just noise? The information content of internet stock message boards. *The Journal of Finance*, *59*(3), 1259–1294.

Armor, D. A., & Taylor, S. E. (1998). Situated optimism: Specific outcome expectancies and self-regulation. In *Advances in Experimental Social Psychology* (Vol. 30, pp. 309-379). Academic Press.

Arslan, Ö., Florackis, C., & Ozkan, A. (2006). The role of cash holdings in reducing investment–cash flow sensitivity: Evidence from a financial crisis period in an emerging market. *Emerging Markets Review*, *7*(4), 320–338.

Baker, M., & Wurgler, J. (2002). Market timing and capital structure. *The Journal of Finance*, *57*(1), 1-32.

Baker, M., & Wurgler, J. (2004). A catering theory of dividends. *The Journal of Finance*, 59(3), 1125-1165.

Baker, M., Stein, J. C., & Wurgler, J. (2003). When does the market matter? Stock prices and the investment of equity-dependent firms. *The quarterly journal of economics*, *118*(3), 969-1005.

Baker, M., Wurgler, J., & Van Nieuwerburgh, S. (2007). Behavioural Corporate Finance: An Updated Survey. *Handbook of Corporate Finance: Empirical Corporate Finance*.

Barroso-Castro, C., Villegas-Periñan, M. del M., & Casillas-Bueno, J. C. (2016). How boards' internal and external social capital interact to affect firm performance. *Strategic Organization*, *14*(1), 6–31.

Baum, C. F., Schäfer, D., & Talavera, O. (2011). The impact of the financial system's structure on firms' financial constraints. *Journal of International Money and Finance*, *30*(4), 678–691.

Beck, T., Demirgüç-Kunt, A., & Maksimovic, V. (2008). Financing patterns around the world: Are small firms different? *Journal of Financial Economics*, *89*(3), 467–487.

Ben-David, I., Graham, J. R., & Harvey, C. R. (2007). Managerial overconfidence and corporate policies. *Working Paper, National Bureau of Economic Research*.

Ben-David, I., Graham, J. R., & Harvey, C. R. (2013). Managerial miscalibration. *The Quarterly Journal of Economics*, 128(4), 1547-1584.

Benton, R. A. (2019). Brokerage and closure in corporate control: Shifting sources of power for a fractured corporate board network. *Organization Studies*, *40*(11), 1631–1656.

Billett, M. T., & Mauer, D. C. (2003). Cross-subsidies, external financing constraints, and the contribution of the internal capital market to firm value. *The Review of Financial Studies*, *16*(4), 1167–1201.

Bizjak, J., Lemmon, M., & Whitby, R. (2009). Option backdating and board interlocks. *The Review of Financial Studies*, *22*(11), 4821–4847.

Bodnaruk, A., Loughran, T., & McDonald, B. (2015). Using 10-K text to gauge financial constraints. *Journal of Financial and Quantitative Analysis*, *50*(4), 623–646.

Bond, S., Harhoff, D., & Van Reenen, J. (2005). Investment, R&D and financial constraints in Britain and Germany. *Annales d'Economie et de Statistique*, 433–460.

Boot, A. W., Milbourn, T. T., & Schmeits, A. (2006). Credit ratings as coordination mechanisms. *The Review of Financial Studies*, *19*(1), 81–118.

Borgatti, S. P., & Everett, M. G. (2006). A graph-theoretic perspective on centrality. *Social Networks*, *28*(4), 466–484.

Botosan, C. A. (1997). Disclosure level and the cost of equity capital. *Accounting Review*, 323–349.

Bottazzi, G., Secchi, A., & Tamagni, F. (2014). Financial constraints and firm dynamics. *Small Business Economics*, *42*(1), 99–116.

Bouwman, C. H. (2011). Corporate governance propagation through overlapping directors. *The Review of Financial Studies*, *24*(7), 2358–2394.

Bradley, D., Gokkaya, S., Liu, X., & Xie, F. (2017). Are all analysts created equal? Industry expertise and monitoring effectiveness of financial analysts. *Journal of Accounting and Economics*, *63*(2–3), 179–206.

Brav, A., Graham, J. R., Harvey, C. R., & Michaely, R. (2005). Payout policy in the 21st century. *Journal of Financial Economics*, *77*(3), 483–527.

Brown, J. L. (2011). The spread of aggressive corporate tax reporting: A detailed examination of the corporate-owned life insurance shelter. *The Accounting Review*, *86*(1), 23–57.

Brown, J. R., & Petersen, B. C. (2009). Why has the investment-cash flow sensitivity declined so sharply? Rising R&D and equity market developments. *Journal of Banking & Finance*, *33*(5), 971–984.

Brown, R., & Sarma, N. (2007). CEO overconfidence, CEO dominance and corporate acquisitions. *Journal of Economics and business*, *59*(5), 358-379.

Buch-Hansen, H. (2014). Interlocking directorates and collusion: An empirical analysis. *International Sociology*, *29*(3), 249–267.

Buehler, R., Griffin, D., & MacDonald, H. (2010). The role of motivated reasoning in optimistic time predictions. *Personality and Social Psychology Bulletin*, *23*(3), 238-247.

Buehler, R., Griffin, D., & Ross, M. (1994). Exploring the "planning fallacy": Why people underestimate their task completion times. *Journal of Personality and Social Psychology*, *67*(3), 366-381.

Buehlmaier, M. M., & Whited, T. M. (2018). Are financial constraints priced? Evidence from textual analysis. *The Review of Financial Studies*, *31*(7), 2693–2728.

Buehlmaier, M. M., & Zechner, J. (2013). Media-based merger arbitrage. Conference on Theories and Practices of Securities and Financial Markets (SFM).

Burt, R. S. (1980). Cooptive corporate actor networks: A reconsideration of interlocking directorates involving American manufacturing. *Administrative Science Quarterly*, 557–582.

Burt, R. S. (1983). Firms, directors and time in the directorate tie market. *Social Networks*, *5*(1), 13–49.

Cai, Y., & Sevilir, M. (2012). Board connections and M&A transactions. *Journal of Financial Economics*, *103*(2), 327–349.

Cain, D. M., Moore, D. A., & Haran, U. (2015). Making sense of overconfidence in market entry. *Strategic Management Journal*, *36*(1), 1-18.

Camerer, C., & Lovallo, D. (1999). Overconfidence and excess entry: An experimental approach. *The American Economic Review*, 89(1), 306-318.

Campbell, J. L., Goldman, N. C., & Li, B. (2021). Do financing constraints lead to incremental tax planning? Evidence from the Pension Protection Act of 2006. *Contemporary Accounting Research*, *38*(3), 1961–1999.

Campbell, T. C., Gallmeyer, M., Johnson, S. A., Rutherford, J., & Stanley, B. W. (2011). CEO optimism and forced turnover. *Journal of Financial Economics*, *101*(3), 695-712.

Campello, M., Graham, J. R., & Harvey, C. R. (2010). The real effects of financial constraints: Evidence from a financial crisis. *Journal of Financial Economics*, *97*(3), 470–487.

Carbo-Valverde, S., Rodriguez-Fernandez, F., & Udell, G. F. (2009). Bank market power and SME financing constraints. *Review of Finance*, *13*(2), 309–340.

Carpenter, M. A., & Westphal, J. D. (2001). The strategic context of external network ties: Examining the impact of director appointments on board involvement in strategic decision making. *Academy of Management Journal*, *44*(4), 639–660.

Carpenter, R. E., & Petersen, B. C. (2002). Is the growth of small firms constrained by internal finance? *Review of Economics and Statistics*, *84*(2), 298–309.

Certo, S. T. (2003). Influencing initial public offering investors with prestige: Signaling with board structures. *Academy of Management Review*, *28*(3), 432–446.

Chambers, J. R., & Windschitl, P. D. (2004). Biases in social comparative judgments: The role of nonmotivated factors in above-average and comparative-optimism effects. *Psychological Bulletin*, *130*(5), 813-838.

Chan, C. Y., Chou, D. W., & Lo, H. C. (2017). Do financial constraints matter when firms engage in CSR?. *The North American Journal of Economics and Finance*, *39*, 241-259.

Chan, K. S., Dang, V. Q., & Yan, I. K. (2012). Chinese firms' political connection, ownership, and financing constraints. *Economics Letters*, *115*(2), 164–167.

Chapman, D. R., Junor, C. W., & Stegman, T. R. (1996). Cash flow constraints and firms' investment behaviour. *Applied Economics*, *28*(8), 1037–1044.

Chen, H. J., & Chen, S. J. (2012). Investment-cash flow sensitivity cannot be a good measure of financial constraints: Evidence from the time series. *Journal of Financial Economics*, *103*(2), 393–410.

Chen, J., Chen, X., & Cheng, Q. (2007). Corporate ownership, corporate governance reform, and timeliness of earnings: A study of the Shanghai Stock Exchange. *Journal of International Accounting, Auditing and Taxation*, *16*(2), 114-137.

Chen, L., & Luo, C. (2014). FDI, market signal and financing constraints of firms in China. *The Journal of International Trade & Economic Development*, *23*(5), 579–599.

Chen, Z. (2020). Does independent industry expertise improve board effectiveness? Evidence from bank CEO turnovers. *International Review of Finance*, *20*(3), 665–699.

Cheng, B., Ioannou, I., & Serafeim, G. (2014). Corporate social responsibility and access to finance. *Strategic Management Journal*, *35*(1), 1–23.

Chirinko, R. S. (1993). Multiple capital inputs, Q, and investment spending. *Journal of Economic Dynamics and Control*, *17*(5–6), 907–928.

Christensen-Szalanski, J. J., & Bushyhead, J. B. (1981). Physicians' use of probabilistic information in a real clinical setting. *Journal of Experimental Psychology: Human Perception and Performance*, *7*(4), 928-935.

Claessens, S., Feijen, E., & Laeven, L. (2008). Political connections and preferential access to finance: The role of campaign contributions. *Journal of Financial Economics*, *88*(3), 554–580.

Cleary, S. (1999). The relationship between firm investment and financial status. *The Journal of Finance*, *54*(2), 673–692.

Cleary, S. (2006). International corporate investment and the relationships between financial constraint measures. *Journal of Banking & Finance*, *30*(5), 1559–1580.

Cleary, S., Povel, P., & Raith, M. (2007). The U-shaped investment curve: Theory and evidence. *Journal of Financial and Quantitative Analysis*, *42*(1), 1–39.

Coad, A. (2010). Exploring the processes of firm growth: Evidence from a vector auto-regression. *Industrial and Corporate Change*, *19*(6), 1677–1703.

Coca-Cola Co. (2011). Proxy statement. https://investors.coca-colacompany.com/filings-reports/proxy-statements/content/0000950123-11-023936/0000950123-11-023936.pdf (last access March 14, 2023)

Cohen, J. R., Hoitash, U., Krishnamoorthy, G., & Wright, A. M. (2014). The effect of audit committee industry expertise on monitoring the financial reporting process. *The Accounting Review*, *89*(1), 243–273.

Connelly, B. L., Certo, S. T., Ireland, R. D., & Reutzel, C. R. (2011). Signaling theory: A review and assessment. *Journal of Management*, *37*(1), 39–67.

Cooper, A. C., Woo, C. Y., & Dunkelberg, W. C. (1988). Entrepreneurs' perceived chances for success. *Journal of Business Venturing*, *3*(2), 97-108.

Cull, R., Li, W., Sun, B., & Xu, L. C. (2015). Government connections and financial constraints: Evidence from a large representative sample of Chinese firms. *Journal of Corporate Finance*, *32*, 271–294.

Czarnitzki, D. (2006). Research and development in small and medium-sized enterprises: The role of financial constraints and public funding. *Scottish Journal of Political Economy*, *53*(3), 335–357.

Czarnitzki, D., & Hottenrott, H. (2011). R&D investment and financing constraints of small and medium-sized firms. *Small Business Economics*, *36*(1), 65–83.

Daniel, K., Hirshleifer, D., & Subrahmanyam, A. (1998). Investor psychology and security market under- and overreactions. The Journal of Finance, 53(6), 1839-1885.

Das, S. R., & Chen, M. Y. (2007). Yahoo! for Amazon: Sentiment extraction from small talk on the web. *Management Science*, *53*(9), 1375–1388.

Dasgupta, S., & Sengupta, K. (2007). Corporate liquidity, investment and financial constraints: Implications from a multi-period model. *Journal of Financial Intermediation*, *16*(2), 151–174.

Dass, N., Kini, O., Nanda, V. K., & Onal, B. (2011). The influence of directors from related industries in shaping firm policies. *Available at SSRN 2131994*.

Dass, N., Kini, O., Nanda, V., Onal, B., & Wang, J. (2014). Board expertise: Do directors from related industries help bridge the information gap? *The Review of Financial Studies*, *27*(5), 1533–1592.

Datta, S., Iskandar-Datta, M., & Patel, A. (1999). Bank monitoring and the pricing of corporate public debt. *Journal of Financial Economics*, *51*(3), 435–449.

Davis, G. F., Yoo, M., & Baker, W. E. (2003). The small world of the American corporate elite, 1982-2001. *Strategic Organization*, *1*(3), 301–326.

Davis, J. H., Schoorman, F. D., & Donaldson, L. (1997). Toward a stewardship theory of management. *Academy of Management review*, *22*(1), 20-47.

De Maeseneire, W., & Claeys, T. (2012). SMEs, foreign direct investment and financial constraints: The case of Belgium. *International Business Review*, *21*(3), 408–424.

Del Giovane, P., Eramo, G., & Nobili, A. (2011). Disentangling demand and supply in credit developments: A survey-based analysis for Italy. *Journal of Banking & Finance*, *35*(10), 2719–2732.

Deloitte Development (2010). Audit committee composition. Audit Committee Brief (June).

Denis, D. J., & Sibilkov, V. (2010). Financial constraints, investment, and the value of cash holdings. *The Review of Financial Studies*, *23*(1), 247-269.

Deshmukh, S., Goel, A. M., & Howe, K. M. (2013). CEO overconfidence and dividend policy. *Journal of Financial Intermediation*, 22(3), 440-463.

Devos, E., Prevost, A., & Puthenpurackal, J. (2009). Are interlocked directors effective monitors? *Financial Management*, *38*(4), 861–887.

Dhaliwal, D., Li, O. Z., Tsang, A., & Yang, Y. G. (2014). Corporate social responsibility disclosure and the cost of equity capital: The roles of stakeholder orientation and financial transparency. *Journal of Accounting and Public Policy*, *33*(4), 328–355.

Diamond, D. W., & Verrecchia, R. E. (1991). Disclosure, liquidity, and the cost of capital. *The Journal of Finance*, *46*(4), 1325–1359.

Ding, S., Guariglia, A., & Knight, J. (2013). Investment and financing constraints in China: Does working capital management make a difference? *Journal of Banking & Finance*, *37*(5), 1490–1507.

Dittmar, A. K. (2000). Why do firms repurchase stock? *The Journal of Business*, 73(3), 331-355.

Djankov, S., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2008). The law and economics of self-dealing. *Journal of Financial Economics*, *88*(3), 430–465.

Domhoff, G. W. (1975). Social clubs, policy-planning groups, and corporations: A network study of ruling-class cohesiveness. *Insurgent Sociologist*, *5*(3), 171–184.

Donaldson, L. (1990). The ethereal hand: Organizational economics and management theory. *Academy of management Review*, *15*(3), 369-381.

Donaldson, L., & Davis, J. H. (1991). Stewardship theory or agency theory: CEO governance and shareholder returns. *Australian Journal of management*, *16*(1), 49-64.

Dosi, G. (2007). Technological innovation, institutions and human purposefulness in socioeconomic evolution: A preface to Christopher Freeman" System of innovation. Selected essays in evolutionary economics". LEM Working Paper Series.

Doukas, J. A., & Petmezas, D. (2007). Acquisitions, overconfident managers, and self-attribution bias. *European Financial Management*, *13*(3), 531-577.

Drobetz, W., Von Meyerinck, F., Oesch, D., & Schmid, M. (2018). Industry expert directors. *Journal of Banking & Finance*, *92*, 195-215.

Drobetz, W., Von Meyerinck, F., Oesch, D., & Schmid, M. (2018). Industry expert directors. *Journal of Banking & Finance*, *92*, 195–215.

Edwards, M. (2019). Expert Directors. *U. Colo. L. Rev.*, *90*, 1051.

Ehrlinger, J., Johnson, K., Banner, M., Dunning, D., & Kruger, J. (2008). Why the unskilled are unaware: Further explorations of (absent) self-insight among the incompetent. *Organizational Behaviour and Human Decision Processes*, *105*(1), 98-121.

El Ghoul, S., Guedhami, O., Kwok, C. C., & Mishra, D. R. (2011). Does corporate social responsibility affect the cost of capital? *Journal of Banking & Finance*, *35*(9), 2388–2406.

Ellis, J. A., Fee, C. E., & Thomas, S. (2018). Playing favorites? Industry expert directors in diversified firms. *Journal of Financial and Quantitative Analysis*, *53*(4), 1679–1714.

Erel, I., Jang, Y., & Weisbach, M. S. (2015). Do acquisitions relieve target firms' financial constraints? *The Journal of Finance*, *70*(1), 289–328.

Erickson, T., & Whited, T. M. (2000). Measurement error and the relationship between investment and q. *Journal of Political Economy*, *108*(5), 1027–1057.

Faccio, M., Masulis, R. W., & McConnell, J. J. (2006). Political connections and corporate bailouts. *The Journal of Finance*, *61*(6), 2597–2635.

Falato, A., Kadyrzhanova, D., & Lel, U. (2014). Distracted directors: Does board busyness hurt shareholder value? *Journal of Financial Economics*, *113*(3), 404–426.

Faleye, O., Hoitash, R., & Hoitash, U. (2018). Industry expertise on corporate boards. *Review of Quantitative Finance and Accounting*, *50*(2), 441–479.

Faleye, O., Kovacs, T., & Venkateswaran, A. (2014). Do better-connected CEOs innovate more?. *Journal of Financial and Quantitative Analysis*, *49*(5-6), 1201-1225.

Fama, E. F. (1980). Agency problems and the theory of the firm. Journal of political economy, 88(2), 288-307.

Fama, E. F., & French, K. R. (2015). A five-factor asset pricing model. *Journal of Financial Economics*, *116*(1), 1–22.

Fama, E. F., & Jensen, M. C. (1983). Separation of ownership and control. *The journal of law and Economics*, *26*(2), 301-325.

Farre-Mensa, J., & Ljungqvist, A. (2016). Do measures of financial constraints measure financial constraints? *The Review of Financial Studies*, *29*(2), 271–308.

Fazzari, S. M., & Athey, M. J. (1987). Asymmetric information, financing constraints, and investment. *The Review of Economics and Statistics*, 481–487.

Fazzari, S. M., & Petersen, B. C. (1993). Working capital and fixed investment: New evidence on financing constraints. *The RAND Journal of Economics*, 328–342.

Fazzari, S., Hubbard, R. G., & Petersen, B. (1988). Investment, financing decisions, and tax policy. *The American Economic Review*, *78*(2), 200–205.

Felix, R. (2016). Examining the spread of high quality reporting through the corporate network. *Advances in Accounting*, *32*, 31–41.

Ferris, S. P., Jagannathan, M., & Pritchard, A. C. (2003). Too busy to mind the business? Monitoring by directors with multiple board appointments. The Journal of finance, 58(3), 1087-1111.

Fich, E. M., & Shivdasani, A. (2006). Are busy boards effective monitors?. *The Journal of finance*, *61*(2), 689-724.

Finnerty, J. D., Miller, C. D., & Chen, R. R. (2013). The impact of credit rating announcements on credit default swap spreads. *Journal of Banking & Finance*, *37*(6), 2011-2030.

Fischhoff, B., Slovic, P., & Lichtenstein, S. (1977). Knowing with certainty: The appropriateness of extreme confidence. *Journal of Experimental Psychology: Human Perception and Performance*, *3*(4), 552-564.

Flyvbjerg, B., & Budzier, A. (2011). Why your IT project may be riskier than you think. *Harvard Business Review*, *89*(9), 23-25.

Fracassi, C. (2017). Corporate finance policies and social networks. *Management Science*, *63*(8), 2420–2438.

Freeman, L. C., Roeder, D., & Mulholland, R. R. (1979). Centrality in social networks: II. Experimental results. *Social Networks*, *2*(2), 119–141.

Friedman, E., Johnson, S., & Mitton, T. (2003). Propping and tunneling. *Journal of Comparative Economics*, *31*(4), 732–750.

Galasso, A., & Simcoe, T. S. (2011). CEO overconfidence and innovation. *Management Science*, *57*(8), 1469-1484.

Garmaise, M. J. (2008). Production in entrepreneurial firms: The effects of financial constraints on labor and capital. *The Review of Financial Studies*, *21*(2), 543–577.

Gatchev, V. A., Spindt, P. A., & Tarhan, V. (2009). How do firms finance their investments?: The relative importance of equity issuance and debt contracting costs. *Journal of Corporate Finance*, *15*(2), 179-195.

Gelos, R. G., & Werner, A. M. (2002). Financial liberalization, credit constraints, and collateral: Investment in the Mexican manufacturing sector. *Journal of Development Economics*, *67*(1), 1–27.

Geroski, P. A., & Jacquemin, A. (1988). The persistence of profits: A European comparison. *The Economic Journal*, *98*(391), 375–389.

Gertler, M. (1992). Financial capacity and output fluctuations in an economy with multi-period financial relationships. *The Review of Economic Studies*, *59*(3), 455-472.

Gervais, S., Heaton, J. B., & Odean, T. (2011). Overconfidence, compensation contracts, and capital budgeting. *The Journal of Finance*, *66*(5), 1735-1777.

Ghosh, S. (2006). Did financial liberalization ease financing constraints? Evidence from Indian firm-level data. *Emerging Markets Review*, *7*(2), 176–190.

Gilchrist, S., & Himmelberg, C. P. (1995). Evidence on the role of cash flow for investment. *Journal of Monetary Economics*, *36*(3), 541–572.

Glaser, M., Schäfers, P., & Weber, M. (2008, October). Managerial optimism and corporate investment: Is the CEO alone responsible for the relation?. In AFA 2008 New Orleans Meetings Paper.

Goel, A. M., & Thakor, A. V. (2008). Overconfidence, CEO Selection, and Corporate Governance. The Journal of Finance, 63(6), 2737-2784.

Goethals, G. R. (2003). The psychodynamics of overconfidence in leaders. In D. van Knippenberg & M. A. Hogg (Eds.), *Leadership and power: Identity processes in groups and organizations* (pp. 95-109). Sage Publications.

Goh, J. C., & Ederington, L. H. (1999). Cross-sectional variation in the stock market reaction to bond rating changes. *The Quarterly Review of Economics and Finance*, *39*(1), 101–112.

Gomes, J. F. (2001). Financing investment. *American Economic Review*, *91*(5), 1263–1285.

Graham, J. R., Kim, H., & Leary, M. (2020). CEO-board dynamics. *Journal of Financial Economics*, *137*(3), 612-636.

Guariglia, A. (2008). Internal financial constraints, external financial constraints, and investment choice: Evidence from a panel of UK firms. *Journal of Banking & Finance*, *32*(9), 1795–1809.

Guest, P. M. (2009). The impact of board size on firm performance: Evidence from the UK. *The European Journal of Finance*, *15*(4), 385–404.

Guiso, L., Pistaferri, L., & Schivardi, F. (2013). Credit within the Firm. *Review of Economic Studies*, *80*(1), 211–247.

Gulati, R., & Westphal, J. D. (1999). Cooperative or controlling? The effects of CEO-board relations and the content of interlocks on the formation of joint ventures. *Administrative Science Quarterly*, *44*(3), 473–506.

Gupta, G., Mahakud, J., & Verma, V. (2020). CEO's education and investment–cash flow sensitivity: An empirical investigation. *International Journal of Managerial Finance*.

Hackbarth, D. (2008). Managerial traits and capital structure decisions. *Journal of Financial and Quantitative Analysis*, *43*(4), 843-881.

Hackbarth, D. (2009). Determinants of corporate borrowing: A behavioural perspective. *The Journal of Corporate Finance*, 15(4), 389-411.

Hadlock, C. J. (1998). Ownership, liquidity, and investment. *The Rand Journal of Economics*, 487–508.

Hadlock, C. J., & Pierce, J. R. (2010). New evidence on measuring financial constraints: Moving beyond the KZ index. *The Review of Financial Studies*, *23*(5), 1909–1940.

Haija, R. M. (2009). The Real" Syriana": Interlocking Directorates Shaping a Defense-Petroleum-Policy Complex [PhD Thesis]. Virginia Tech.

Hall, B. J., & Murphy, K. J. (2002). Stock options for undiversified executives. *Journal of Accounting and Economics*, *33*(1), 3-42.

Han, S., & Qiu, J. (2007). Corporate precautionary cash holdings. *Journal of Corporate Finance*, *13*(1), 43–57.

Hann, R. N., Ogneva, M., & Ozbas, O. (2013). Corporate diversification and the cost of capital. *The Journal of Finance*, *68*(5), 1961–1999.

Harris, I. C., & Shimizu, K. (2004). Too busy to serve? An examination of the influence of overboarded directors. *Journal of Management Studies*, *41*(5), 775–798.

Harris, M., & Raviv, A. (2008). A theory of board control and size. *The Review of Financial Studies*, *21*(4), 1797-1832.

Harrison, A. E., Love, I., & McMillan, M. S. (2004). Global capital flows and financing constraints. *Journal of Development Economics*, *75*(1), 269–301.

Haunschild, P. R., & Beckman, C. M. (1998). When do interlocks matter?: Alternate sources of information and interlock influence. *Administrative Science Quarterly*, 815–844.

Hauswald, R., & Marquez, R. (2006). Competition and strategic information acquisition in credit markets. *The Review of Financial Studies*, *19*(3), 967–1000.

Hayashi, F. (1982). Tobin's marginal q and average q: A neoclassical interpretation. *Econometrica: Journal of the Econometric Society*, 213–224.

Hayward, M. L. A., & Hambrick, D. C. (1997). Explaining the premiums paid for large acquisitions: Evidence of CEO hubris. *Administrative Science Quarterly*, 42(1), 103-127.

Heaton, J. B. (2002). Managerial optimism and corporate finance. *Financial Management*, *31*(2), 33-45.

Hedges, L. V., & Nowell, A. (1995). Sex differences in mental test scores, variability, and numbers of high-scoring individuals. *Science*, *269*(5220), 41-45.

Heine, S. J., & Renshaw, K. (2002). Interjudge agreement, self-enhancement, and liking: Cross-cultural divergences. *Personality and Social Psychology Bulletin*, *28*(5), 578-587.

Henry, P. B. (2000). Do stock market liberalizations cause investment booms? *Journal of Financial Economics*, *58*(1–2), 301–334.

Héricourt, J., & Poncet, S. (2009). FDI and credit constraints: Firm-level evidence from China. *Economic Systems*, *33*(1), 1–21.

Hewlett-Packard (2011). 2012 proxy statement. https://s2.q4cdn.com/602190090/files/doc_financials/proxy/hp-proxy-pdf.PDF (last access March 14, 2023)

Higgins, M. C., & Gulati, R. (2003). Getting off to a good start: The effects of upper echelon affiliations on underwriter prestige. *Organization Science*, *14*(3), 244–263.

Hillman, A. J., & Dalziel, T. (2003). Boards of directors and firm performance: Integrating agency and resource dependence perspectives. *Academy of Management review*, *28*(3), 383-396.

Hillman, A. J., Cannella Jr, A. A., & Harris, I. C. (2002). Women and racial minorities in the boardroom: How do directors differ? *Journal of Management*, *28*(6), 747–763.

Hillman, A. J., Nicholson, G., & Shropshire, C. (2008). Directors' multiple identities, identification, and board monitoring and resource provision. *Organization Science*, *19*(3), 441–456.

Hillman, A. J., Shropshire, C., & Cannella Jr, A. A. (2007). Organizational predictors of women on corporate boards. *Academy of Management Journal*, *50*(4), 941–952.

Hillman, A. J., Withers, M. C., & Collins, B. J. (2009). Resource dependence theory: A review. *Journal of Management*, *35*(6), 1404–1427.

Hillman, A. J., Zardkoohi, A., & Bierman, L. (1999). Corporate political strategies and firm performance: Indications of firm-specific benefits from personal service in the US government. *Strategic Management Journal*, *20*(1), 67–81.

Hirshleifer, D. A., Low, A., & Teoh, S. H. (2012). Are overconfident CEOs better innovators? *The Journal of Finance*, *67*(4), 1457-1498.

Hirst, D. E., Hopkins, P. E., & Wahlen, J. M. (2008). Fair values, income measurement, and bank analysts' risk and valuation judgments. *The Accounting Review*, *83*(4), 871-897.

Hoberg, G., & Maksimovic, V. (2015). Redefining financial constraints: A text-based analysis. *The Review of Financial Studies*, *28*(5), 1312–1352.

Hoffrage, U. (2016). Overconfidence. In *Cognitive illusions* (pp. 291-314). Psychology Press.

Hoitash, U., Hoitash, R., & Bedard, J. C. (2009). Corporate governance and internal control over financial reporting: A comparison of regulatory regimes. *The accounting review*, *84*(3), 839-867.

Holthausen, R. W., & Leftwich, R. W. (1986). The effect of bond rating changes on common stock prices. *Journal of Financial Economics*, *17*(1), 57–89.

Hoskisson, R. E., Wright, M., Filatotchev, I., & Peng, M. W. (2013). Emerging multinationals from mid-range economies: The influence of institutions and factor markets. *Journal of Management Studies*, *50*(7), 1295-1321.

Hovakimian, A., & Hovakimian, G. (2009). Cash flow sensitivity of investment. *European Financial Management*, *15*(1), 47–65.

Hovakimian, G. (2009). Determinants of investment cash flow sensitivity. *Financial Management*, *38*(1), 161–183.

Hribar, P., & Jenkins, N. T. (2004). The effect of accounting restatements on earnings revisions and the estimated cost of capital. *Review of Accounting Studies*, *9*(2), 337–356.

Hu, C., & Liu, Y. J. (2015). Valuing diversity: CEOs' career experiences and corporate investment. *Journal of Corporate Finance*, *30*, 11-31.

Huang, A. H., Zang, A. Y., & Zheng, R. (2014). Evidence on the information content of text in analyst reports. *The Accounting Review*, *89*(6), 2151–2180.

Huang, J. B., Tan, N., & Zhong, M. R. (2014). Incorporating Overconfidence into Real Option Decision-Making Model of Metal Mineral Resources Mining Project. Discrete Dynamics in Nature and Society, 2014(1), 232516.

Huang, S., Teoh, S. H., & Zhang, Y. (2014). Tone management. *The Accounting Review*, 89(3), 1083-1113.

Hull, J., Predescu, M., & White, A. (2004). The relationship between credit default swap spreads, bond yields, and credit rating announcements. *Journal of Banking & Finance*, *28*(11), 2789–2811.

Intintoli, V. J., Kahle, K. M., & Zhao, W. (2018). Director connectedness: Monitoring efficacy and career prospects. *Journal of Financial and Quantitative Analysis*, *53*(1), 65–108.

Jegadeesh, N., & Wu, D. (2013). Word power: A new approach for content analysis. *Journal of Financial Economics*, *110*(3), 712–729.

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behaviour, agency costs, and ownership structure. Journal of Financial Economics, 3(4), 305-360.

Johnson, S., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2000). Tunneling. *American Economic Review*, *90*(2), 22–27.

Johnson, S., Schnatterly, K., Bolton, J. F., & Tuggle, C. (2011). Antecedents of new director social capital. *Journal of Management Studies*, *48*(8), 1782–1803.

Kadapakkam, P. R., Kumar, P. C., & Riddick, L. A. (1998). The impact of cash flows and firm size on investment: The international evidence. *Journal of banking & Finance*, *22*(3), 293-320.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263-291.

Kaplan, S. N., & Zingales, L. (1997). Do investment-cash flow sensitivities provide useful measures of financing constraints? *The Quarterly Journal of Economics*, *112*(1), 169–215.

Kaplan, S. N., & Zingales, L. (2000). Investment-cash flow sensitivities are not valid measures of financing constraints. *The Quarterly Journal of Economics*, *115*(2), 707–712.

Kaplan, S. N., Klebanov, M. M., & Sorensen, M. (2012). Which CEO characteristics and abilities matter? *The Journal of Finance*, *67*(3), 973-1007.

Kesner, I. F. (1988). Directors' characteristics and committee membership: An investigation of type, occupation, tenure, and gender. *Academy of Management Journal*, *31*(1), 66–84.

Kim, C., & Zhang, L. (2016). Corporate political connections and tax aggressiveness. *Contemporary Accounting Research*, *33*(1), 78–114.

Kim, J. Y., Howard, M., Cox Pahnke, E., & Boeker, W. (2016). Understanding network formation in strategy research: Exponential random graph models. *Strategic Management Journal*, *37*(1), 22–44.

Kim, J., Yang, I., Yang, T., & Koveos, P. (2021). The impact of R&D intensity, financial constraints, and dividend payout policy on firm value. *Finance Research Letters*, *40*, 101802.

Kim, S., & Sohn, P. (2013). Market timing performance in the Korean Fund Market: Evidence from portfolio holdings. *Procedia Economics and Finance*, *5*, 443–452.

Klayman, J., Soll, J. B., González-Vallejo, C., & Barlas, S. (1999). Overconfidence: It depends on how, what, and whom you ask. *Organizational Behaviour and Human Decision Processes*, *79*(3), 216-247.

Koenig, T., & Gogel, R. (1981). Interlocking corporate directorships as a social network. *American Journal of Economics and Sociology*, *40*(1), 37–50.

Koenig, T., Gogel, R., & Sonquist, J. (1979). Models of the significance of interlocking corporate directorates. *American Journal of Economics and Sociology*, *38*(2), 173–186.

Koo, J. H., & Yang, D. (2018). Managerial overconfidence, self-attribution bias, and downwardly sticky investment: evidence from Korea. Emerging Markets Finance and Trade, 54(1), 144-161.

Kor, Y. Y., & Misangyi, V. F. (2008). Outside directors' industry-specific experience and firms' liability of newness. *Strategic Management Journal*, *29*(12), 1345–1355.

Kor, Y. Y., & Sundaramurthy, C. (2009). Experience-based human capital and social capital of outside directors. *Journal of management*, *35*(4), 981-1006.

Koskinen, J., & Edling, C. (2012). Modelling the evolution of a bipartite network—Peer referral in interlocking directorates. *Social Networks*, *34*(3), 309–322.

Krueger, J., & Mueller, R. A. (2002). Unskilled, unaware, or both? The better-than-average heuristic and statistical regression predict errors in estimates of own performance. *Journal of Personality and Social Psychology*, *82*(2), 180-188.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*(6), 1121-1134.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of personality and social psychology*, *77*(6), 1121.

Kyle, A. S., & Wang, F. A. (1997). Speculation duopoly with agreement to disagree: Can overconfidence survive the market test? *Journal of Finance*, *52*(5), 2073-2090.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. W. (1997). Legal determinants of external finance. *The Journal of Finance*, *52*(3), 1131–1150.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. W. (2000). Agency problems and dividend policies around the world. *The Journal of Finance*, *55*(1), 1–33.

Laeven, L. (2003). Does financial liberalization reduce financing constraints? *Financial Management*, 5–34.

Lamb, N. H., & Roundy, P. (2016). The "ties that bind" board interlocks research: A systematic review. *Management Research Review*.

Lamont, O., Polk, C., & Saaá-Requejo, J. (2001). Financial constraints and stock returns. *The Review of Financial Studies*, *14*(2), 529–554.

Langer, E. J. (1975). The illusion of control. *Journal of Personality and Social Psychology*, *32*(2), 311-328.

Larcker, D. F., So, E. C., & Wang, C. C. (2013). Boardroom centrality and firm performance. *Journal of Accounting and Economics*, *55*(2–3), 225–250.

Leland, H. E., & Pyle, D. H. (1977). Informational Asymmetries, Financial Structure, and Financial Intermediation. The Journal of Finance, 32(2), 371-387.

Leon, F. (2015). Does bank competition alleviate credit constraints in developing countries? *Journal of Banking & Finance*, *57*, 130–142.

Li, F. (2010). Textual analysis of corporate disclosures: A survey of the literature. *Journal of Accounting Literature*, *29*(1), 143–165.

Li, F. (2010). The information content of forward-looking statements in corporate filings—A naïve Bayesian machine learning approach. *Journal of Accounting Research*, *48*(5), 1049–1102.

Li, F. (2010). The information content of forward-looking statements in corporate filings—A naïve Bayesian machine learning approach. *Journal of Accounting Research*, 48(5), 1049-1102.

Lin, C., Ma, Y., & Xuan, Y. (2011). Ownership structure and financial constraints: Evidence from a structural estimation. *Journal of Financial Economics*, *102*(2), 416–431.

Lin, Y. C. (2007). The cash flow sensitivity of cash: evidence from Taiwan. *Applied financial economics*, *17*(12), 1013-1024.

Lin, Y. H., Chen, C. J., & Lin, B. W. (2017). The influence of strategic control and operational control on new venture performance. *Management Decision*, *55*(5), 1042-1064.

López-Gracia, J., & Sogorb-Mira, F. (2015). Financial constraints and cash–cash flow sensitivity. *Applied Economics*, *47*(10), 1037–1049.

Lorsch, J., & Young, J. (1990). Pawns or potentates: The reality of America's corporate boards. *Academy of Management Perspectives*, *4*(4), 85–87.

Loughran, T., & McDonald, B. (2011). When is a liability not a liability? Textual analysis, dictionaries, and 10-Ks. *The Journal of Finance*, 66(1), 35-65.

Love, I. (2003). Financial development and financing constraints: International evidence from the structural investment model. *The Review of Financial Studies*, *16*(3), 765–791.

Love, I., & Martínez Pería, M. S. (2015). How bank competition affects firms' access to finance. *The World Bank Economic Review*, *29*(3), 413–448.

Luo, Q., & Hu, Z. (2011). The moral hazard of controlling shareholder and corporate cash holdings. *Economic Research Journal*, *2*, 125–137.

Luo, X., Wang, H., Raithel, S., & Zheng, Q. (2015). Corporate social performance, analyst stock recommendations, and firm future returns. *Strategic Management Journal*, *36*(1), 123–136.

Lyandres, E. (2007). Costly external financing, investment timing, and investment–cash flow sensitivity. *Journal of Corporate Finance*, *13*(5), 959–980.

Maditinos, D. I., Tsinani, A., & Šević, Ž. (2015). Managerial optimism and the impact of cash flow sensitivity on corporate investment: The case of Greece. International Journal of Business and Economic Sciences Applied Research, 8(2).

Malmendier, U., & Tate, G. (2005). CEO overconfidence and corporate investment. *The Journal of Finance*, *60*(6), 2661-2700.

Malmendier, U., & Tate, G. (2008). Who makes acquisitions? CEO overconfidence and the market's reaction. Journal of financial Economics, 89(1), 20-43.

Malmendier, U., & Tate, G. (2015). Behavioural CEOs: The role of managerial overconfidence. *Journal of Economic Perspectives*, *29*(4), 37-60.

Mariolis, P. (1975). Interlocking directorates and control of corporations: The theory of bank control. *Social Science Quarterly*, 425–439.

Martin, G., Gözübüyük, R., & Becerra, M. (2015). Interlocks and firm performance: The role of uncertainty in the directorate interlock-performance relationship. *Strategic Management Journal*, *36*(2), 235–253.

Masulis, R., Ruzzier, C., Xiao, S., & Zhao, S. (2012). *Do independent expert directors matter?*

McCallum, A., & Nigam, K. (1998). A comparison of event models for naive bayes text classification. *AAAI-98 Workshop on Learning for Text Categorization*, *752*(1), 41–48.

McDonald, M. L., & Westphal, J. D. (2011). My brother's keeper? CEO identification with the corporate elite, social support among CEOs, and leader effectiveness. *Academy of Management Journal*, *54*(4), 661–693.

Mellers, B., Stone, E., Atanasov, P., Rohrbaugh, N., Metz, S. E., Ungar, L., ... & Tetlock, P. (2014). The psychology of intelligence analysis: Drivers of prediction accuracy in world politics. *Journal of Experimental Psychology: Applied*, *20*(1), 1-14.

Meng, X., & Tian, J. J. (2020). Board expertise and executive incentives. *Management Science*, *66*(11), 5448–5464.

Mintz, B. A., & Schwartz, M. (1987). *The power structure of American business*. University of Chicago Press.

Mizruchi, M. S. (1982). *The American corporate network 1904-1974* (Vol. 138). SAGE Publications, Incorporated.

Mizruchi, M. S. (1989). Similarity of political behavior among large American corporations. American Journal of Sociology, 95(2), 401-424.

Mizruchi, M. S. (1989). Similarity of political behaviour among large American corporations. *American Journal of Sociology*, *95*(2), 401–424.

Mizruchi, M. S. (1996). What do interlocks do? An analysis, critique, and assessment of research on interlocking directorates. Annual review of sociology, 22(1), 271-298.

Mizruchi, M. S., & Stearns, L. B. (1988). A longitudinal study of the formation of interlocking directorates. *Administrative Science Quarterly*, 194–210.

Mizruchi, M. S., & Stearns, L. B. (1994). A longitudinal study of borrowing by large American corporations. *Administrative Science Quarterly*, 118–140.

Modigliani, F., & Miller, M. H. (1958). The cost of capital, corporation finance and the theory of investment. *The American Economic Review*, *48*(3), 261–297.

Mohamed, E. B., Fairchild, R., & Bouri, A. (2014). Investment cash flow sensitivity under managerial optimism: New evidence from NYSE panel data firms. Journal of Economics Finance and Administrative Science, 19(36), 11-18.

Moore, D. A., & Healy, P. J. (2008). The trouble with overconfidence. *Psychological Review*, *115*(2), 502-517.

Moore, D. A., & Schatz, D. (2017). The three faces of overconfidence. *Social and Personality Psychology Compass*, *11*(8), e12331.

Moore, D. A., & Small, D. A. (2007). Error and bias in comparative judgment: On being both better and worse than we think we are. *Journal of Personality and Social Psychology*, *92*(6), 972-989.

Morck, R., Shleifer, A., & Vishny, R. W. (1990). Do managerial objectives drive bad acquisitions? *The Journal of Finance*, 45(1), 31-48.

Müller, E., & Zimmermann, V. (2009). The importance of equity finance for R&D activity. *Small Business Economics*, *33*(3), 303–318.

Muravyev, A., Talavera, O., & Schäfer, D. (2009). Entrepreneurs' gender and financial constraints: Evidence from international data. *Journal of Comparative Economics*, *37*(2), 270–286.

Myers, S. C. (1977). Determinants of corporate borrowing. Journal of Financial Economics, 5(2), 147-175.

Myers, S. C. (1984). The capital structure puzzle. *The Journal of Finance*, *39*(3), 574-592.

Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics*, *13*(2), 187–221.

Myint, Y. M., Vyakarnam, S., & New, M. J. (2005). The effect of social capital in new venture creation: The Cambridge high-technology cluster. *Strategic Change*, *14*(3), 165–177.

Nanda, V., & Onal, B. (2016). Incentive contracting when boards have related industry expertise. *Journal of Corporate Finance*, *41*, 1–22.

Neale, M. A., & Bazerman, M. H. (1985). The effects of framing and negotiator overconfidence on bargaining behaviours and outcomes. *Academy of Management Journal*, *28*(1), 34-49.

Norden, L., & Weber, M. (2004). Informational efficiency of credit default swap and stock markets: The impact of credit rating announcements. *Journal of Banking & Finance*, *28*(11), 2813–2843.

NYSE (2016). What directors think. https://www.nyse.com/publicdocs/WDT_Report_2016.pdf (last access March 14, 2023).

Oehmichen, J., Schrapp, S., & Wolff, M. (2017). Who needs experts most? B oard industry expertise and strategic change—a contingency perspective. *Strategic Management Journal*, *38*(3), 645–656.

Omer, T. C., Shelley, M. K., & Tice, F. M. (2014). Do well-connected directors affect firm value?. Journal of Applied Finance (Formerly Financial Practice and Education), 24(2), 17-32.

Ong, C. H., Wan, D., & Ong, K. S. (2003). An exploratory study on interlocking directorates in listed firms in Singapore. *Corporate Governance: An International Review*, *11*(4), 322-334.

Opler, T., Pinkowitz, L., Stulz, R., & Williamson, R. (1999). The determinants and implications of corporate cash holdings. *Journal of Financial Economics*, *52*(1), 3–46.

Opper, S., Nee, V., & Holm, H. J. (2017). Risk aversion and guanxi activities: A behavioral analysis of CEOs in China. *Academy of Management Journal*, *60*(4), 1504-1530.

Pajares, F., & Kranzler, J. (1995). Self-efficacy beliefs and general mental ability in mathematical problem-solving. *Contemporary Educational Psychology*, *20*(4), 426-443.

Pál, R., & Ferrando, A. (2010). Financing constraints and firms' cash policy in the euro area. The European Journal of Finance, 16(2), 153-171.

Pál, R., & Ferrando, A. (2010). Financing constraints and firms' cash policy in the euro area. *The European Journal of Finance*, *16*(2), 153–171.

Palmer, D. A., Jennings, P. D., & Zhou, X. (1993). Late adoption of the multidivisional form by large US corporations: Institutional, political, and economic accounts. Administrative science quarterly, 100-131.

Palmer, D., Friedland, R., & Singh, J. V. (1986). The ties that bind: Organizational and class bases of stability in a corporate interlock network. *American Sociological Review*, 781–796.

Panetta, F., Schivardi, F., & Shum, M. (2009). Do mergers improve information? Evidence from the loan market. *Journal of Money, Credit and Banking*, *41*(4), 673–709.

Park, K. H., Byun, J., & Choi, P. M. S. (2019). Managerial overconfidence, corporate social responsibility activities, and financial constraints. *Sustainability*, *12*(1), 61.

Pennings, J. M. (1980). Interlocking directorates: Origins and consequences of connections among organizations' Board of Directors. Jossey-Bass.

Petersen, M. A., & Rajan, R. G. (1995). The effect of credit market competition on lending relationships. *The Quarterly Journal of Economics*, *110*(2), 407–443.

Pfeffer, J., & Salancik, G. R. (1978). A resource dependence perspective. In *Intercorporate relations. The structural analysis of business*. Cambridge University Press Cambridge.

Pfeffer, J., & Salancik, G. R. (2003). *The external control of organizations: A resource dependence perspective*. Stanford University Press.

Phua, K., Tham, T. M., & Wei, C. (2018). Are overconfident CEOs better leaders? Evidence from stakeholder commitments. *Journal of Financial Economics*, *127*(3), 519-545.

Poncet, S., Steingress, W., & Vandenbussche, H. (2010). Financial constraints in China: Firm-level evidence. *China Economic Review*, *21*(3), 411–422.

Price, P. C., Pentecost, H. C., & Voth, R. D. (2012). Perceived event frequency and the optimistic bias: Evidence for a two-process model of personal risk judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(3), 763-774.

PricewaterhouseCoopers LLP (2012). Insights from the Boardroom 2012 Board evolution: progress made, yet challenges persist. https://www.votre-administrateur.com/wp-content/uploads/2012/07/pwc-annual-corporate-directors-survey.pdf (last access March 14, 2023)

Provan, K. G. (1980). Board power and organizational effectiveness among human service agencies. *Academy of Management Journal*, *23*(2), 221–236.

Pugliese, A., Minichilli, A., & Zattoni, A. (2014). Integrating agency and resource dependence theory: Firm profitability, industry regulation, and board task performance. *Journal of Business Research*, *67*(6), 1189-1200.

Purda, L., & Skillicorn, D. (2015). Accounting variables, deception, and a bag of words: Assessing the tools of fraud detection. *Contemporary Accounting Research*, *32*(3), 1193–1223.

Ratti, R. A., Lee, S., & Seol, Y. (2008). Bank concentration and financial constraints on firm-level investment in Europe. *Journal of Banking & Finance*, *32*(12), 2684–2694.

Rauh, J. D. (2006). Investment and financing constraints: Evidence from the funding of corporate pension plans. *The Journal of Finance*, *61*(1), 33–71.

Renneboog, L., & Zhao, Y. (2014). Director networks and takeovers. *Journal of Corporate Finance*, *28*, 218–234.

Rice, T., & Strahan, P. E. (2010). Does credit competition affect small-firm finance? *The Journal of Finance*, *65*(3), 861–889.

Richardson, S. (2006). Over-investment of free cash flow. *Review of Accounting Studies*, 11(2-3), 159-189.

Rish, I. (2001). An empirical study of the naive Bayes classifier. *IJCAI 2001 Workshop on Empirical Methods in Artificial Intelligence*, *3*(22), 41–46.

Roll, R. (1986). The hubris hypothesis of corporate takeovers. *The Journal of Business*, 59(2), 197-216.

Rossi, M., Chouaibi, J., Chouaibi, S., Jilani, W., & Chouaibi, Y. (2021). Does a board characteristic moderate the relationship between CSR practices and financial performance? Evidence from European ESG firms. *Journal of Risk and Financial Management*, *14*(8), 354.

Rossi, M., Nerino, M., & Capasso, A. (2015). Corporate governance and financial performance of Italian listed firms. The results of an empirical research. *Corporate Ownership & Control*, *12*(2), 628–643.

Ryan, R. M., O'Toole, C. M., & McCann, F. (2014). Does bank market power affect SME financing constraints? *Journal of Banking & Finance*, *49*, 495–505.

Santos, A., & Cincera, M. (2022). Determinants of financing constraints. *Small Business Economics*, *58*(3), 1427–1439.

Sarto, F., & Saggese, S. (2022). Board industry expertise and innovation input: Evidence on the curvilinear relationship and the moderating effect of CEO. *European Journal of Innovation Management*, *25*(6), 775–803.

Savignac, F. (2008). Impact of financial constraints on innovation: What can be learned from a direct measure? *Econ. Innov. New Techn.*, *17*(6), 553–569.

Schoorman, F. D., Bazerman, M. H., & Atkin, R. S. (1981). Interlocking directorates: A strategy for reducing environmental uncertainty. *Academy of Management Review*, *6*(2), 243–251.

Schrand, C. M., & Zechman, S. L. C. (2012). Executive overconfidence and the slippery slope to financial misreporting. *Journal of Accounting and Economics*, *53*(1-2), 311-329.

Schumpeter, J. A. (1942). Creative destruction. *Capitalism, Socialism and Democracy*, *82*(1), 206-207.

Shefrin, H. (2002). Beyond greed and fear: Understanding behavioural finance and the psychology of investing. Oxford University Press.

Shen, C. H., & Lin, C. Y. (2016). Political connections, financial constraints, and corporate investment. *Review of Quantitative Finance and Accounting*, *47*, 343-368.

Shipilov, A. V., Greve, H. R., & Rowley, T. J. (2010). When do interlocks matter? Institutional logics and the diffusion of multiple corporate governance practices. *Academy of Management Journal*, *53*(4), 846–864.

Shleifer, A., & Vishny, R. W. (1997). A survey of corporate governance. *The Journal of Finance*, *52*(2), 737–783.

Shrader, C. B., Hoffman, A. N., & Stearns, T. M. (1991). Agency directors and network centrality: An examination of resource dependencies. *Journal of Managerial Issues*, 46–61.

Shropshire, C. (2010). The role of the interlocking director and board receptivity in the diffusion of practices. *Academy of Management Review*, *35*(2), 246–264.

Silva, F., & Carreira, C. (2012). Do financial constraints threat the innovation process? Evidence from Portuguese firms. *Economics of Innovation and New Technology*, *21*(8), 701–736.

Simon, D. P. (1991). Segmentation in the Treasury bill market: Evidence from cash management bills. *Journal of Financial and Quantitative Analysis*, *26*(1), 97–108.

Simoni, M., & Caiazza, R. (2012). Interlocks network structure as driving force of coopetition among Italian firms. *Corporate Governance: The International Journal of Business in Society*.

Society of Corporate Secretaries and Governance Professionals and Deloitte Development LLC (2012). Board Practices Report: Providing Insight into the Shape of Things to Come. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Risk/dttl-gccg-risk-boardpracticesreport.pdf (last access March 14, 2023)

Society of Corporate Secretaries and Governance Professionals and Deloitte Development LLC (2014). 2014 Board Practices Report. https://www2.deloitte.com/content/dam/Deloitte/za/Documents/governance-risk-compliance/ZA_board_practices_report_infographic_21092015.pdf (last access March 14, 2023)

Stearns, L. B., & Mizruchi, M. S. (1986). Broken-tie reconstitution and the functions of interorganizational interlocks: A reexamination. *Administrative Science Quarterly*, 522–538.

Stearns, L. B., & Mizruchi, M. S. (1993). Board composition and corporate financing: The impact of financial institution representation on borrowing. *Academy of Management Journal*, *36*(3), 603–618.

Steiner, M., & Heinke, V. G. (2001). Event study concerning international bond price effects of credit rating actions. *International Journal of Finance & Economics*, *6*(2), 139–157.

Stiglitz, J. E., & Weiss, A. (1981). Credit rationing in markets with imperfect information. *The American Economic Review*, *71*(3), 393–410.

Stucki, T. (2014). Success of start-up firms: The role of financial constraints. *Industrial and Corporate Change*, *23*(1), 25–64.

Svenson, O. (1981). Are we all less risky and more skillful than our fellow drivers? *Acta Psychologica*, *47*(2), 143-148.

Svenson, O. (1981). Are we all less risky and more skillful than our fellow drivers?. *Acta psychologica*, *47*(2), 143-148.

Tetlock, P. C. (2007). Giving content to investor sentiment: The role of media in the stock market. *The Journal of Finance, 62*(3), 1139-1168.

Tetlock, P. C., Saar-Tsechansky, M., & Macskassy, S. (2008). More than words: Quantifying language to measure firms' fundamentals. *The Journal of Finance*, 63(3), 1437-1467.

Tobler, C., Visschers, V. H. M., & Siegrist, M. (2012). Consumers' knowledge about climate change. *Climatic Change, 114*(2), 189-209.

Tricker, R. I. (2015). *Corporate governance: Principles, policies, and practices*. Oxford University Press, USA.

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, 5(4), 297-323.

Ullah, B. (2020). Financial constraints, corruption, and SME growth in transition economies. *The Quarterly Review of Economics and Finance*, *75*, 120–132.

Useem, M. (1984). Corporate social and political action: Research in corporate and social performance and policy. SAGE Publications Sage CA: Los Angeles, CA.

Useem, M., & Karabel, J. (1986). Pathways to top corporate management. *American Sociological Review*, 184–200.

Uzzi, B. (1999). Embeddedness in the making of financial capital: How social relations and networks benefit firms seeking financing. *American Sociological Review*, 481–505.

Von Meyerinck, F., Oesch, D., & Schmid, M. (2016). Is director industry experience valuable? *Financial Management*, *45*(1), 207–237.

Wagenaar, W. A., & Keren, G. (1986). Does the expert know? The reliability of predictions and confidence ratings of experts. In *Intelligent decision support in process environments* (pp. 87-107). Springer.

Wang, C., Xie, F., & Zhu, M. (2015). Industry expertise of independent directors and board monitoring. *Journal of Financial and Quantitative Analysis*, *50*(5), 929–962.

Wang, S. (2017). *Are independent directors with industry expertise more informed?*

Wei, K. J., & Zhang, Y. (2008). Ownership structure, cash flow, and capital investment: Evidence from East Asian economies before the financial crisis. *Journal of Corporate Finance*, *14*(2), 118–132.

Weinstein, N. D., Kolb, K., & Goldstein, B. D. (2000). Using time intervals between expected events to communicate risk magnitudes. *Risk Analysis*, *20*(5), 707-719.

Westphal, J. D., Seidel, M.-D. L., & Stewart, K. J. (2001). Second-order imitation: Uncovering latent effects of board network ties. *Administrative Science Quarterly*, *46*(4), 717–747.

Whited, T. M. (1992). Debt, liquidity constraints, and corporate investment: Evidence from panel data. *The Journal of Finance*, *47*(4), 1425–1460.

Whited, T. M., & Wu, G. (2006). Financial constraints risk. *The Review of Financial Studies*, *19*(2), 531–559.

Withers, M. C., Hillman, A. J., & Cannella Jr, A. A. (2012). A multidisciplinary review of the director selection literature. *Journal of Management*, *38*(1), 243–277.

Withers, M., Kim, J. Y. R., & Howard, M. (2018). The evolution of the board interlock network following Sarbanes-Oxley. *Social Networks*, *52*, 56–67.

Ye, B., & Yuan, J. (2008). Firm value, managerial confidence, and investments: The case of China. *Journal of Leadership studies*, *2*(3), 26-36.

Zajac, E. J. (1988). Interlocking directorates as an interorganizational strategy: A test of critical assumptions. *Academy of Management Journal*, *31*(2), 428–438.

Zeitlin, M. (1974). Corporate ownership and control: The large corporation and the capitalist class. *American Journal of Sociology*, *79*(5), 1073–1119.

Zhang, H. (2005). Exploring conditions for the optimality of naive Bayes. *International Journal of Pattern Recognition and Artificial Intelligence*, *19*(02), 183–198.

Zhao, T., & Xiao, X. (2019). The impact of corporate social responsibility on financial constraints: Does the life cycle stage of a firm matter? *International Review of Economics & Finance*, *63*, 76–93.

Zikmund-Fisher, B. J., Ubel, P. A., Smith, D. M., Derry, H. A., McClure, J. B., Stark, A., ... & Fagerlin, A. (2010). Communicating side effect risks in a tamoxifen prophylaxis decision aid: The debiasing influence of pictographs. *Patient Education and Counseling*, *81*(2), 224-229.

Zona, F., Gomez-Mejia, L. R., & Withers, M. C. (2018). Board interlocks and firm performance: Toward a combined agency–resource dependence perspective. *Journal of Management*, *44*(2), 589-618.

Zweigenhaft, R. L., & Domhoff, G. W. (1998). Diversity in the power elite: Have women and minorities reached the top? Yale University Press.