Jamshed Iqbal

Essays on the Relationship between Corporate Governance Mechanisms and Risk-Taking by Financial Institutions

ACTA WASAENSIA 403

Vaasan yliopisto
UNIVERSITY OF VAASA

ACADEMIC DISSERTATION

To be presented, with the permission of the Board of the School of Accounting and Finance of the University of Vaasa, for public examination in Auditorium Nissi (K218) on the 15th of June, 2018, at noon.

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Julkaisija
Vaasan yliopisto

Julkaisupäivämäärä
Kesäkuu 2018

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Julkaisun tyyppi
Artikkeliväitöskirja

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Julkaisusarjan nimi, osan numero
Acta Wasaensia, 403

Yhteystiedot
Vaasan yliopisto
Laskentatoimen ja rahoituksen yksikkö
PL 700
FI-65101 VAASA

ISBN
978-952-476-810-8 (painettu)
978-952-476-811-5 (verkkojulkaisu)

ISSN
0355-2667 (Acta Wasaensia 403, painettu)
2323-9123 (Acta Wasaensia 403, verkkoaineisto)

Sivumäärä
178

Kieli
Englanti

Julkaisun nimike
Esseitä hallinto- ja ohjausjärjestelmien vaikutuksesta rahoituslaitosten riskisyyteen

Tiivistelmä

Tämä väitöskirja koostuu neljästä esseestä, jotka käsittelevät eri näkökulmista hallinto- ja ohjausjärjestelmien vaikutusta pankkien ja muiden rahoituslaitosten riskisyyteen. Väitöskirjan kahdessa ensimmäisessä esseessä tarkastellaan hallinto- ja valvontakäytäntöjen vaikutusta yhdysvaltalaisten rahoituslaitosten riskinottoon. Ensimmäisessä esseessä tutkitaan rahoituslaitosten hallintojärjestelmien vahvuuden ja systeemiriskin suhdetta. Tulokset osoittavat, että omistajalähtöiset hallinto-järjestelmät ja omistajaystävälliset hallitukset lisäävät rahoituslaitosten systeemiriskiä. Toisessa esseessä selvitetään hallintojärjestelmien vaikutusta rahoituslaitosten maksukyvyttömyysriskiin. Tutkimuksessa todetaan, että omistajalähtöiset hallintojärjestelmät kasvattavat rahoituslaitosten maksukyvyttömyysriskiä sekä distance-to-default -indikaattorilla että luottoriskijohdannaisten hinnoista mitattuna.

Kolmas ja neljäs essee tarkastelevat ylimmän johdon palkitsemisjärjestelmien ja erityisesti riskinottokannustimien suhdetta pankkien ja muiden rahoituslaitosten riskisyyteen. Kolmannen esseen tulokset osoittavat, että ylimmän johdon optio-perusteisilla riskinottokannustimilla on negatiivinen vaikutus rahoituslaitosten systeemiriskiin. Toisaalta tulokset myös osoittavat, että johdon riskinottokannustimet lisäsivät rahoituslaitosten riskisyyttä rahoitusmarkkinakriisin aikana vuonna 2008. Neljännessä esseessä verrataan toimitusjohtajan kokonaispalkkaa suhteessa muihin ylimpiin johtajiin ja tutkitaan tämän palkitsemiseriarvoisuuden vaikutusta yhdysvaltalaisten pankkien riskisyyteen. Tutkimustulokset osoittavat, että toimitus-johtajan ja muun ylimmän johdon palkkaeron kutistuminen kasvattaa pankkien riskisyyttä.

Asiasanat
Hallinto- ja ohjausjärjestelmät, rahoituslaitokset, pankit, systeemiriski, maksukyvyttömyysriski, johdon palkitseminen

Publisher	Date of publication	
Vaasan yliopisto	June 2018	
Author(s) Jamshed Iqbal	**Type of publication** Doctoral thesis by publication	
Orcid ID https://orcid.org/0000-0002-1354-5785	**Name and number of series** Acta Wasaensia, 403	
Contact information University of Vaasa The School of Accounting and Finance P.O. Box 700 FI-65101 Vaasa Finland	**ISBN** 978-952-476-810-8 (print) 978-952-476-811-5 (online)	
	ISSN 0355-2667 (Acta Wasaensia 403, print) 2323-9123 (Acta Wasaensia 403, online)	
	Number of pages 178	**Language** English

Title of publication
Essays on the Relationship between Corporate Governance Mechanisms and Risk-Taking by Financial Institutions

Abstract

This dissertation is comprised of four related empirical essays on corporate governance in financial institutions. Specifically, each essay focuses on slightly different aspects of corporate governance and risk-taking by financial institutions. The first essay examines the relationship between corporate governance and the systemic risk of financial institutions. Empirical findings indicate that financial institutions with stronger and more shareholder-focused corporate governance structures and boards of directors are associated with higher levels of systemic risk. The second essay investigates whether corporate governance is related to insolvency risk of financial institutions. The essay finds that the strength of corporate governance mechanisms is positively related to insolvency risk of financial institutions as proxied by Merton's distance-to-default measure and credit default swap spread.

The third essay examines whether the systemic risk of financial institutions is associated with the risk-taking incentives generated by executive compensation. This essay documents a negative association between systemic risk and the risk-taking incentives of the top executives. However, the results also demonstrate that financial institutions with greater managerial risk-taking incentives had higher levels of systemic risk in the midst of the global financial crisis in 2008. The fourth essay investigates the relationship between Chief Executive Officer (CEO) pay-share (pay inequality between the CEO and the other top executives) and risk-taking in large bank holding companies (BHCs). This essay finds that higher CEO pay-share is associated with lower BHC risk.

Keywords
Corporate Governance, Financial Institutions, Systemic Risk, Insolvency Risk, Executive Compensation, Financial Crisis, Risk-Taking

ACKNOWLEDGEMENT

This little book is the realization of a dream. For that, I can never, adequately and properly, submit my thankful praises to the Ever All-Gracious, the Ever All-Merciful Creator of all the Worlds for providing me resources and all the help to accomplish this task, for which I could never imagine, plan and organize. I can still remember the day when I came to Vaasa to pursue my doctoral studies. Over these years, numerous souls contributed to my success.

First, I would like to express my sincere gratitude to Professor Sami Vähämaa for recruiting me as a doctoral student and supporting me throughout my doctoral studies. I not only received the literary and philosophical training from him but also learned how to be a good human. I would also like to thank my second supervisor, Professor Jukka Sihvonen, for providing valuable comments on previous drafts of the essays. I especially appreciate him for always giving important suggestions during the research seminars organized by the department.

I would like to thank the pre-examiners of this dissertation, Professor James Gilkeson from the University of Central Florida and Professor Antonio Trujillo-Ponce from the Universidad Pablo de Olavide. Their valuable comments helped me to improve the readability, quality and the exposition of the dissertation. I especially thank Professor Gilkeson for extensive and detailed comments on the previous versions of the essays. This changed my perspective towards the corporate governance among financial institutions and paved the way for future research.

During my doctoral studies, I have had the privilege to work in an excellent workplace and research environment. For that, I thank Professor Sami Vähämaa, Professor Stefan Sundgren, Professor Timo Rothovius, Professor Juha Junttila and Professor Panu Kalmi for providing competent and cooperative research and work environment. I would also like to thank Shaker Ahmed, Klaus Grobys, and Antti Klemola for their friendship, support and time. I will always cherish the time spent at the School of Accounting and Finance.

I greatly acknowledge the financial support for my studies and dissertation from the Department of Accounting and Finance of the University of Vaasa, the Jenny and Antti Wihuri Foundation, Finnish Foundation for Economic Education, Marcus Wallenberg Foundation, Finnish Cultural Foundation (The South Ostrobothnia Regional Fund), and Säästöpankkien Säätiöiden apurahat.

I would also express my deepest gratitude to my mother. For the last 17 years, I had to live far away from her to complete my education, but she is always there in my heart and an important part of my prayers. My special thank and tribute to my better half, Farah. She has always motivated me to excel. Everything becomes easy and beautiful when she is by my side.

Finally, I would, indeed, remiss if I do not have a special thanks and appreciation for Searat Ali, Waheed Akbar Bhatti, Nazim Hussain, Arshad Iqbal, Jarno Kiviaho, Waqar Nadeem, and Zeeshan Ullah for providing me motivation and immense support for the completion of this very task.

Vaasa, May 2018

Jamshed Iqbal

Contents

Publications

This doctoral dissertation consists of an introductory chapter and the following four essays:

I. Iqbal, J., Strobl, S., & Vähämaa, S. 2015. Corporate Governance and the Systemic Risk of Financial Institutions. *Journal of Economics and Business*, 82, 42-61.[1]

II. Ali, S., & Iqbal, J. 2018. Corporate Governance and the Insolvency Risk of Financial Institutions. Proceedings of the 2018 Financial Markets & Corporate Governance Conference; Proceedings of the International Finance and Banking Society, 2017 Oxford Conference; and Proceedings of the 29th Australasian Finance and Banking Conference.

III. Iqbal, J., & Vähämaa, S. 2017. Managerial Risk-Taking Incentives and the Systemic Risk of Financial Institutions. Proceedings of the 30th Australasian Finance and Banking Conference.

IV. Iqbal, J. 2018. CEO Pay-Share and Risk-Taking in Large Bank Holding Companies. Proceedings of the 57th Annual Meeting of Southwestern Finance Association; and Proceedings of the 2018 Annual Meeting of the Finnish Economic Association.

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1 INTRODUCTION

This doctoral dissertation examines the relationship between corporate governance mechanisms and risk-taking by financial institutions in four inter-related essays. Corporate governance is among those public policy issues that has received considerable attention from both policymakers and scholars. After the global financial crisis, corporate governance of financial institutions has received even more attention than that of non-financial firms. This dissertation can broadly be divided into two sections. The first section investigates whether the strength of corporate governance mechanisms is related to risk-taking in financial institutions. The first and second essays examine whether the strength of corporate governance mechanisms can explain the cross-sectional variation in systemic risk and insolvency risk around the time of the recent financial crisis. The second section focuses on executive compensation and risk-taking by financial institutions. The third and fourth essays examine whether the risk-taking incentives generated by executive compensation are related to risk-taking by financial institutions.

'Stronger' corporate governance not only affects the performance of the firms, measured by Tobin's Q (Gompers, Ishii, and Metrick, 2003; Brown and Caylor, 2006; Chhaochharia and Laeven, 2009; Ammann et al., 2011) but also encourages increased risk-taking that results in higher growth of firms (John, Litov, and Yeung, 2008).[1] However, for financial institutions, the optimal degree of risk-taking is higher than for non-financial firms because market participants expect government support for financial institutions if they become distressed. Implicit and explicit government guarantees encourage financial institutions to take more risks (see Acharya, Anginer and Warburton, 2016).[2] In addition, shareholder-friendly governance mechanisms may further encourage to adopt riskier corporate policies (Chava and Purnanadam, 2010) which may, in turn, lead to higher insolvency risk in financial institutions. In contrast to non-financial firms, expectation of government support in times of distress, implicit and explicit government guarantees, provide a unique environment to consider financial

[1] Corporate governance mechanisms and the board of directors are considered to be stronger and more shareholder-friendly when they provide effective monitoring and stronger protection of shareholder's interests, and more generally, better alignment of managers' interests with those of the shareholders. Adams (2012) and de Haan and Vlahu (2016) provide comprehensive discussions about the corporate governance of financial institutions and the elements of "good" governance.

[2] Implicit government guarantee is the expectation by market that government may provide bailout (Acharya et al., 2016). It is referred as implicit because government does not explicitly provide commitment to intervene. Implicit government guarantees are not limited to only banks but also for other financial institutions (Zhao, 2018).

institutions separately (Acharya et al., 2016; Zhao, 2018) because stronger corporate governance mechanisms in financial institutions can lead to greater risk-taking (Erkens, Hung, and Matos, 2012; Anginer, Demirguc-Kunt, Huizinga, and Ma, 2014).[3]

In the aftermath of the global financial crisis, it has been widely argued by politicians, banking supervisors, and other authorities that the crisis can be, at least to some extent, attributed to flaws in the corporate governance practices of financial institutions (see, e.g., Kirkpatrick, 2009; Financial Stability Forum, 2009; Basel Committee on Banking Supervision, 2010; Board of Governors of the Federal Reserve System, 2010; Haldane, 2012). These allegations seem reasonable given that corporate governance can be broadly considered as the set of mechanisms for addressing agency problems and controlling risk within the firm. In general, strong corporate governance practices, and especially effective board oversight is supposed to encourage the firm's top management to act in the best interest of shareholders and other stakeholders (Shleifer and Vishny, 1997). So, was something actually wrong with the corporate governance of financial institutions at the onset of the global financial crisis?

Driven by this question, one purpose of this dissertation is to explore the role of corporate governance in the global financial crisis by investigating the association between the strength of corporate governance mechanisms, the risk-taking incentives generated by executive compensation, top executive compensation, and risk-taking by financial institutions. The empirical findings reported in this dissertation indicate that financial institutions with stronger and more shareholder-focused corporate governance mechanisms and boards are associated with higher systemic risk and insolvency risk, suggesting that what is often described as good corporate governance may encourage more risk-taking in the financial industry.[4] Furthermore, empirical findings also indicate that financial institutions with higher managerial risk-taking incentives and higher CEO pay-share were associated with greater firm risk, especially systemic risk. Financial institutions are heavily regulated because of their important role in the financial system. Apart from regulations, financial institutions' governance is complicated because of large number of stakeholders (Adams and Mehran, 2012). Thus, financial institutions should be considered separately in empirical corporate

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[3] For instance, Acharya et al. (2016) find that bondholders of the financial institutions, especially large ones, expect that the government will protect them in case of failure of the institution.

[4] In general, the findings of this dissertation are broadly consistent with the recent literature on bank risk-taking (see e.g., Laeven and Levine, 2009; Pathan, 2009; Chava and Purnanandam, 2010; Fortin, Goldberg and Roth, 2010; Fahlenbrach and Stulz, 2011; Adams and Mehran, 2012; Beltratti and Stulz, 2012; Bai and Elyasiani, 2013; DeYoung, Peng and Yan, 2013; Ellul and Yerramilli, 2013).

governance research because the governance mechanism considered "good" in non-financial firms may actually encourage inappropriate level of risk-taking in financial institutions.

This doctoral dissertation consists of an introductory chapter and four interrelated essays on corporate governance in financial institutions. The remainder of the introductory chapter is organized as follows: Section 2 describes the contribution of the dissertation, the contribution of each essay and the limitations, Section 3 provides a brief discussion of the agency theory, Section 4 discusses how the corporate governance of financial institutions differs from that of non-financial firms, and Section 5 provides summaries of the four essays.

2 CONTRIBUTION OF THE DISSERTATION

This dissertation, consisting of four essays, provides new evidence on the subject of corporate governance in the financial industry by empirically examining the relationship between the strength of corporate governance mechanisms and risk-taking by financial institutions. Although all four essays are related, each examines the issue from a different perspective. The first essay focuses on the linkage between corporate governance and the systemic risk of financial institutions around the time of the recent financial crisis. It shows that "good" corporate governance practices may have encouraged more risk-taking in the financial industry. The second essay empirically examines the association between corporate governance mechanisms and insolvency risk among financial institutions. In this essay, both traditional (distance-to-default) and innovative market-based (credit default swap (CDS) spread) measures are used as proxies for insolvency risk. The third essay investigates the relationship of managerial risk-taking incentives generated by executive compensation with the systemic risk of financial institutions around the time of the recent global financial crisis. The fourth essay examines the relationship between CEO pay-share, measured as the ratio of CEO total annual compensation to the total annual compensation of the CEO and the next four most-highly paid executives in the bank holding company (BHC), with the BHC risk.

As a whole, this dissertation makes important contributions to the banking literature and each essay specifically contributes to the recent debate on corporate governance and risk-taking in the financial industry. Individually, each of the four essays adds to various streams of the corporate governance literature related to corporate governance and the insolvency risk of financial institutions, the strength of corporate governance mechanisms, and the systemic risk of financial institutions, managerial risk-taking incentives and the systemic risk of financial institutions, and executive compensation and bank risk-taking. A more detailed description of the contribution of each essay is provided below.

The first essay contributes to the existing literature by empirically examining whether the strength of corporate governance mechanisms can explain the cross-sectional variation in the systemic risk of U.S. financial institutions in the period around the recent financial crisis. A growing body of literature has examined how certain firm-specific attributes are related to the systemic risk of financial institutions. Studies by Brunnermeier, Dong and Palia (2012), Pais and Stork (2013), Mayordomo, Rodriguez-Moreno and Peña (2014), Calluzzo and Dong (2015), and Acharya and Thakor (2016), among others, have documented that the size of the institution, the amount of equity capital, and the extent of lending activities are important factors for explaining the cross-sectional variation in systemic risk. This essay provides evidence that stronger corporate governance is associated with higher levels of systemic risk among financial institutions. This essay also contributes to the literature on bank risk-taking (see e.g., Pathan, 2009; Fortin et al., 2010; Beltratti and Stulz, 2012; Erkens et al., 2012). These studies document that shareholder-friendly corporate governance mechanisms encourage more risk-taking in financial industry as compared to non-financial firms. This essays contributes by providing empirical evidence that shareholder-friendly corporate governance mechanisms are positively associated with the level of systemic risk among financial institutions.

The second essay contributes to the literature in the following ways. First, it contributes to the literature in corporate finance that relates firm-level characteristics to the failure of financial institutions. Previous contributions to this literature mostly emphasize investigating the influence of accounting variables on financial institutions' failure probabilities.[5] Studies on the role of corporate governance in the failure of financial institutions are relatively scarce. This essay contributes by showing that the strength of corporate governance mechanisms plays an important role in the insolvency risk of financial institutions. Second, we contribute to the literature on the effects of corporate governance on risk-taking in financial institutions (see Laeven and Levine, 2009; Pathan, 2009; Fahlenbrach and Stulz, 2011; Beltratti and Stulz, 2012; Erkens et al, 2012; Peni and Vahamaa, 2012; Berger et al., 2014; Iqbal et al., 2015).[6] These studies mainly find that shareholder-friendly corporate governance mechanisms encourage more risk-taking in the financial industry. As far as we know, this is one of the few studies to show the relevance of corporate governance to a financial institution's insolvency risk especially in the context of the recent global financial crisis. Further, most of the previous studies on board effectiveness do not include financial institutions in their sample (see Adams et al., 2010).[7] Lastly, building on the earlier contributions,

[5] For instance, see Meyer and Pfifer (1970), Martin (1977), Whalen and Thomson (1988), Aubuchon and Wheelock (2010), Cole and White (2012), Berger and Bouwman (2013), Ng and Roychowdhury (2014). However, studies on the role of corporate governance in the failure of financial institutions are relatively scarce.

[6] Mehran, Morrison and Shapiro (2011) survey studies investigating the relationship between corporate governance and measures of risk.

[7] Most of the studies before GFC excluded financial firms from their sample because they were considered highly regulated. The additional regulatory oversight maybe viewed as a substitute (John, Mehran and Qian, 2010; Adams and Mehran, 2012) for corporate governance in financial institutions. However, governance of financial institutions may be different from that of non-financial firms because of several reasons. For instance, financial institutions have larger number of stakeholders which complicates the governance of financial institutions. Apart from investors and depositors, regulators also have stake in the performance of financial institution because performance of financial institutions can also affect the health of the overall economy (Adams and Mehran, 2012). Implicit and explicit government guarantees provide financial institutions a different risk environment

we utilize the market-based CDS spread data to proxy insolvency risk, which also accounts for credit risk.

The third essay contributes to the literature in the following ways: First, it contributes to the literature of managerial risk-taking incentives (Chava and Purnanadam, 2010; Fahlenbrach and Stulz, 2011; Bai and Elyasiani, 2013; Guo, Jalal and Khaksari, 2015). This essay contributes to this literature by relating the managerial risk-taking incentives generated by executive compensation to the systemic risk of financial institutions. Second, it contributes to the systemic risk literature that investigates how certain firm-specific attributes are related to the systemic risk (Brunnermeier et al., 2012; Pais and Stork, 2013; Mayordomo et al., 2014; Calluzzo and Dong, 2015; Acharya and Thakor, 2016). Third, it contributes to the literature on corporate governance and risk-taking in the financial industry (Fahlenbrach and Stulz, 2011; Bai and Elyasiani, 2013; Ellul and Yerramilli, 2013; Berger et al., 2014). Last, it contributes to the literature on shareholder-focused corporate governance structures and systemic risk (Iqbal et al., 2015; Battaglia and Gallo, 2017).

The fourth essay makes several important contributions to the existing literature and recent policy debate regarding CEO compensation in large BHCs. First, this study contributes to the bank risk-taking literature (Laeven and Levine 2009; Pathan 2009; Fortin et al., 2010; Beltratti and Stulz 2012; Ellul and Yerramilli 2013; Berger et al., 2014; Cheng, Hong and Scheinkman, 2015).[8] Second, this study contributes to the bank compensation literature (Fahlenbrach and Stulz, 2011; Bai and Elyasiani, 2013). Third, this study contributes to the CEO pay-share literature (Bebchuk, Cremers and Peyer, 2011; Kini and Williams, 2012; Bai and Elyasiani, 2013). Bebchuk et al. (2011) find that CEO pay-share is negatively associated with firm value as measured by Tobin's Q. On the other hand, Kini and Williams (2012) find that CEO pay-share is positively associated with firm risk.[9] Kini and Williams (2012) regard CEO pay-share as a tournament incentive that drives top executives to compete for the position of CEO. However, the above studies exclude the banking sector from their samples. Among banking studies, this study is closely related to that of Bai and Elyasiani (2013) who investigate whether CEO pay-share is related to the stability of BHC. They find that greater CEO pay-share ratio is related to greater stability among BHCs as measured by the *z*-score. However, the sample is based on data from 1992 to 2008, and therefore before the advent of the

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that are not applicable to non-financial firms. Therefore, it is important to consider financial institutions separately.

[8] For detailed review of literature on executive compensation and risk-taking in banks, see de Haan and Vlahu (2016).

[9] Kini and Williams (2012) examine two measures of risk - cash flow volatility and stock return volatility.

Dodd-Frank Act. This essay uses comprehensive data on BHCs from 1992 to 2016, including the post Dodd-Frank years and using the sample of only economically significant BHCs (defined as those having assets greater than $10 billion in 2010 constant dollars).

2.1 Limitations of the dissertation

Although this dissertation attempts to holistically examine the relationship between corporate governance mechanisms and risk-taking by financial institutions, the present study has at least the following limitations:

a) This dissertation examines risk-taking by financial institutions from a stock market perspective. However, regulators and supervisors mostly look at accounting-based information generated by financial institutions rather than stock market risk.[10]

b) To develop comprehensive but parsimonious framework, the dissertation uses comprehensive governance indices rather than looking at each variable in isolation.[11]

c) Data limitations resulted in the exclusion of some financial institutions from the empirical analysis. The samples of the essays are limited to publicly listed financial institutions.

d) In all four essays, we have tried to account for all the firm-specific characteristics that may affect the level of risk-taking by financial institutions. However, we were unable to account for important credit market measures, such as credit ratings, due to data unavailability.

e) This dissertation only uses data on U.S. financial institutions, and thus, the findings may not necessarily be generalized to other countries.

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[10] Recently, several studies have emphasized the importance of monitoring general and market based risks in the financial system (e.g., Knaup and Wagner, 2010; Acharya et al., 2012, Ellul and Yerramilli, 2013; Acharya et al., 2017)

[11] Such as board composition, board size, CEO duality, audit committees, poison pill adoption, executive ownership, etc.

3 CORPORATE GOVERNANCE AND AGENCY THEORY

> *"Corporate Governance deals with the ways in which suppliers of finance to corporates assure themselves of getting return on their investment."*
>
> *(Shleifer and Vishny, 1997, p. 737)*

Traditionally, corporate governance addresses the oversight of the board of directors on top management to make sure that decision making within the firm is in line with the objectives of the firm and its shareholders.

Agency theory is, perhaps, the most important theory in corporate governance research (Ang, Cole, and Lin, 2000; Wasserman, 2006; Durisin and Puzone, 2009). Agency theory, developed by Coase (1937), Jensen and Meckling (1976), and Fama and Jensen (1983), is directed at the key issue of agency relationship. According to Jensen and Meckling (1976), the agency relationship is created by a contract in which one or more persons (principal or principals) engage another person (the agent) to take actions on their behalf. [12] Through this contract, principals delegate their decision-making authority to agent(s). Similarly, in modern corporations, shareholders (principals) hire managers (agents) to operate the firm and delegate decision-making authority to the managers. However, problems arise when the managers do not perform for the owners but for themselves.

Agency theory tries to resolve two problems that can arise in an agency relationship. First, *agency problem* may arise when the objectives or interests of principal and agent differ. It is expensive or rather difficult for the principal to verify that the agent behaves appropriately. Second, *risk sharing problem* may occur when the principal and the agent have different risk preferences. Therefore, because of the different risk preferences, the principal and the agent may prefer different actions to achieve their objectives.

According to agency theory, corporate managers may be more risk averse than shareholders because of their undiversified human capital investment in the firm and benefits associated with control of the firm (Faleye and Krishnan, 2017). This creates a conflict of interests (or misalignment of interests) between the managers and shareholders.[13] With more control and power, managers can run firms for their own benefit at a loss of shareholders' benefits (Adams, Almeida and Ferreira,

[12] Agency theory uses 'contract' as a metaphor to describe the agency relationship. See Shleifer and Vishny (1997) for details.

[13] The objective of shareholders is to maximize their wealth so they want management to take more risks. However, managers may not be willing to take on more risks because of their human capital and wealth invested in the firm (de Haan and Vlahu, 2016).

2005). However, for outsiders (investors) and principals, it is not possible to comprehensively monitor the activities of managers. Therefore, there is a need for mechanisms to monitor the activities of managers so that they do not run the firm for their own benefit. The literature offers several possible solutions to mitigate the conflict of interests between managers and shareholders, such as properly constructed board of directors. In this regard, Fama and Jensen (1983) assert that the board of directors is the apex of controlling decisions in organizations, and with respect to decision making, is the ultimate legal authority (Adams and Ferreira, 2007). Therefore, research on corporate governance often focuses on the role of the board of directors in organizations.[14] The board of directors acts as a monitor and tries to make sure that the funds provided by the principals are not wasted or misused.

Another way to mitigate the conflict of interests is to provide the managers with stock ownership. In this way, managers' interests will be better aligned with those of the firm's shareholders because stock ownership would provide a direct link between the wealth of managers and shareholders (Murphy, 1999). Granting stocks would affect the motivation of managers and they would adopt riskier policies to maximize the wealth of shareholders (Ross, 2004; Chava and Purnanandam, 2010). In addition to monitoring by the board of directors, literature also offers solutions such as oversight by blockholders, shareholders' direct intervention, the threat of takeover bid, and the threat of firing (see e.g., Adams and Mehran, 2012; de Haan and Vlahu, 2016).

Better corporate governance, therefore, should provide incentives for managers to formulate policies that are risk seeking and do not reflect their own preferences. As a result, firms with strong corporate governance mechanisms should have a greater level of risk than those with weaker corporate governance mechanisms (Ferreira and Laux, 2007; John et al., 2008). However, given than investors are sensitive to downside losses (Ang, Chen and Xing, 2006), strong corporate governance mechanisms should aim to encourage value enhancing risk-taking (John et al., 2008).

[14] Adams et al. (2010) provide a thorough review of previous studies in corporate governance with a particular focus on board of directors.

4 CORPORATE GOVERNANCE IN FINANCIAL INSTITUTIONS

> *"Most studies of board effectiveness exclude financial firms from their samples. As a result, we know very little about the effectiveness of banking firm governance."*
>
> *(Adams and Mehran, 2012, p. 243).*

As discussed previously, management may not always work in the best interests of owners (Jensen and Meckling, 1976) and with more control and power managers can run the firms for their own benefit (Adams et al., 2005). Importantly, for outsiders (investors), it is not possible to comprehensively monitor the activities of managers because managers always have more and superior information about the firm. Therefore, there is a need for mechanisms to monitor the activities of managers so that they do not run the firm for their own benefit. This section discusses corporate governance mechanisms such as 1) the board of directors, 2) ownership structure, and 3) managerial compensation in the context of financial institutions. Further, the section addresses how governance mechanisms differ between financial and non-financial firms.

4.1 Why Corporate Governance May Differ for Financial Institutions?

According to agency theory, managers are risk averse and would decrease the overall risk of the firm to protect their human capital and wealth invested in the firm (Bebchuk, Fried and Walker, 2002). However, the shareholders of financial institutions may require a higher level of risk-taking, from managers (Mehran and Mollineaux, 2012). For financial institutions, the optimal degree of risk-taking is different than for non-financial firms because market participants expect government support for financial institutions if they become distressed. Implicit and explicit government guarantees may encourage financial institutions to take more risks (see, Acharya et al., 2016) as compared to non-financial firms.[15] The excess returns generated by increased risk would benefit shareholders and financial institutions, but the higher level of risk-taking maybe detrimental for the society at large during the times of economic downturn (Mehran and Mollineaux, 2012). For instance, DeYoung et al. (2013) find that shareholders and corporate

[15] Implicit government guarantee is the expectation by the market that government may provide bailout (Acharya et al., 2016). It is referred as implicit because government does not explicitly provide commitment to intervene. Implicit government guarantees are not limited to only banks but also for other financial institutions (Zhao, 2018).

boards encouraged increased risk-taking prior to the crisis which was, ultimately, costly to the shareholders during the period of the recent financial crisis.

Because financial institutions can generally take more risk than non-financial firms, they are heavily regulated and supervised. The additional regulatory oversight is viewed both as substitute (John et al., 2010) or complementary (Adams and Mehran, 2012) for corporate governance in financial institutions. Because the presence of regulation affects the internal corporate governance mechanisms in financial institutions, most of the corporate governance studies exclude financial institutions from their sample. Thus, much of the corporate governance theory and research is based on non-financial firms (Adams and Mehran, 2012; Mehran and Mollineaux, 2012). The key differences between the governance mechanisms of financial and non-financial firms are 1) regulations and supervision, 2) the capital structure of financial institutions (e.g., high leverage and deposits), and 3) complex and opaque business activities.[16]

First, regulation and supervision differentiates corporate governance of financial institutions from non-financial institutions. The financial industry is highly regulated which affects the internal corporate governance mechanisms of financial institutions. Major decisions within financial institutions, such as investment, growth, compensation, are greatly influenced not only by internal governors (board of directors) but also by external governors (regulators, market participants, and legislators).[17] Both internal and external governors can require different level of risk-taking by financial institutions. Strong regulations on financial institutions are justified because they play an important role in the health of the overall economy and their failure can negatively affect the economy (see e.g., de Haan and Vlahu, 2016; John, de Masi and Paci, 2016). Accordingly, the regulations in the financial industry are there to protect and promote the overall stability of the financial system, and that is why regulators impose several constraints on the financial industry, and especially on banks (Caprio and Levine, 2012). These constraints can be on capital requirements, loan and investment choices, and interstate banking (John, Saunders, and Senbet, 2000). Furthermore, regulators can impose restrictions on the corporate governance mechanisms in financial industry such as constraints on ownership concentration, executive compensation, and the composition of boards of directors (Laeven and Levine, 2009; Ellul and Yerramilli, 2013). Regulation may also reduce the incentives of

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[16] Extensive literature examines the corporate governance mechanisms in financial institutions and how they are different from non-financial firms. For instance, Caprio and Levine (2002), Macey and O'Hara (2003), Levine (2004), Mülbert (2010), Becht, Bolton, and Roell (2012), Mehran and Mollineaux (2012), Laeven (2013), Van der Elst (2015).

[17] For the detailed discussion, see e.g. Adams and Mehran (2012) and Mehran and Mollineaux (2012).

blockholders to effectively monitor the boards of directors of financial institutions (Adams and Mehran, 2003).[18]

The capital structure of financial institutions is another crucial difference between the governance of financial and non-financial firms. For banks, debt can exceed 90 percent of the capital structure (Adams and Mehran, 2003; Macey and O'Hara, 2003; Levine, 2004; Laeven, 2013). In this regard, Gornall and Strebulaev (2014) argue that the leverage ratio of banks, measured as debt divided by the total assets, can be up to 95 percent, whereas in non-financial firms, the average leverage typically ranges between 20 to 30 percent. The presence of high leverage in financial institutions also exacerbates the conflict of interest between shareholders and debtholders. Since debtholders are the primary claimholders, their objectives can differ considerably from those of the shareholders (John and Qian, 2003). For instance, the presence of debt in capital structure would benefit shareholders more than debtholders if a firm adopts riskier policies (Jensen and Meckling, 1976; Adams and Mehran, 2003).

The capital structure can also affect executive compensation in financial institutions. According to agency theory, shareholders want managers to be compensated with stock options because stock options would increase the managers' pay-performance sensitivity and would align the interests between shareholders and managers. A higher level of stock options provides top managers with a stronger incentive to undertake risky investment strategies (Adams and Mehran, 2003; Chava and Purnanandam, 2010), and this can reward shareholders at the expense of debtholders (Jensen and Meckling, 1976). However, debtholders anticipate these risk-taking incentives generated by executive compensation, and can demand higher premium which would increase cost of debt for financial institutions (see, de Haan and Vlahu, 2016). In this regard, Adams and Mehran (2003) argue that it is less important to make executive compensation dependent on firm performance in regulated industries because stock-based compensation can result in increased cost of debt and greater risk-taking.

Third, the complexity and opacity of business activities and assets are also important attributes that make the governance of financial institutions important. Compared to non-financial firms, financial institutions are highly interconnected among themselves and substantial part of their business activities involve other financial institutions (Mülbert, 2010). Thus, competitors and customers can also affect the governance of financial institutions (Mülbert, 2010; Adams and Mehran,

[18] For instance, in unregulated industries, blockholders invest in firms and become board members to affect firm policies but in a regulated environment blockholders become passive (Adams and Mehran, 2003).

2012). For instance, to comply with the Sarbanes–Oxley Act (SOX) and the listing rules, banks had to either exclude the customers from the board of directors or increase the board size to meet the independence requirement (Adams and Mehran, 2012). Further, unlike non-financial firms, financial industry is prone to contagion and problems at one financial institution can spread to the other financial institutions (Allen and Carletti, 2013).

4.2 Related Literature

4.2.1 The Board of Directors

Like any other company, the role of the board of directors of a financial institution is to monitor, advise, and hire and fire managers (Adams and Ferreira, 2007; Adams et al., 2010). The board of directors can also be viewed as a tool to ensure that the managers run the firm in the shareholders' best interest. The monitoring function of the board ensures that managers act in the interests of the shareholders and the advisory function of the board provides managers with guidelines on decision making in the firm. Regulation and supervision of financial institutions may serve as a substitute for corporate governance and make monitoring function less important. However, it can be argued that effective supervision is a complementary force which can affect the internal governance mechanisms (Adams and Mehran, 2012).

Several characteristics of the board are regarded as "good corporate governance" in corporate governance literature, for instance, greater board independence (more independent directors on the board).[19] However, the previous literature on corporate governance in financial institutions provides mixed evidence regarding board independence and its relationship with performance. In this regard, Adams and Mehran (2012) find that board independence is not associated with the performance of bank holding companies. Further, de Andres and Vallelado (2008) find an inverted U-shaped association between board independence and the performance of banks when examining a sample of international banks. Moreover, using a large sample of U.S. bank holding companies, Pathan and Faff (2013) find an inverse relation between board independence and the performance of the banks. Using a sample of international financial institutions, Erkens et al., (2012)

[19] According to the Sarbanes–Oxley Act (SOX) of 2002 and the NYSE and Nasdaq exchange listing rules, the majority of the directors on the board should be independent. Independent director should have no connection to company except being a board member.
Adams and Mehran (2012) argue that independent directors, being outsiders, can provide effective monitoring of managers.

find that financial institutions with more independent boards had worse stock returns during the period of the financial crisis. Further, many governance reforms, such as the Sarbanes–Oxley Act (SOX) of 2002, have “one-size-fits-all” approach and do not take into account the special features of governance of financial institutions. Therefore, the level of board independence should be addressed carefully and separately in financial institutions (Adams and Mehran, 2012).

Studies that investigate board size in financial institutions, relate it to performance and risk measures. In this regard, Adams and Mehran (2012) find a positive association between board size and the performance of large U.S. bank holding companies. These results are in contrast with the traditional view and findings for non-financial firms. Because of free-rider issues, larger boards may not act in the interests of shareholders (e.g. Mehran, Morrison, and Shapiro, 2011; Aebi, Sabato, and Schmid, 2012). These contradictory results can be explained in the context of the nature of business of financial institutions. Financial institutions are complex and can benefit from large boards (Adams and Mehran, 2012; Erkens et al., 2012). Using a sample of U.S. banks, Aebi et al. (2012) report similar findings even during the period of the financial crisis. Regarding the relationship of board size and risk-taking, using a large sample of U.S. bank holding companies, Pathan (2009) finds that small board size is related to a higher level of bank risk. More recently, Berger et al. (2016) report a similar inverse relationship between board size and risk-taking using data on U.S. commercial banks. Using a sample of international financial institutions, Erkens et al., (2012) find no relationship between board size and stock returns during the period of the financial crisis.

The literature on corporate governance among financial institutions also examines several other characteristics of the board. For instance, Sun and Liu (2014) investigate the role of audit committees in bank risk-taking. They find that banks with audit committees that include long-tenured board members are associated with lower bank risk, and banks with audit committees staffed by busy directors are associated with higher bank risk. Further, Aebi et al. (2012) investigate the influence of a Chief Risk Officer (CRO) on a bank’s board. They find that banks in which a CRO was reporting to the board of directors rather than to the CEO delivered stronger performance during the period of the financial crisis. Ellul and Yerramilli (2013) construct a risk management index (RMI) based on six variables to measure the independence and strength of the risk management role at bank holding companies. They find that bank holding companies with a higher RMI were related to lower tail risk before the financial crisis and stronger performance during the financial crisis. Erkens et al. (2012) find no relationship between the presence of risk committees and stock returns for a sample of international financial institutions during the period of the financial crisis.

4.2.2 Ownership Structure

Another important mechanism that affects agency-related issues is the firm's ownership structure. Whether dispersed or concentrated, ownership structures influence agency problems in financial institutions. In the case of a dispersed ownership structure, small shareholders have little incentive to monitor managers because of a lack of expertise, the free-rider problem resulting from monitoring expenses, and poor shareholder protection.[20] So, when the firm has numerous small owners (shareholders) who cannot effectively monitor procedures, management has more power to allocate resources at its own discretion (John and Senbet, 1998). On the other hand, large shareholders have more incentives to monitor the actions of management and therefore they are more informed and use their voting rights more efficiently. However, large shareholders might also benefit at the expense of small owners (Shleifer and Vishny, 1997), despite being less affected by the free rider problem. Moreover, large shareholders can also encourage firms to adopt riskier policies, which may increase their wealth at the expense of debtholders and society in general (Mehran and Mollineaux, 2012).

The recent literature, however, does not support the view that concentrated ownership should matter (de Haan and Vlahu, 2016). Using a sample of U.S. commercial banks over the period of 2005 to 2008, Grove, Patelli, Victoravich, and Xu (2011) find that concentrated ownership is not associated with bank performance (measured by excess returns and return on assets).[21] Further, Aebi et al. (2012) document that large shareholders, institutional shareholders having more than 5 percent equity ownership, do not necessarily provide effective monitoring for bank risk-taking. However, Beltratti and Stulz (2012) show that concentrated ownership is associated with bank risk-taking during the period of the financial crisis. Erkens et al. (2012) document that financial institutions with greater institutional ownership were taking more risk before the financial crisis started, and thus performed worse during the period of the financial crisis. However, regarding the effect of concentrated ownership, previous literature

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[20] The free-rider problem arises via delegation of power from many to few. In this, no individual has enough resources to monitor the principals (Grossman and Hart, 1980). The free-rider problem can be avoided by takeover bid mechanism (Grossman and Hart, 1980), better shareholder protection (effective rights of minority shareholders) (Rossi and Volpin, 2004), and concentrated ownership (Bukhart and Panunzi, 2006).

[21] They measure the concentrated ownership by percentage of outstanding shares owned by blockholders. A blockholder is defined as "a shareholder who holds more than five percent of a firm's outstanding shares" (Grove et al., 2011).

suggests that it depends on shareholder protection laws and regulation. Using a sample of international banks, Laeven and Levine (2009) find that banks with large controlling shareholders have higher bank risk, proxied by z-score. However, this effect is mitigated by the presence of strong shareholder protection laws.

4.2.3 Executive Compensation

Another important measure to ensure that managers act in the interests of the shareholders is to design executive compensation policies appropriately. For instance, by tying executive compensation with firm performance, shareholders can provide incentives for the managers to work for the firm and serve the interests of shareholders. In this regard, equity-based compensation offers a suitable instrument to align the interests of managers with those of shareholders. Because in equity-based compensation, executive compensation depends on the share price or other metrics (see e.g., Frydman and Jenter, 2010; de Haan and Vlahu, 2016). Conyon (2014) reports that executive compensation in the U.S. grew considerably from 1992 to 2012, and most CEO compensation is provided in the form of stock options, restricted stock, and bonuses related to stock price. Regarding financial institutions, Adams and Mehran (2003) report an increase in option-based executive compensation in banks over the period of 1986 to 1999.

Most of the previous empirical literature is dominated by studies investigating the consequences of managerial incentives generated by bonuses and option-based compensation (e.g., Becht et al., 2012; Fahlenbrach and Stulz, 2011; Bai and Elyasiani, 2013; Zalewska, 2016). For instance, Chen, Steiner and Whyte (2006) show that an option-based managerial compensation structure and option-based managerial wealth induces more risk-taking in commercial banks. DeYoung, Peng and Yan (2013) find that banks with CEOs having greater risk-taking incentives took more risk around 2000 to take advantage of growth opportunities.[22] More recently, Guo et al. (2015) document that bank risk increases incrementally with the level of incentive compensation, both short-term and long-term. Bai and Elyasiani (2013) show that higher managerial risk-taking incentives and especially higher compensation sensitivity to stock return volatility induce greater risk-taking.

However, compensation dependent on performance can also have undesirable effects. In order to benefit from better performance, managers can take more risk

[22] DeYoung et al. (2013) use delta and vega as risk-taking incentives. Delta measures the dollar gain or loss in personal executive wealth for a one percent change in the stock price of the firm. Vega measures the dollar gain or loss in personal executive wealth for a one percentage point change in the stock return volatility of the firm.

than optimal (de Haan and Vlahu, 2016) and increased risk-taking, during the periods of economic distress, can lead to unexpected large losses (Beltratti and Stulz, 2012). For instance, Fahlenbrach and Stulz (2011) argue that better alignment of interests between management and shareholders may not have the desired performance outcomes for financial institutions.[23] Fahlenbrach and Stulz (2011) show that banks with CEOs whose incentives were better aligned with those of shareholders did not perform better during the period of the recent financial crisis. Beltratti and Stulz (2012) document for an international sample of banks that banks with more shareholder-friendly boards performed worse during the period of financial crisis.[24] Erkens et al. (2012) argue that managerial risk-taking incentives can encourage managers to adopt riskier policies which were looking lucrative before the financial crisis but were costly to shareholders during the financial crisis.

In summary, despite the growing literature on the relationship between different board characteristics and risk-taking and performance of financial institutions, ownership structure and performance of financial institutions, and executive compensation structure and risk-taking in financial institutions, there is still no consensus on the strength of corporate governance mechanisms in the financial industry (see e.g., de Haan and Vlahu, 2016; John, Masi and Paci, 2016). The literature does not provide satisfactory answers to several important questions, including what is the role of board characteristics and expertise in risk-taking in the financial industry, and the effects of managerial incentives on risk-taking by financial institutions.[25]

[23] Providing managers with greater risk-taking compensation incentives.
[24] Beltratti and Stulz (2012, p. 16) conclude that "banks that grew more in sectors that turned out to perform poorly during the crisis were pursuing policies favored by shareholders before the crisis as their boards were more shareholder-friendly but suffered more during the crisis when these risks led to unexpectedly large losses."
[25] Most extant studies show that executive compensation structures motivate bank managers to take more risks that may not be favorable for the shareholders during the economic downturn (de Haan and Vlahu, 2016).

5 SUMMARY OF THE ESSAYS

This dissertation encompasses four essays on the relationship between corporate governance and risk taking by financial institutions. First three essays are co-authored, and the fourth essay is single-authored. The contribution of each co-author is described below:

Essay 1 "Corporate governance and the systemic risk of financial institutions" is co-authored with Professor Sami Vähämaa and Dr. Sascha Strobl. Jamshed Iqbal is the main author of this essay. Professor Sami Vähämaa was the initiator of the research idea. Jamshed Iqbal was responsible for the collection of data, methodological design of the paper, initial tests and the initial interpretation of the results. Professor Vähämaa contributed to this paper by providing detailed comments on the different versions of the paper and by writing and rewriting some parts of the text. Professor Vähämaa also participated in the statistical analyses. Dr. Sascha Strobl contributed to this paper throughout the research process by giving detailed comments on different versions of the paper and by writing some parts of the text.

Essay 2 "Corporate governance and the insolvency risk of financial institutions" is co-authored with Dr. Searat Ali. Jamshed Iqbal is the main author of this essay and is responsible for the research idea, data collection for the corporate governance and control variables, research design, and the writing of the essay. The empirical analysis section is a result of joint efforts by both authors. Dr. Searat Ali further contributed by collecting data regarding the insolvency risk variables and offering valuable comments and suggestions for improving the essay.

Essay 3 "Managerial risk-taking incentives and the systemic risk of financial institutions" is co-authored with Professor Sami Vähämaa. Jamshed Iqbal is the main author of this essay, and is responsible for the research idea, data collection, methodological design of the paper, initial tests and the initial interpretation of the results. Professor Vähämaa contributed to this paper by providing detailed comments on the different versions of the paper and by writing and rewriting some parts of the text. Professor Vähämaa also participated in the statistical analyses.

Essay 4 "CEO pay-share and risk-taking in large bank holding companies" is single-authored by Jamshed Iqbal.

Brief summaries of the four essays are provided in the following:

5.1 Corporate governance and the systemic risk of financial institutions

The first essay investigates the association between corporate governance and the systemic risk of financial institutions around the recent financial crisis. Systemic risk can be broadly defined as a measure of the relation of a particular financial institution's risk-taking to the overall risk-taking in the financial industry. As recently noted, for instance, by Anginer et al. (2014), the contribution of an individual financial institution to the system's deficiency may be more relevant than the stand-alone risk of that institution during periods of market stress. Despite the amplified interest in the measurement of systemic risk over the past few years, surprisingly little is known about the institution specific attributes that may influence the level of systemic risk. This essay aims to extend the prior literature by empirically examining whether the systemic risk of U.S. financial institutions is affected by the strength of corporate governance mechanisms.

In the aftermath of the global financial crisis, it has been widely argued by politicians, banking supervisors, and other authorities that the crisis can be, at least to some extent, attributed to flaws in the corporate governance practices of financial institutions (see e.g., Kirkpatrick, 2009; Basel Committee on Banking Supervision, 2010; Board of Governors of the Federal Reserve System, 2010; Haldane, 2012). These allegations seem reasonable given that corporate governance can be broadly considered as the set of mechanisms for addressing agency problems and controlling risk within the firm. In general, strong corporate governance practices and especially effective board oversight are supposed to encourage the firm's top management to act in the best interests of shareholders and other stakeholders (Shleifer and Vishny, 1997). So, was something wrong with the corporate governance of financial institutions at the onset of the global financial crisis? We show in this paper that "good" corporate governance practices may have encouraged rather than constrained excessive risk-taking in the financial industry. Specifically, our empirical findings demonstrate that financial institutions with stronger and more shareholder-focused corporate governance mechanisms and boards of directors are associated with higher levels of systemic risk.

Our study contributes to the existing literature by empirically examining whether the strength of corporate governance mechanisms can explain the cross-sectional variation in the systemic risk of U.S. financial institutions around the recent financial crisis. The measures of systemic risk used in our empirical analysis are the marginal expected shortfall (*MES*) and systemic risk (*SRISK*) proposed by Acharya, Engle and Richardson (2012). *MES* measures the decline of a firm's equity when the market drops more than two percent and *SRISK* the expected capital shortage of a firm amidst a financial market crisis. We utilize the Corporate Governance Quotient as well as the Board Quotient issued by Institutional Shareholder Services (ISS) to measure the strength of corporate governance mechanisms and the board of directors within financial institutions.

In brief, our empirical findings indicate that financial institutions with stronger and more shareholder-focused corporate governance mechanisms and boards are associated with greater systemic risk, suggesting that good corporate governance may encourage increased risk-taking in the financial industry. We also document that the positive association between good governance and systemic risk was particularly strong amidst the financial crisis in 2008. In general, our findings regarding the effects of strong governance on systemic risk are broadly consistent with the previous literature on bank risk-taking (see e.g., Pathan, 2009; Fortin et al., 2010; Beltratti and Stulz, 2012). We believe that the results reported in this paper offer several important implications. Most importantly, our results demonstrate that "good", shareholder-focused corporate governance mechanisms in the financial sector may not be enough to constrain risk-taking and to prevent financial crises in the future.

5.2 Corporate governance and the insolvency risk of financial institutions

This essay empirically examines the connection between corporate governance and insolvency risk of financial institutions. This study uses both traditional (distance-to-default) and market-based (credit default swap (CDS) spread) measures to proxy for insolvency risk. CDS spread is the market estimate of default/insolvency risk. Bolton, Mehran and Shapiro (2015) link CEO compensation to CDS spread as a measure of default risk. Recent studies (e.g., Bolton, Mehran, and Shapiro, 2015) utilize CDS spread to proxy insolvency risk and suggest that it is preferable because it also accounts for creditors risk (Colonnello, 2017; Feldhutter, Hotchkiss, and Karakas, 2016).[26]

This essay contributes to the growing corporate governance literature that connects corporate governance mechanisms to risk-taking by financial institutions (Pathan, 2009; Laeven and Levine, 2009; Erkens et al., 2012; Berger et al., 2016; Iqbal et al., 2015). This essay contributes to the literature in the following ways: First, building on prior studies, it relates corporate governance to insolvency risk

[26] Blanco, Brennan, and Marsh (2005) and Norden and Weber (2009) find that CDSs provide an accurate and informative measure of credit risk.

for a large sample of U.S. financial institutions. This is one of the few studies to show the relevance of corporate governance to a financial institution's insolvency risk. This essay shows that strong governance mechanisms significantly affect the insolvency risk of financial institutions that can cause instability in the overall financial system. Secondly, this essay provides some evidence that financial institutions with strong boards have a greater insolvency risk. It is still relevant to study the relationship between board strength and insolvency risk because the existing literature does not provide a satisfactory answer regarding the role of boards in controlling the agency relationship (Adams et al., 2010). Further, most of the previous studies on board effectiveness do not include financial firms in their sample (see Adams et al., 2010). This essay also confirms the previous literature (Adams and Mehran, 2012) indicating that in the financial industry, restrictions on board size can be counter-productive. Lastly, this essay contributes to the recent literature that relates corporate governance to CDS spread. Several recent studies incorporate CDS spreads (Hart and Zingales, 2010; Bolton, Mehran and Shapiro, 2015), suggesting CDS spread is an important measure of risk.

This essay finds that the insolvency risk of financial institutions, proxied by either its market-based distance to default or CDS spread, is positively associated with the shareholder-friendliness of its corporate governance. Further, this positive association between corporate governance and insolvency risk is more important for larger financial institutions and during the financial crisis. The findings are broadly consistent with the prior literature on risk-taking by financial institutions (see e.g., Pathan, 2009; Fortin, Goldberg and Roth, 2010; Beltratti and Stulz, 2012; Erkens et al., 2012). These findings suggest that stronger corporate governance mechanisms may encourage greater risk-taking in the financial industry. A potential explanation for these results is that shareholder-friendly boards of directors encouraged managers to take more risks to increase shareholder return prior to the crisis (Laeven and Levine, 2009: Erkens et al., 2012). DeYoung et al. (2013) argue that prior to the global financial crisis (during 2000–2006), CEO compensation in banks was changed which encouraged more risk-taking. Because financial institutions are entering into more complex activities and have broadened their scope, this effect may have been amplified in recent years, making it difficult for regulators to keep pace with the changes. The results in this essay are economically significant and robust to several additional analyses, including propensity score matching to mitigate the concerns regarding endogeneity.

5.3 Managerial risk-taking incentives and the systemic risk of financial institutions

This essay examines whether the systemic risk of financial institutions is associated with the compensation-based risk-taking incentives of the top executives. In the aftermath of the global financial crisis of 2008-2009, policy makers, regulators, and bank supervision authorities have alleged that the risk-taking incentives generated by executive compensation policies at banking organizations were among the factors contributing to the development of the crisis (see e.g., Kirkpatrick, 2009; Basel Committee on Banking Supervision, 2010; Board of Governors of the Federal Reserve System, 2009b, 2010; Mehran et al., 2011). Furthermore, the financial crisis revealed the distinct adverse consequences of bank risk-taking and systemic risk on global financial stability, economic growth, and societal well-being. Given that the compensation policies of top executives are generally designed to mitigate agency problems and to maximize shareholder value, the incentives generated by executive compensation may encourage more risk-taking in the financial industry (e.g., Chen et al., 2006; Bebchuk, Cohen and Spamann, 2010; Bebchuk and Spamann, 2010; Bai and Elyasiani, 2013).

Do compensation-based risk-taking incentives of the top executives increase the riskiness of financial institutions and the level of systemic risk? In this paper, we aim to address this question by empirically examining the linkage between systemic risk and the sensitivities of chief executive officer (CEO) and chief financial officer (CFO) compensation to changes in stock prices and stock return volatility.[27] Using data on large, publicly traded U.S. financial institutions, we find ambiguous evidence on the association between managerial risk-taking incentives and the systemic risk of financial institutions. Our results indicate that the sensitivities of top executive compensation to volatility are negatively related to systemic risk. However, our empirical findings also demonstrate that financial institutions with greater managerial risk-taking incentives were associated with significantly higher levels of systemic risk in 2008, during the peak of the global financial crisis.

This essay proceeds with the basic hypothesis that managerial risk-taking incentives encourage managers to increase the riskiness of the firm by adopting riskier financial policies (Chava and Purnanandam, 2010). In financial institutions, that can increase the level of systemic risk especially during the

[27] We follow Chava and Purnanadam (2010) to analyze the effect of risk-taking incentives of both CEOs and CFOs. They show that CFO's risk-taking incentives can influence corporate financial policies.

periods of distress. To empirically examine the notion, this essay uses delta and vega measures of manager's stock and option holdings as the proxies for risk-taking incentives.[28] Delta, the sensitivity of a manager's portfolio to stock price, measures the dollar gain or loss in a manager's wealth if the firm's stock price changes (Kini and Williams, 2012).[29] A higher delta will encourage the manager to increase the wealth of the firm's shareholders because delta is also used as a proxy for incentive alignment between shareholders and management (Fahlenbrach and Stulz, 2011). Vega is the sensitivity of a manager's portfolio to changes in equity volatility. Vega provides a relatively direct measure for the risk-taking incentives of a manager because managers with a higher vega tend to gain from greater firm risk. This essay shows that greater managerial risk-taking incentives may have encouraged increased risk-taking in the financial industry, especially during the period of the recent financial crisis. Specifically, the empirical findings show that financial institutions with CEOs and CFOs having higher managerial risk-taking incentives were associated with greater levels of systemic risk during the financial crisis. For the overall sample, this essay finds either an inverse or an insignificant relationship between risk-taking incentives and the systemic risk of financial institutions, which is in line with agency theory holding that executives should take risks to increase the wealth of shareholders (Jensen and Meckling, 1976).

In our empirical analysis, we use data on 71 large U.S. financial institutions over the period 2005-2010. We measure the systemic risk of individual financial institutions with the market-based approach proposed by Acharya et al. (2012), Acharya et al. (2017), and Brownlees and Engle (2017).[30] Specifically, we use the marginal expected shortfall (*MES*) and systemic risk (*SRISK*) to gauge systemic risk. *MES* measures the decline of a financial institution's equity capital when the market drops more than two percent in a single day. *SRISK* is the expected capital shortage of an institution during a financial crisis.[31] Essentially, *MES* and *SRISK* aim to measure how exposed a given financial institution is to aggregate tail shocks in the financial system.

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[28] Several studies use Delta and Vega as proxies of risk-taking incentives e.g. Chava and Purnanandam (2010), Fahlenbrach and Stulz (2011) and Kini and Williams (2012).

[29] Chava and Purnanandam (2010) provide discussion on how Delta is risk-taking incentive.

[30] Several alternative approaches for measuring systemic risk have been proposed in the literature in the aftermath of the global financial crisis. Different approaches are discussed and compared, for instance, in Bisias, Flood, Lo, and Valavanis (2012), Hattori, Kikuchi, Niwa and Uchida (2014), and Kleinow, Moreira, Strobl and Vahamaa (2017).

[31] A firm is considered to be as systemically risky if it is likely to face a capital shortage during the periods of financial turmoil (Acharya et al., 2017). This capital shortage can be damaging to the real economy because the failure of a systemically risky firm will have effects throughout the financial industry (Acharya et al., 2017).

The empirical findings reported in this paper indicate that the relationship between managerial risk-taking incentives and systemic risk is ambiguous. The results show that the sensitivities of top executive compensation to volatility (i.e., the CEO and CFO vegas) are generally negatively associated with systemic risk, while there is essentially no relationship between pay-performance sensitivity (i.e., the delta) and systemic risk. Our regressions indicate that one standard deviation increases in CEO and CFO vegas are associated with approximately six percent reductions in *SRISK*. These findings are in stark contrast with the hypothesis that greater managerial risk-taking incentives would increase the level of systemic risk.

On the other hand, our empirical results indicate that financial institutions with greater managerial risk-taking incentives were associated with significantly higher levels of systemic risk in 2008, during the peak of the global financial crisis. The positive association between the pre-crisis deltas and vegas of the top executives and systemic risk during the crisis is economically significant; our estimates indicate that a one standard deviation increase in deltas and vegas increases *MES* by about 25-40 basis points during the crisis. The documented positive association between CEO and CFO risk-taking incentives and systemic risk during the severe market turmoil in 2008 may indicate that financial institutions with greater compensation-based managerial risk-taking incentives were taking more risk before the crisis in order to maximize shareholder wealth, and that these risks were then materialized and exposed during the financial crisis (Erkens et al., 2012).

5.4 CEO pay-share and risk-taking in large bank holding companies

This essay examines whether CEO pay-share (pay inequality between the CEO and the other top executives) is associated with risk-taking among large bank holding companies (BHCs).[32] The main hypothesis in this study is that BHCs with greater CEO pay-share should have higher risk (default risk and tail risk). This is because, according to tournament theory, an executive's rank in the firm determines his/her compensation (Lazear and Rosen, 1981). Ang, Lauterbach, and Schreiber (2002) argue that greater CEO pay is justified because CEOs have a greater responsibility towards the firm. However, tournament theory provides different arguments for

[32] Bebchuk et al. (2011), Kini and Williams (2012), and Bai and Elyasiani (2013) use CEO pay-share as a measure of CEO power and risk incentive measures of CEO compensation. The regulatory burden under the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank) generally depends on bank size. BHCs with assets above USD 10 billion are subject to greater oversight than BHCs with less than USD 10 billion in assets. Therefore, this study considers BHCs as large if the book value of their assets is greater than USD 10 billion in 2010 constant dollars.

this view and argues how the CEO's compensation can be several times greater than those of the other executives.[33] In this regard, Lazear and Rosen (1981) propose a tournament model where workers in the firm are compensated based on their ranks. In this way, not only monitoring costs are reduced but it also gives workers incentive to win the tournament and receive the prize. In the case of executives, CEO's pay is the prize because that is substantially greater than those of other executives. Greater CEO pay motivates other top executives to be the next CEO and win the tournament (Ang et al., 2002). In order to achieve this, executives adopt riskier policies to increase their performance (Kini and Williams, 2012). So, greater pay inequality would also result in the better performance of the firm (Lin, Yeh and Shih, 2013). However, in order to achieve the higher level of performance executives will take on more risks in the presence of tournament incentives (Goel and Thakor, 2008). In doing so, the executives will increase the overall risk of the firm. In the banking industry, the pay inequality between the CEO and the other top executives is even larger (Ang et al., 2002) and this larger pay inequality may result in increased risk-taking in the banking industry.

In contrast to the tournament theory, Bebchuk et al. (2011) argue that firms might differ in terms of tournament incentives for senior executives and thus CEO pay-share level might differ in the firms. Because the CEO has power over the decision-making in the firm, the CEO might affect the level of pay-share. Therefore, a high CEO pay-share might indicate governance problems in the firm where CEO can extract greater pay. The ability to extract greater pay can also refer to the additional information that other CEO power proxies (e.g. CEO is also the founder and CEO duality) may not capture.[34] With more power, CEOs can run the firm for his/her own benefits at the expense of the shareholders (Adams, Almeida, and Ferreira, 2005). Thus, greater CEO power may result in lower firm value (Bebchuk, Cohen, and Ferrel, 2009) and lower credit rating (Ashbaugh-Skaife, Collins, and Lafond, 2006). In banks, CEO power is also associated with less bank risk (Pathan, 2009). This might be because managers are risk averse (Jensen and Meckling, 1976) and therefore adopt safer policies to protect their own investment in the firm (Pathan, 2009). Furthermore, the higher risk would also increase the probability of default by increasing the bankruptcy costs (Parrino et al., 2005). Therefore, unlike other senior executives, CEOs do not have strong incentives to adopt riskier policies. Consistent with these arguments, the main alternative hypothesis in this study is that BHCs with greater CEO pay-share should be less risky.

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[33] Ang et al. (2002) report that bank CEOs, on average, earn 1.8 times more than the next most highly paid executive in the bank, and 2.6 times more than the fifth most highly paid executive.

[34] CEO Power is "the power the CEO has over the board and other top executives" (Adams, Almeida, and Ferreira, 2005, p 1408).

Using an unbalanced panel of 122 large and economically significant U.S. BHCs (those with assets greater than USD 10), this study finds that greater CEO pay-share is associated with lower BHC risk. These findings are consistent with the alternative hypothesis (CEO power argument) suggesting that powerful CEOs reduce the overall risk exposure of the BHC to protect their own human capital and financial wealth. These results are robust against a number of alternative estimation methods, different sample periods (before GFC, and after Dodd-Frank), and even against tests for addressing endogeneity where CEO pay-share is instrumented with industry median pay-share. These results may suggest that when CEO pay-share rises, CEOs become more risk averse and powerful, and thus implement less risk business policies.

The findings of this study have important implications for researchers, the board of directors, shareholders, and regulators. Most of the previous studies focused on the composition of CEO pay. This study highlights the importance of inequality of compensation amongst the top executive team. The inverse relationship between CEO pay-share and BHC risk supports the view of possible risk aversion. The findings caution researchers against considering powerful CEOs as only risk-seekers. Moreover, the results indicate that shareholders and boards of directors can influence CEO pay share to alter the risk-taking propensity of the management.

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Zhao, L. 2018. Market-based estimates of implicit government guarantees in European financial institutions. *European Financial Management*, 24, 79–112.

Publications

This doctoral dissertation consists of an introductory chapter and the following four essays:

I. Iqbal, J., Strobl, S., & Vähämaa, S. 2015. Corporate Governance and the Systemic Risk of Financial Institutions. *Journal of Economics and Business*, 82, 42-61.[35]

II. Ali, S., & Iqbal, J. 2018. Corporate Governance and the Insolvency Risk of Financial Institutions. Proceedings of the 2018 Financial Markets & Corporate Governance Conference; Proceedings of the International Finance and Banking Society, 2017 Oxford Conference; and Proceedings of the 29th Australasian Finance and Banking Conference.

III. Iqbal, J., & Vähämaa, S. 2017. Managerial Risk-Taking Incentives and the Systemic Risk of Financial Institutions. Proceedings of the 30th Australasian Finance and Banking Conference.

IV. Iqbal, J. 2018. CEO Pay-Share and Risk-Taking in Large Bank Holding Companies. Proceedings of the 57th Annual Meeting of Southwestern Finance Association; and Proceedings of the 2018 Annual Meeting of the Finnish Economic Association.

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Journal of Economics and Business 82 (2015) 42–61

Contents lists available at ScienceDirect

Journal of Economics and Business

Corporate governance and the systemic risk of financial institutions☆

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ARTICLE INFO

Article history:
Received 1 October 2014
Received in revised form 10 June 2015
Accepted 15 June 2015
Available online 2 July 2015

Keywords:
Corporate governance
Boards
Systemic risk
Bank risk-taking
Financial crisis

JEL classification:
G01
G20
G21
G30
G32
G34

ABSTRACT

This paper studies the relationship between corporate governance and the systemic risk of financial institutions. Specifically, using a sample of large U.S. financial institutions from 2005 to 2010, we examine whether the strength of corporate governance mechanisms can explain the cross-sectional variation in systemic risk around the recent financial crisis. Our empirical findings indicate that financial institutions with stronger and more shareholder-focused corporate governance structures and boards of directors are associated with higher levels of systemic risk. Thus, our results suggest that good corporate governance may encourage rather than constrain excessive risk-taking in the financial industry.

☆ We would like to thank two anonymous referees, Jens Hagendorff (the guest editor), Renée Adams, Iftekhar Hasan, Shane Magee, Praveen Malla, Liang Song, John H. Thornton, and participants at the 27th Australasian Finance and Banking Conference, the 51st Eastern Finance Association Meeting, the Hanken School of Economics Workshop on Corporate Governance, and the University of Vaasa Banking Research Workshop for valuable comments and suggestions. J. Iqbal and S. Vähämaa gratefully acknowledge the financial support of the Academy of Finland. Part of this paper was written while S. Vähämaa was visiting the University of Central Florida.

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http://dx.doi.org/10.1016/j.jeconbus.2015.06.001

1. Introduction

This paper focuses on the linkage between corporate governance and the systemic risk of financial institutions around the recent financial crisis. Systemic risk can be broadly defined as a measure of the relation of a particular financial institution's risk-taking to the overall risk-taking in the financial industry. As recently noted, for instance, by Anginer, Demirguc-Kunt, and Zhu (2014), the contribution of an individual financial institution to the system's deficiency may be more relevant than the stand-alone risk of that institution during periods of market stress. Despite the amplified interest toward the measurement of systemic risk over the past few years, surprisingly little is so far known about the institution specific attributes that may influence the level of systemic risk[1]. In this paper, we aim to extend the prior literature by empirically examining whether the systemic risk of U.S. financial institutions is affected by the strength of corporate governance mechanisms.

In the aftermath of the global financial crisis, it has been widely argued by politicians, banking supervisors, and other authorities that the crisis can be, at least to some extent, attributed to flaws in the corporate governance practices of financial institutions (see e.g., Kirkpatrick, 2009; Basel Committee on Banking Supervision, 2010; Board of Governors of the Federal Reserve System, 2010; Haldane, 2012). These allegations seem reasonable given that corporate governance can be broadly considered as the set of mechanisms for addressing agency problems and controlling risk within the firm. In general, strong corporate governance practices, and especially, effective board oversight are supposed to encourage the firm's top management to act in the best interest of shareholders and other stakeholders (Shleifer & Vishny, 1997). So was something actually wrong with the corporate governance of financial institutions at the onset of the global financial crisis? We show in this paper that "good" corporate governance practices may have encouraged rather than constrained excessive risk-taking in the financial industry. Specifically, our empirical findings demonstrate that financial institutions with stronger and more shareholder-focused corporate governance mechanisms and boards of directors are associated with higher levels of systemic risk[2].

At first glance, it may seem somewhat counterintuitive that financial institutions with stronger corporate governance mechanisms are associated with higher levels of systemic risk. However, consistent with traditional shareholder value maximization, well-governed financial institutions may have tried to improve their profitability to placate shareholders before the crisis by increasing the level of risk-taking. Empirical support for this view is provided, for instance, by Beltratti and Stulz (2012), who document that banks with more shareholder-friendly boards took more risk at the onset of the global financial crisis and performed significantly worse during the crisis. Investors may have neglected or became less sensitive to the surge in bank risk-taking because of the growing complexity and opaqueness of banking activities (e.g., Mehran, Morrison, & Shapiro, 2011). Furthermore, as noted by Mehran et al. (2011), there is a "dark side to expertise" on the board of directors; expert board members may be hired to justify and increase risk-taking for the sake of value maximization instead of aiding in monitoring the top management. Consistent with this view, Minton, Taillard, and Williamson (2014) document that independent directors with financial expertise encouraged increasing bank risk-taking prior to the global financial crisis, and moreover, that the board's expertise is strongly negatively associated with bank performance during the crisis.

Fahlenbrach, Prilmeier, and Stulz (2012) argue that institution specific characteristics are responsible for the high correlation they find between stock returns in the 1998 financial crisis and the recent crisis. They label this argument as the risk culture hypothesis. According to Fahlenbrach et al. (2012), the business model of a financial institution, especially if it is successful, can be hard to change and reinforces the culture of the company. Acharya and Volpin (2010), in turn, argue that firms can,

[1] Among the few exceptions are the recent studies by Acharya and Thakor (2011), Brunnermeier, Dong, and Palia (2012), Pais and Stork (2013), Anginer et al. (2014), Mayordomo, Rodriguez-Moreno, and Peña (2014), and Calluzzo and Dong (2015). We discuss the related systemic risk literature in Section 2.

[2] Corporate governance mechanisms and the board of directors are considered to be stronger and more shareholder-friendly when they provide effective monitoring and stronger protection of shareholder's interests, and more generally, better alignment of managers' interests with those of the shareholders. Adams (2012) and de Haan and Vlahu (2015) provide comprehensive discussions about the corporate governance of financial institutions and the elements of "good" governance.

at least to some extent, choose their corporate governance arrangements which affect and are also affected by the governance choices of other firms. Hence, the choice of corporate governance arrangements of a given firm may have externalities on other firms. Both lines of thought view corporate governance structures as endogenous but, especially, the risk culture hypothesis of Fahlenbrach et al. (2012) implies long lags and a general tendency of governance mechanisms influencing the level of risk-taking and not the other way around.

In this paper, we presume that corporate governance mechanisms may influence the corporate risk culture, and consequently, the level of systemic risk. Given the moral hazard problems caused by the "too-big-to-fail" phenomenon and deposit insurance systems (e.g., Merton, 1978), shareholder-focused governance mechanisms may encourage bank managers to adopt more risky business strategies and operations which, in turn, may lead to increased systemic risk[3]. Because financial institutions do not have to directly pay for the negative consequences of their excessive risk-taking, shareholder-focused corporate governance structures of individual institutions may not only increase the riskiness of a specific institution but also create negative externalities on the financial system by increasing the aggregate level of systemic risk[4].

Our study contributes to the existing literature by empirically examining whether the strength of corporate governance mechanisms can explain the cross-sectional variation in the systemic risk of U.S. financial institutions around the recent financial crisis. The measures of systemic risk used in our empirical analysis are the marginal expected shortfall (MES) and systemic risk (SRISK) proposed by Acharya, Engle, and Richardson (2012). MES measures the decline of a firm's equity when the market drops more than 2 percent and SRISK the expected capital shortage of a firm amidst a financial market crisis. We utilize the Corporate Governance Quotient as well as the Board Quotient issued by Institutional Shareholder Services (ISS) to measure the strength of corporate governance mechanisms and board of directors within financial institutions.

In brief, our empirical findings indicate that financial institutions with stronger and more shareholder-focused corporate governance mechanisms and boards are associated with higher systemic risk, suggesting that good corporate governance may encourage rather than constrain excessive risk-taking in the financial industry. We also document that the positive association between good governance and systemic risk was particularly strong amidst the financial crisis in 2008. In general, our findings regarding the effects of strong governance on systemic risk are broadly consistent with the previous literature on bank risk-taking (see e.g., Pathan, 2009; Fortin, Goldberg, & Roth, 2010; Beltratti & Stulz, 2012). We believe that the results reported in this paper offer several important implications. Most importantly, our results demonstrate that "good", shareholder-focused corporate governance mechanisms in the financial sector may not be enough to constrain risk-taking and to prevent financial crises in the future.

The remainder of the paper is organized as follows. Section 2 reviews the related literature on systemic risk and bank risk-taking. Section 3 describes the data and introduces the variables used in the empirical analysis. Section 4 presents the methods and reports our empirical findings on the association between corporate governance mechanisms and the systemic risk of financial institutions. Finally, the last section summarizes the findings and concludes the paper.

2. Related literature

The empirical analysis presented in this paper is closely related to two recent streams of literature. First, our analysis complements the growing body of literature on factors influencing the systemic risk of financial institutions. Despite the amplified academic and regulatory interest toward the measurement of systemic risk over the past few years, surprisingly little is so far known about the institution specific attributes that may affect the level of systemic risk. Among the few exceptions are the studies by Acharya and Thakor (2011), Brunnermeier et al. (2012), Pais and Stork (2013), Anginer et al.

[3] Acharya (2009, 2011) provides a detailed discussion on how moral hazard problems and the "too-big-to-fail" phenomenon may contribute to systemic risk.

[4] A comprehensive discussion on the incentives for excessive risk-taking in the financial industry is provided in de Haan and Vlahu (2015).

(2014), Mayordomo et al. (2014), and Calluzzo and Dong (2015). These studies document that the size of the institution, the amount of equity capital, the extent of lending activities, and the proportion of non-performing loans are important factors for explaining the systemic risk of financial institutions (Acharya & Thakor, 2011; Brunnermeier et al., 2012; Pais & Stork, 2013; Mayordomo et al., 2014; Calluzzo & Dong, 2015). More specifically, prior studies find strong evidence that larger institutions with lower capital ratios are associated with higher levels of systemic risk. Furthermore, the findings of Brunnermeier et al. (2012) suggest that the amount of non-interest income is positively related to systemic risk, while Mayordomo et al. (2014) report that holdings of certain types of financial derivatives may increase the level of systemic risk. Finally, Anginer et al. (2014) document that increasing bank competition may reduce systemic risk by encouraging risk diversification. To the best of our knowledge, the current study is the first attempt to empirically examine the relationship between corporate governance mechanisms and the systemic risk of financial institutions.

In addition to the literature about factors influencing systemic risk, our paper is closely related to the large body of literature about the role of corporate governance mechanisms and boards of directors in the financial industry (see e.g., Caprio, Laeven, & Levine, 2007; de Andres & Vallelado, 2008; Fahlenbrach & Stulz, 2011; Yeh, Chung, & Liu, 2011; Adams & Mehran, 2012; Aebi, Sabato, & Schmid, 2012; Beltratti & Stulz, 2012; Erkens, Hung, & Matos, 2012; Peni & Vahamaa, 2012; Pathan & Faff, 2013; Wang & Hsu, 2013; Minton et al., 2014). These studies document that differences in corporate governance mechanisms and observable board characteristics across firms are reflected in the financial performance and market valuation of financial institutions. Interestingly, the findings of Beltratti and Stulz (2012), Aebi et al. (2012), Erkens et al. (2012), and Peni and Vahamaa (2012) suggest that strong corporate governance mechanisms and shareholder-friendly boards were significantly negatively associated with bank performance during the global financial crisis.

Perhaps most related to the empirical analysis presented in this paper, the recent studies by Pathan (2009), Laeven and Levine (2009), Fortin et al. (2010), Beltratti and Stulz (2012), Peni and Vahamaa (2012), Berger, Kick, and Schaeck (2014), and Minton et al. (2014) examine the influence of governance and board structures on the risk-taking of financial institutions. In brief, these studies demonstrate that good corporate governance mechanisms and shareholder-friendly boards of directors are positively associated with both balance-sheet and market-based measures of risk-taking. Overall, the previous studies suggest that shareholder-focused corporate governance structures combined with the shareholder value maximization objective may encourage excessive risk-taking in the financial industry[5]. Our study builds upon the prior bank risk-taking literature by empirically examining how strong corporate governance and shareholder-friendly boards affect the level of systemic risk. Based on the findings documented in the prior literature, we postulate that financial institutions with stronger and more shareholder-focused corporate governance mechanisms and boards of directors are associated with higher systemic risk.

3. Data and variables

Our analysis is based on a sample of 71 large, publicly traded U.S. financial institutions and a sample period which spans fiscal years 2005–2010. To empirically investigate the relationship between corporate governance mechanisms and the systemic risk of financial institutions, we collect data on systemic risk, corporate governance mechanisms, and financial statement and balance sheet variables from NYU Stern's V-Lab website, Institutional Shareholder Services (ISS)/RiskMetrics, and Bureau van Dijk Bankscope, respectively. Essentially, the sample used in the analysis is an intersection of the available data from V-Lab and ISS/RiskMetrics. We first identify all financial firms (commercial banks, investment banks, non-bank lending institutions, and financial services firms) for which systemic risk data is available from NYU Stern's V-Lab. We then eliminate from this initial sample the institutions with insufficient data on the ISS/RiskMetrics corporate governance measures. This leaves us

[5] de Haan and Vlahu (2015) provide a comprehensive discussion about bank corporate governance and the risk-taking incentives in the financial industry.

with a final sample of 71 individual financial institutions and an unbalanced panel of 332 firm-year observations[6]. The list of financial institutions included in the sample is presented in Appendix A.

3.1. Systemic risk measures

The dependent variable in our empirical analysis is systemic risk. Several alternative approaches for the measurement of systemic risk have been proposed in the literature (see e.g., Acharya, Pedersen, Philippon, & Richardson, 2010; Mayordomo et al., 2014). These approaches can be broadly classified into measures based on balance sheet variables and measures based on financial market data. Whereas the measures based on balance sheet information are slow-moving and backward-looking in nature, the market-based measures can provide more timely and forward-looking assessments of systemic risk.

In our study, we use the two market-based systemic risk measures proposed by Acharya et al. (2012): (i) marginal expected shortfall (MES) and (ii) systemic risk (SRISK). The data on these two systemic risk measures are obtained from NYU Stern's V-Lab website. These measures are based on the approach of Brownlees and Engle (2011) and utilize publicly available stock market data and attempt to capture the capital shortfall of an institution amidst a financial crisis based on its stock return volatility and correlation with the market.

Acharya et al. (2012) define systemic risk (SRISK) as the amount of "capital that a firm is expected to need if we have another financial crisis". SRISK for financial institution i at time t can be formally expressed as:

$$\text{SRISK}_{i,t} = E_{i,t}\left(\text{Capital Shortfall}_i \middle| \text{Crisis}\right) \quad (1)$$

Capital Shortfall in Eq. (1) is estimated under the assumption of an unchanged value of debt if a crisis occurs within the next six months while the value of equity of the financial institution is low. In practice, SRISK is estimated based on the marginal expected shortfall (MES), which attempts to capture the expected loss of equity capital of a firm amidst market turmoil. If a financial institution has high MES, most of the institution's equity capital will be depleted during a financial crisis, and hence, the institution will be in danger of failure. This also implies that under-capitalization of financial institutions contributes positively to the total systemic risk.

Formally, Acharya et al. (2012) define MES as the expected daily percentage decrease in equity value of a financial institution when the aggregate stock market declines by more than 2 percent on a single day. The estimated MES is further extrapolated to a market turmoil that is much more severe and lasts for a longer period to obtain the Long Run Marginal Expected Shortfall (LRMES). Acharya et al. (2012) define LRMES as:

$$\text{LRMES}_{i,t} = 1 - \exp\left(-18 \times \text{MES}_{i,t}\right) \quad (2)$$

Based on LRMES, Acharya et al. (2012) estimate SRISK of financial institution i at time t as follows:

$$\text{SRISK}_{i,t} = E_{i,t}\left[k\left(\text{Debt}_{i,t} + \text{Equity}_{i,t}\right) - \text{Equity}_{i,t} \middle| \text{Crisis}\right] \quad (3)$$

$$\text{SRISK}_{i,t} = k\left(\text{Debt}_{i,t}\right) - (1-k)\left(1 - \text{LRMES}_{i,t}\right)\text{Equity}_{i,t} \quad (4)$$

where k denotes the prudential capital ratio which is taken to be 8 percent, LRMES is the Long Run Marginal Expected Shortfall, Equity is the market value of equity, and Debt is the market value of debt. Hence, SRISK is the amount of capital needed by a firm in a severe turmoil in which the current equity falls according to the LRMES and the level of debt stays constant.

MES and SRISK can be calculated based on historical stock price data without simulation or using simulation. The systemic risk measures used in this study are calculated without simulation in order to maximize the number of individual financial institutions included in the sample. In the approach

[6] Several recent studies have used relatively small samples of financial institutions (see e.g., de Andres & Vallelado, 2008; Fortin et al., 2010; Fahlenbrach & Stulz, 2011; Adams, 2012; Adams & Mehran, 2012; Peni and Vahamaa, 2012; Peni, Smith, & Vahamaa, 2013; Mayordomo et al., 2014).

without simulation, MES, or the expected daily decrease in equity value of a financial institution when the aggregate stock markets declines by more than 2 percent is first calculated based on the institution's stock return volatility, correlation with the aggregate market, and extreme stock price movements. Then, these estimates are extrapolated to a financial crisis—involving a greater decline in asset prices over a longer period of time. Based on these extrapolated decreases in equity value, and under the assumption that a financial institution needs at least 8 percent of equity capital relative to the value of assets, SRISK is estimated as the amount of capital that the institution would need to obtain amidst a severe financial crisis. In our empirical analysis, the year-end (December) estimates of MES and SRISK are used.

3.2. Corporate governance measures

We use the Corporate Governance Quotient (CGQ) index issued by Institutional Shareholder Services (ISS) to measure the strength of the corporate governance mechanisms of financial institutions[7]. These data are obtained from the RiskMetrics Group. CGQ is based on 67 different firm-specific attributes, which represent both the internal and external governance of the firm. The different corporate governance elements included in CGQ are audit committees, board of directors, charter/bylaws, director education, executive and director compensation, ownership, progressive practices, and state of incorporation. The governance data underlying the CGQ is collected from public filings, company websites, and surveys conducted by the ISS. The values of CGQ may range from 0 to 100, with higher values of the quotient corresponding to stronger, more shareholder-focused corporate governance mechanisms.

In addition to the aggregate governance measure CGQ, we also use the ISS Board Quotient (BoardQ) to measure the strength of board monitoring and oversight. Given that the board of directors is the most important internal governance mechanism within a firm, it is of interest to examine the effects of board strength on the systemic risk of financial institutions. Institutional Shareholder Services calculates the Board Quotient based on 20 different board attributes such size, independence, busyness, attendance, and CEO duality. The Board Quotient may take values from 1 to 5, with higher values of the quotient representing stronger, more shareholder-friendly boards of directors.

3.3. Control variables

In order to examine the association between corporate governance and systemic risk, we need to account for several institution-specific factors that may affect the level of systemic risk. Following the prior bank risk-taking literature (e.g., Pathan, 2009; Fortin et al., 2010; Brunnermeier et al., 2012; Berger et al., 2014; Mayordomo et al., 2014), we control for firm size, capital ratio, profitability, growth, and asset as well as income structure. The most important control variable when comparing financial institutions is size. Previous studies have documented that the business strategies, product compositions, and corporate governance structures of financial institutions are affected by the size of the institution. Moreover, larger institutions are likely to have greater systemic importance. Consistent with the literature, we measure institution size (Size) by the logarithm of total assets. Brunnermeier et al. (2012) document that larger banks are associated with higher systemic risk, while Mayordomo et al. (2014) do not find any significant relation between size and systemic risk.

The second most important control variable in comparisons of financial institutions is capital ratio (or leverage ratio). The amount of equity capital is the main variable of interest for banking supervisor and can be considered as a proxy for the soundness and financial health of the institution. Previous studies (Acharya & Thakor, 2011; Brunnermeier et al., 2012; Mayordomo et al., 2014) have documented that the amount of equity capital is an important factor for explaining the systemic risk of financial institutions. We measure Capital ratio as the ratio of equity capital to total assets.

[7] The ISS Corporate Governance Quotient been previously used as a proxy for the strength of corporate governance, for instance, in Chhaochharia and Laeven (2009), Ertugrul and Hegde (2009), and Peni et al. (2013).

Table 1
Descriptive statistics.

Variable	Mean	Median	St. dev.	Min	Max	P25	P75	No. of obs.
Dependent variables								
Marginal expected shortfall (%)	2.510	2.340	1.097	0.840	8.650	1.66	3.11	332
Systemic risk ($ billions)	4.103	−0.435	20.909	−67.659	136.467	−1.825	2.327	332
Corporate governance variables								
Corporate Governance Quotient	48.439	47.650	29.481	0.500	99.400	21.25	72.675	398
Board Quotient	2.719	3.000	1.399	1.000	5.000	1	4	398
Control variables								
Size	257.413	57.210	481.591	0.539	3221.972	15.937	193.321	367
Capital ratio	12.683	9.880	13.725	−3.600	90.510	7.907	12.02	367
Return on assets	1.119	0.970	3.075	−18.420	22.570	0.458	1.394	367
Loans to assets	50.695	60.260	24.629	0.000	90.740	34.833	69.495	338
Loan growth	14.637	6.990	58.459	−72.260	704.490	−1.465	17.097	310
Deposits to assets	0.616	0.694	0.245	0.001	0.900	0.498	0.796	362
Non-interest income	49.939	43.580	31.553	−76.020	175.130	30.015	74.15	367

The table reports the descriptive statistics for the sample. The sample consists of 71 publicly traded U.S. financial institutions. Systemic risk is measured with the following two variables: (i) marginal expected shortfall (MES) is the expected daily percentage decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent and (ii) systemic risk (SRISK) is the expected capital shortfall (in $ billions) of a financial institution in a crisis scenario. The corporate governance variables are defined as follows: Corporate Governance Quotient is the Corporate Governance Quotient (CGQ) index issued by Institutional Shareholder Services (ISS) and Board Quotient is a CGQ sub-index which measures the strength of the board of directors. The control variables are defined as follows: Size is measured as the logarithm of total assets, Capital ratio is the ratio of equity to total assets, Return on assets is the ratio of net income to total assets, Loans to assets is the ratio of net loans to totals assets, Loan growth is the percentage change in loans from year $t-1$ to year t, Deposits to assets is the ratio of deposits to total assets, and Non-interest income is the ratio of non-interest income to total income.

In addition to Size and Capital ratio, we account for the institution's financial performance, growth, and asset and income structure. We measure financial performance with Return on assets which is calculated as the ratio of net income to total assets. Growth is measured as the percentage change in the amount of outstanding loans. We control for the institution's business model and asset structure with the ratio of net loans to total assets (Loans to assets) and the ratio of deposits to total assets (Deposits to assets). Finally, we use the ratio of non-interest income to total income (Non-interest income) to control for the level of income diversification and non-traditional banking activities. The data on our control variables are obtained from Bureau van Dijk Bankscope.

4. Empirical analysis

4.1. Descriptive statistics and correlations

The descriptive statistics for variables used in the empirical analysis are presented in Table 1. As can be noted from the table, the financial institutions included in our sample are very heterogeneous in terms of the strength of corporate governance and board oversight, as CGQ varies from a minimum of 0.5 to a maximum of 99.4 and the BoardQ takes values between 1 and 5. Hence, the descriptive statistics indicate that our sample of large U.S. financial institutions contains firms with very strong and very weak governance mechanisms. In addition to the corporate governance measures, the sample is also heterogeneous in terms of systemic risk. Table 1 shows that MES varies from a minimum of 0.84 percent to a maximum of 8.65 percent, while SRISK ranges from −67.7 billion to 136.5 billion with a mean value of 4.1 billion USD.

It can be further noted from the descriptive statistics in Table 1 that the sample is also very heterogeneous in terms of the control variables. Although all of the sample firms are large, publicly traded financial institutions, there is considerable variation in size with the amount of total assets varying from 540 million to 3.2 trillion USD. The ratios of Loans to assets and Deposits to assets reflect the inclusions of commercial banks as well as other types of financial institutions (investment banks, non-bank lending institutions, and financial services firms) in the sample. Overall, it can be concluded from Table 1 that our empirical analysis is based on a very heterogeneous sample of financial institutions.

Table 2
Correlations.

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Marginal expected shortfall	0.556	0.130	0.142	0.319	0.018	−0.210	−0.405	0.032	−0.286	0.297
(2) Systemic risk		0.183	0.206	0.450	−0.183	−0.275	−0.261	−0.041	−0.163	0.004
(3) Corporate Governance Quotient			0.761	0.253	−0.176	0.013	−0.182	−0.005	−0.006	0.131
(4) Board Quotient				0.287	−0.120	−0.019	−0.173	−0.085	−0.023	0.159
(5) Total assets					−0.435	−0.133	−0.195	−0.136	−0.199	0.180
(6) Capital ratio						0.450	−0.136	0.200	−0.223	0.150
(7) Return on assets							−0.192	0.195	−0.203	0.224
(8) Loans to assets								−0.130	0.460	−0.702
(9) Loan growth									−0.184	0.151
(10) Deposits to assets										−0.446
(11) Non-interest income										1.000

The table reports pairwise correlations for the variables used in the empirical analysis. Marginal expected shortfall is the expected daily percentage decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent, Systemic risk is the expected capital shortfall of a financial institution in a crisis scenario, Corporate Governance Quotient is the Corporate Governance Quotient (CGQ) index issued by Institutional Shareholder Services (ISS), Board Quotient is a CGQ sub-index which measures the strength of the board of directors, Size is measured as the logarithm of total assets, Capital ratio is the ratio of equity to total assets, Return on assets is the ratio of net income to total assets, Loans to assets is the ratio of net loans to totals assets, Loan growth is the percentage change in loans from year $t-1$ to year t, Deposits to assets is the ratio of deposits to total assets, and Non-interest income is the ratio of non-interest income to total income.

Table 2 reports the pairwise correlations among the variables used in the analysis. It can be noted from the table that the two systemic risk measures (MES and SRISK) are positively correlated with the two corporate governance variables (CGQ and BoardQ), suggesting that financial institutions with stronger, more shareholder-oriented corporate governance mechanisms and boards are associated with higher levels of systemic risk. Not surprisingly, the two systemic risk measures (0.556) as well as the two corporate governance measures (0.761) are strongly positively correlated with each other. The correlations also indicate that larger financial institutions tend to have better governance practices as Size is strongly positively correlated with both CGQ and BoardQ.

Table 2 further shows that the systemic risk measures are strongly positively correlated with Size and negatively correlated with Loans to assets and Deposits to assets. Hence, consistent with the findings of Brunnermeier et al. (2012) and Mayordomo et al. (2014), the correlations suggest that larger banks which are more involved in non-traditional banking activities are associated with higher levels of systemic risk. Finally, it is worth noting that several of our control variables are strongly correlated with each other[8]. Most notably, Table 2 indicates that Size is strongly negatively correlated with Capital ratio, while Capital ratio and Return on assets, in turn, exhibit a significant positive correlation with each other. Furthermore, the three variables which measure the asset and income structure (Loans to assets, Deposits to assets, and Non-interest income) of the financial institutions are strongly correlated with each other.

4.2. Univariate tests

Before conducting our main analysis with panel regressions, we begin the analysis by examining the relationship between corporate governance and systemic risk in a univariate setting. Specifically, we divide our sample into two subsamples based on CGQ and test for differences in the means and medians of the variables between the two subsamples. The first subsample contains the financial institutions with stronger corporate governance mechanisms (institutions with CGQ values in the top three deciles), while the second subsample consists of institutions with weaker corporate governance mechanisms (institutions with CGQ values in the bottom three deciles). After constructing the stronger

[8] We perform several robustness checks to ensure that our empirical findings are not affected by multicollinearity.

Table 3
Univariate tests.

Variable	Stronger governance		Weaker governance		Difference	Difference
	Mean	Median	Mean	Median	in means	in medians
Dependent variables						
Marginal expected shortfall	2.689	2.590	2.278	2.020	0.411**	0.570***
Systemic risk	11.279	−0.117	0.720	−0.512	10.560***	0.395*
Corporate governance variables						
Corporate Governance Quotient	84.973	85.000	13.146	13.000	71.827***	72.000***
Board Quotient	3.917	4.000	1.400	1.000	2.517***	3.000***
Control variables						
Size	18.560	18.525	17.530	17.190	1.031***	1.334***
Capital ratio	9.108	9.148	13.157	10.270	−4.049***	−1.122***
Return on assets	0.720	0.900	1.083	0.995	−0.363	−0.095
Loans to assets	47.822	48.040	57.949	67.200	−10.127***	−19.160***
Loan growth	16.232	6.720	11.811	7.640	4.421	−0.920
Deposits to assets	0.642	0.689	0.629	0.693	0.014	−0.004
Non-interest income	52.500	45.325	45.507	40.535	6.993	4.790*

The table reports the results of two-tailed *t*-tests and Wilcoxon rank-sum tests for the null hypothesis that there is no difference in the means and medians between financial institutions with stronger and weaker corporate governance structures. The stronger governance subsample consists of financial institutions with Corporate Governance Quotients in the top 30% and the weaker governance subsample consists of institutions with Corporate Governance Quotients in the bottom 30% of the sample. Marginal expected shortfall is the expected daily percentage decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent, Systemic risk is the expected capital shortfall of a financial institution in a crisis scenario, Corporate Governance Quotient is the Corporate Governance Quotient (CGQ) index issued by Institutional Shareholder Services (ISS), Board Quotient is a CGQ sub-index which measures the strength of the board of directors, Size is measured as the logarithm of total assets, Capital ratio is the ratio of equity to total assets, Return on assets is the ratio of net income to total assets, Loans to assets is the ratio of net loans to totals assets, Loan growth is the percentage change in loans from year $t-1$ to year t, Deposits to assets is the ratio of deposits to total assets, and Non-interest income is the ratio of non-interest income to total income.

* Denote significance at the 0.10 level.
** Denote significance at the 0.05 level.
*** Denote significance at the 0.01 level.

and weaker governance subsamples, we perform two-tailed *t*-tests and Wilcoxon/Mann–Whitney median tests under the null hypothesis that there are no differences in the means and medians between the financial institutions with stronger and weaker corporate governance mechanisms.

The results of the univariate tests are reported in Table 3. As can be noted from the table, the differences in MES and SRISK between the two subsamples in terms of both means and medians are positive and statistically significant. Hence, the univariate tests provide considerable evidence to suggest that financial institutions with stronger, more shareholder-focused corporate governance mechanisms are associated with higher systemic risk. The differences in systemic risk measures between the two subsamples are also economically highly significant; the mean difference in SRISK between the stronger and weaker governance subsamples is about 10.6 billion USD. As an illustration of the differences, Fig. 1 plots the values of SRISK for institutions with stronger and weaker corporate governance mechanisms. Regarding the control variables, the univariate tests in Table 3 indicate that financial institutions with stronger governance practices are significantly larger, more highly levered, and have a lower amount of loans relative to total assets and a higher percentage of non-interest income.

4.3. Regression results

We examine the association between corporate governance and systemic risk by estimating several alternative fixed-effects panel regressions of the following form:

$$\begin{aligned}\text{Risk}_{i,t} = {} & \alpha + \beta_1 \text{Governance}_{i,t-1} + \beta_2 \text{Size}_{i,t-1} + \beta_3 \text{Capital ratio}_{i,t-1} + \beta_4 \text{Return on assets}_{i,t-1} \\ & + \beta_5 \text{Loans to assets}_{i,t-1} + \beta_6 \text{Loan growth}_{i,t-1} + \beta_7 \text{Deposits to assets}_{i,t-1} \\ & + \beta_8 \text{Non-interest income}_{i,t-1} + \sum_{k=1}^{n-1} \alpha_k \text{Firm}_i^k + \sum_{y=2006}^{2010} \omega_y \text{Year}_i^y + \varepsilon_{i,t}\end{aligned} \quad (5)$$

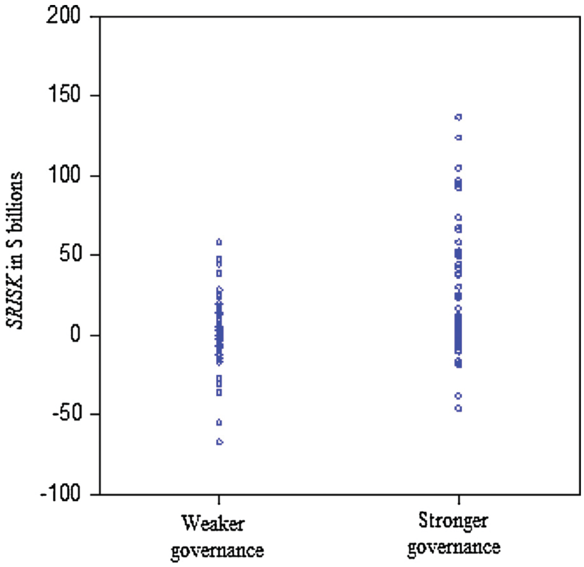

Fig. 1. The figure plots the values of systemic risk (SRISK) for financial institutions with stronger and weaker corporate governance structures.

where the dependent variable $\text{Risk}_{i,t}$ is one of the two alternative systemic risk measures for financial institution *i* at time *t*. The first measure is MES calculated as the expected daily decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent, while the second measure is SRISK defined as the expected capital shortfall of a financial institution in a crisis scenario. $\text{Governance}_{j,t}$ is either the CGQ which measures the strength of the institution's corporate governance mechanisms or BoardQ which measures the strength of the board of directors. We also estimate modified versions of Eq. (5) in which we include an interaction variable Governance × Year^{2008} in order to examine the effect of corporate governance on systemic risk amidst the financial crisis.

As discussed above, we include several firm-specific financial variables in the regressions to control for the effects of observable characteristics of financial institutions that may affect the level systemic risk. These control variables are defined as follows: Size is measured as the logarithm of total assets, Capital ratio is the ratio of equity to total assets, Return on assets is the ratio of net income to total assets, Loans to assets is the ratio of net loans to totals assets, Loan growth is the percentage change in loans from year $t-1$ to year *t*, Deposits to assets is the ratio of deposits to total assets, and Non-interest income is the ratio of non-interest income to total income. Finally, we control for potential time fixed-effects with fiscal year dummy variables (Year_i) and we also estimate regression specifications with firm fixed-effects to account for omitted variables and unobservable firm-characteristics (Firm_i).

Table 4 reports the estimates of six alternative versions of Eq. (5) with the marginal expected shortfall (MES) as the dependent variable. Models 1 and 4 are parsimonious models which include only Size, Capital ratio, and Return on assets as the control variables, while Models 2 and 5 include the full set of controls as well as year and firm fixed-effects. Finally, in Models 3 and 6, we also include the financial crisis interaction variables CGQ × Year^{2008} and BoardQ × Year^{2008}, respectively. The adjusted R^2s of the parsimonious models are about 45 percent, and the inclusion of the additional control variables and firm fixed-effects increases the adjusted R^2s to about 75 percent. The *F*-statistics are statistically significant at the 1 percent level in all six alternative regression specifications.

As can be seen from Table 4, the coefficient estimates for CGQ and BoardQ are positive and statistically significant in Models 1, 3, 4, and 5, and also the coefficients for the crisis interaction variables

Table 4
Corporate governance and marginal expected shortfall (MES).

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Corporate governance variables						
CGQ	0.003* (1.96)	0.003 (1.47)	0.002* (1.81)			
CGQ × Year^{2008}			0.011*** (11.53)			
BoardQ				0.039** (2.06)	0.071** (2.26)	0.039 (1.10)
BoardQ × Year^{2008}						0.147*** (3.08)
Control variables						
Size	0.25*** (3.09)	0.127 (0.42)	0.089 (0.31)	0.253*** (3.00)	0.134 (0.45)	0.093 (0.32)
Capital ratio	0.025*** (6.48)	−0.037** (−2.41)	−0.036** (−2.51)	0.024*** (7.08)	−0.035** (−2.11)	−0.033** (−2.32)
Return on assets	−0.008 (−0.31)	−0.152** (−2.17)	−0.154** (−2.07)	−0.007 (−0.30)	−0.143** (−2.23)	−0.131* (−1.83)
Loans to assets		−0.008** (−2.03)	−0.010* (−1.95)		−0.009** (−1.98)	−0.011* (−1.79)
Loan growth		−0.001*** (−4.15)	−0.001*** (−5.42)		−0.001*** (−3.49)	0.000** (−2.30)
Deposits to assets		−0.857 (−1.07)	−0.842 (−1.01)		−0.954 (−1.23)	−0.848 (−1.130)
Non-interest income		0.002 (−1.11)	−0.002 (−1.00)		−0.004 (−1.28)	−0.005 (−1.32)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	No	Yes	Yes	No	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	44.45%	74.22%	75.63%	44.18%	74.31%	74.82%
F-stat.	28.22***	10.95***	11.56***	27.91***	10.99***	11.11***

The table reports the estimates of six alternative versions of the following panel regression specification:

$$\begin{aligned}\text{MES}_{i,t} \quad = \quad & \alpha_0 + \beta_1\text{Governance}_{i,t-1} + \beta_2\text{Size}_{i,t-1} + \beta_3\text{Capital ratio}_{i,t-1} \\ & + \beta_4\text{Return on assets}_{i,t-1} + \beta_5\text{Loans to assets}_{i,t-1} + \beta_6\text{Loan growth}_{i,t-1} \\ & + \beta_7\text{Deposits to assets}_{i,t-1} + \beta_8\text{Non-interest income}_{i,t-1} + \sum_{k=1}^{n-1}\alpha_k\text{Firm}_i^k + \sum_{y=2006}^{2010}\omega_y\text{Year}_i^y + \varepsilon_{i,t}\end{aligned}$$

where the dependent variable $\text{MES}_{i,t}$ is the marginal expected shortfall for firm *i* at time *t* calculated as the expected daily percentage decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent. $\text{Governance}_{i,t}$ is either CGQ (Corporate Governance Quotient) which measures the strength of the firm's corporate governance mechanisms or BoardQ (Board Quotient) which measures the strength of the board of directors. The control variables are defined as follows: Size is measured as the logarithm of total assets, Capital ratio is the ratio of equity to total assets, Return on assets is the ratio of net income to total assets, Loans to assets is the ratio of net loans to totals assets, Loan growth is the percentage change in loans from year $t-1$ to year *t*, Deposits to assets is the ratio of deposits to total assets, and Non-interest income is the ratio of non-interest income to total income. Firm_i^k is a dummy variable for firm *i* and Year_i^y is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and within-firm clustering.

* Denote significance at the 0.10 level.

** Denote significance at the 0.05 level.

*** Denote significance at the 0.01 level.

in Models 3 and 6 are positive and statistically highly significant. Hence, consistent with the univariate tests reported in Table 3, our regression results indicate that financial institutions with stronger, more shareholder-focused corporate governance structures and boards of directors are associated with higher systemic risk. This finding is broadly consistent with the previous literature on the effects of corporate governance on traditionally used measures of bank risk-taking (see e.g., Pathan, 2009; Fortin et al., 2010).

The coefficient estimate for CGQ in Model 1 suggests that a ten-point increase in the Corporate Governance Quotient increases MES on average by approximately three basis points. Given that the average book value of equity for the sample institutions is about 18 billion USD, a three basis point increase in MES can be considered economically significant. Furthermore, the coefficients for Model 3 indicate that the overall positive association between CGQ and MES was statistically significantly stronger amidst the financial crisis; the coefficient estimate for CGQ $\times$ Year^{2008} implies that a ten-point increase in CGQ would be associated with a 12 basis point increase in MES in year 2008. The estimates of Models 4 and 5 suggest that a one-point increase in BoardQ is associated with an economically significant 4–7 basis point increase in MES. Regarding the control variables, the two-way fixed-effects specification in Table 4 indicate that systemic risk is significantly negatively related to Capital ratio, Return on assets, Loan to assets, and Loan growth, suggesting that financial institutions with lower capital ratios, lower profitability, and lower amounts of outstanding loans have higher systemic risk.

The regression results with systemic risk (SRISK) as the dependent variable are presented in Table 5. Similar to Table 4, we report the estimates of six alternative versions of Eq. (5). The adjusted R^2s of these regressions vary from 30 percent to 53 percent and the *F*-statistics are significant at the 1 percent level, indicating a good fit of the estimated models. Again, the test variable of interest in Models 1–3 is CGQ, while in Models 4–6 we use BoardQ as the governance measure. Overall, the estimates with SRISK as the dependent variable are very similar to the MES results reported in Table 4. Most importantly, the coefficient estimates for CGQ and BoardQ are positive and statistically significant in every model specification, and thereby provide further evidence to suggest that financial institutions with stronger corporate governance mechanisms and more shareholder-oriented boards of directors are associated with higher systemic risk.

In addition to being statistically significant, the results in Table 5 can be considered economically significant. The coefficient estimates for the parsimonious Models 1 and 4, for instance, suggest that a 10-point increase in CGQ increases SRISK on average by 950 million USD and that a one-point increase in BoardQ is associated with a 2.36 billion USD increase in SRISK. Furthermore, similar to Table 4, the coefficient estimates for the interaction variables CGQ $\times$ Year^{2008} and BoardQ $\times$ Year^{2008} are positive and statistically highly significant in Models 3 and 6, indicating that the positive association between good corporate governance and systemic risk was particularly strong amidst the financial crisis in 2008. With respect to the control variables, it can be noted from Table 5 that the level of systemic risk is affected, at least to some extent, by Size, Capital ratio, Return on assets, and Deposits to assets.

Overall, the regression results reported Tables 4 and 5 as well as the univariate tests in Table 3 provide strong evidence that financial institutions with stronger and more shareholder-focused corporate governance mechanisms and boards of directors are associated with higher levels of systemic risk. Given that corporate governance is essentially a mechanism for controlling risk-taking, it may appear somewhat counterintuitive that financial institutions with stronger governance mechanisms have higher systemic risk. It has been argued in the prior literature (e.g., Mehran et al., 2011; Beltratti & Stulz, 2012; de Haan & Vlahu, 2015) that strong, shareholder-friendly governance practices may motivate excessive risk-taking in the financial industry in order to increase shareholders' wealth. Our empirical findings provide support to this argument.

4.4. Additional tests

We perform a number of additional tests to examine the robustness of our empirical findings. First, in order to mitigate concerns related to endogeneity and reverse causality, we estimate alternative regression specifications to test whether the percentage change in systematic risk from year $t-1$ to

Table 5
Corporate governance and systemic risk (SRISK).

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Corporate governance variables						
CGQ	0.095*** (5.94)	0.179*** (3.39)	0.155*** (3.43)			
CGQ × $Year^{2008}$			0.168** (2.27)			
BoardQ				2.355*** (3.87)	4.597** (2.22)	4.298** (1.99)
BoardQ × $Year^{2008}$						1.416*** (2.74)
Control variables						
Size	6.094*** (3.32)	22.051** (2.37)	21.45** (2.16)	6.019*** (3.19)	22.971** (2.11)	22.576** (1.99)
Capital ratio	0.137* (1.82)	−0.444** (−2.41)	−0.427*** (−2.84)	0.112* (1.66)	−0.289 (−1.13)	−0.267 (−1.13)
Return on assets	−0.428*** (−3.33)	−0.808 (−1.49)	−0.832 (−1.43)	−0.415*** (−3.52)	−0.195 (−1.02)	−0.075 (−0.28)
Loans to assets		0.075 (1.00)	0.046 (0.53)		0.015 (0.14)	−0.008 (−0.07)
Loan growth		−0.010 (−1.05)	−0.009 (−1.05)		−0.003 (−0.33)	−0.002 (−0.18)
Deposits to assets		−84.300* (−1.86)	−84.059* (−1.82)		−91.584* (−1.95)	−90.557* (−1.90)
Non-interest income		−0.035 (−0.17)	−0.034 (−0.16)		−0.137 (−0.619)	−0.146 (−0.65)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	No	Yes	Yes	No	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	30.12%	51.74%	52.26%	30.74%	53.05%	52.89%
F-stat.	15.65***	4.7***	4.72***	16.09***	4.9***	4.82***

The table reports the estimates of six alternative versions of the following panel regression specification:

$$\begin{aligned} \text{SRISK}_{i,t} = {} & \alpha_0 + \beta_1 \text{Governance}_{i,t-1} + \beta_2 \text{Size}_{i,t-1} + \beta_3 \text{Capital ratio}_{i,t-1} \\ & + \beta_4 \text{Return on assets}_{i,t-1} + \beta_5 \text{Loans to assets}_{i,t-1} + \beta_6 \text{Loan growth}_{i,t-1} \\ & + \beta_7 \text{Deposits to assets}_{i,t-1} + \beta_8 \text{Non-interest income}_{i,t-1} + \sum_{k=1}^{n-1} \alpha_k \text{Firm}_i^k + \sum_{y=2006}^{2010} \omega_y \text{Year}_i^y + \varepsilon_{i,t} \end{aligned}$$

where the dependent variable $SRISK_{i,t}$ is the Systemic risk for firm *i* at time *t* calculated as the is the expected capital shortfall in a crisis scenario. $Governance_{i,t}$ is either CGQ (Corporate Governance Quotient) which measures the strength of the firm's corporate governance mechanisms or BoardQ (Board Quotient) which measures the strength of the board of directors. The control variables are defined as follows: Size is measured as the logarithm of total assets, Capital ratio is the ratio of equity to total assets, Return on assets is the ratio of net income to total assets, Loans to assets is the ratio of net loans to totals assets, Loan growth is the percentage change in loans from year $t-1$ to year *t*, Deposits to assets is the ratio of deposits to total assets, and Non-interest income is the ratio of non-interest income to total income. $Firm_i^k$ is a dummy variable for firm *i* and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors which are adjusted for heteroskedasticity and within-firm clustering.

* Denote significance at the 0.10 level.

** Denote significance at the 0.05 level.

*** Denote significance at the 0.01 level.

year t is influenced by the strength of governance mechanisms in year $t-1$[9]. Consistent with the risk culture hypothesis of Fahlenbrach et al. (2012), we assume that corporate governance mechanisms have a long-term effect on the risk-taking culture of financial institutions that may cause measures of systemic risk to increase or decrease over time.

Table 6 reports the estimates of eight alternative versions of Eq. (5) in which the percentage change in systemic risk is used as the dependent variable[10]. In Models 1–4, the dependent variable is the percentage change in MES, while in Models 5–8 we use the percentage change in SRISK as the dependent variable. The estimates of these change regressions are qualitatively similar to our main analysis, and thereby provide further evidence that strong corporate governance mechanisms may have a positive effect on systemic risk, at least amidst financial market turmoil. As can be noted from Table 6, the coefficient estimates for the interaction variables CGQ $\times$ Year^{2008} and BoardQ $\times$ Year^{2008} are positive and statistically highly significant in Models 2, 4, 6, and 8. These estimates indicate that the increase in systemic risk during the financial crisis was higher for financial institutions with more shareholder-oriented governance mechanisms and boards. Interestingly, however, the coefficients for CGQ and BoardQ are insignificant in the models without the financial crisis interactions while being negative and statistically significant in the models which include the interaction terms. The negative coefficients for CGQ and BoardQ are smaller in magnitude than the coefficient estimates for the interactions terms, suggesting that overall effect of strong governance on the percentage change in systemic risk was positive in 2008. In general, consistent with our main analysis, the estimates of the change regressions suggest that the association between governance mechanisms and systemic risk is notably affected by the financial crisis. In addition to the corporate governance variables, it is worth noting from Table 6 that the percentage changes in MES are positively associated with Loans to assets and Growth, while the changes in SRISK are strongly negatively related to Return on assets.

To further address concerns related to reverse causality, we follow the approach of Jo and Harjoto (2012) to investigate the causal effect of lagged CGQ and BoardQ on MES and SRISK as well as the inverted causal effect of lagged MES and SRISK on CGQ and BoardQ. These additional regression estimates (not tabulated) indicate that both the first and the second lags of the corporate governance measures are statistically significantly positively related to our systemic risk measures, while the lagged systemic risk variables cannot explain the governance measures. This suggests that the direction of causation is from corporate governance to systemic risk and not vice versa. We also re-estimate alternative versions of Eq. (5) using the second lags of CGQ and BoardQ. The estimates of these regressions are consistent with our main analysis and indicate that also longer lags of the corporate governance variables are positively associated with the level of systemic risk.

Third, to ensure that our results are not affected by multicollinearity, we estimate constrained versions of Eq. (5) from which either Capital Ratio or Return on Assets is excluded as well as specifications from which either Loans to assets or Non-interest income is excluded[11]. As can be noted from Table 2, the correlation coefficient between Capital Ratio and Return on Assets is 0.45, while Loans to assets and Non-interest income are strongly negatively correlated with a correlation coefficient of -0.70. The estimates of the constrained regression specifications (not tabulated) are consistent with our main regressions and indicate a positive association between the corporate governance variables and the two measures of systemic risk. Hence, we conclude that our results are not driven by multicollinearity.

[9] As noted in the survey by de Haan and Vlahu (2015), governance mechanisms and especially board characteristics have often been treated as exogenous variables in the literature despite that there are theoretical arguments as well as empirical evidence suggesting that governance structures are endogenous. Adams et al. (2010), for instance, argue that corporate governance mechanisms are largely endogenous.

[10] The change regressions reported in Table 6 do not include firm fixed-effects. A large proportion of the changes in MES and SRISK can be explained by firm fixed-effects and the coefficients for the corporate governance variables become statistically insignificant at the conventional significance levels when firm fixed-effects are included in the regressions.

[11] VIF tests suggest that our regression results should not be influenced by multicollinearity as all the VIF values are below 5.

Table 6
Corporate governance and changes in systemic risk.

Variable	Percentage change in marginal expected shortfall (MES)				Percentage change in systemic risk (SRISK)			
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
Corporate governance variables								
CGQ	−0.001 (−1.39)	−0.001** (−2.42)			0.000 (0.02)	−0.012** (−2.18)		
CGQ × Year^{2008}		0.004*** (6.60)				0.057*** (8.14)		
BoardQ			0.001 (0.06)	−0.017 (−0.96)			0.073 (0.26)	−0.241*** (−3.22)
BoardQ × Year^{2008}				0.065*** (3.19)				1.176*** (12.38)
Control variables								
Total assets	0.021 (0.75)	0.021 (0.77)	0.020 (0.71)	0.021 (0.74)	−0.029 (−0.25)	−0.025 (−0.21)	−0.037 (−0.35)	−0.015 (−0.12)
Capital ratio	−0.004 (−1.16)	−0.004 (−1.10)	−0.004 (−0.98)	−0.004 (−0.98)	0.024 (0.83)	0.027 (0.91)	0.025 (0.94)	0.022 (0.86)
Return on assets	−0.032 (−1.37)	−0.033 (−1.38)	−0.031 (−1.32)	−0.028 (−1.23)	−0.265*** (−4.71)	−0.272*** (−4.85)	−0.255*** (−4.90)	−0.199*** (−2.69)
Loans to assets	0.002** (2.15)	0.002** (2.10)	0.003** (2.51)	0.002** (2.39)	−0.014* (−1.71)	−0.015* (−1.90)	−0.014* (−1.83)	−0.018** (−2.45)
Loan growth	−0.000*** (−2.93)	−0.000*** (−2.76)	−0.000*** (−2.84)	−0.000** (−2.42)	0.001 (0.83)	0.001 (0.95)	0.001 (1.03)	0.002** (2.22)
Deposits to assets	−0.159 (−1.07)	−0.157 (−1.00)	−0.165 (−1.12)	−0.152 (−1.02)	0.100 (0.10)	0.133 (0.13)	0.047 (0.05)	0.282 (0.29)
Non-interest income	0.000 (0.53)	0.000 (0.40)	0.000 (0.49)	0.000 (0.33)	−0.009 (−1.52)	−0.011 (−1.55)	−0.010 (−1.44)	−0.012 (−1.47)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	64.94%	65.75%	64.78%	65.34%	−2.65%	3.58%	−2.53%	3.68%
F-stat.	32.35***	30.76***	32.10***	30.22***	0.56	1.57*	0.58	1.59*

The table reports the estimates of eight alternative versions of the following panel regression specification:

$$\Delta \text{Systemic risk}_{i,t}/\text{Systemic risk}_{i,t-1} = \alpha_0 + \beta_1 \text{Governance}_{i,t-1} + \beta_2 \text{Size}_{i,t-1} + \beta_3 \text{Capital ratio}_{i,t-1} + \beta_4 \text{Return on assets}_{i,t-1} + \beta_5 \text{Loans to assets}_{i,t-1} + \beta_6 \text{Loan growth}_{i,t-1} + \beta_7 \text{Deposits to assets}_{i,t-1} + \beta_8 \text{Non-interest income}_{i,t-1} + \varepsilon_{i,t}$$

where the dependent variable Systemic risk$_{i,t}$ is the systemic risk for firm *i* at time *t* and and Δ is the first difference operator. The level of systemic risk is measured with the following two variables: (i) marginal expected shortfall (MES) is the expected daily decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent and (ii) systemic risk (SRISK) is the expected capital shortfall of a financial institution in a crisis scenario. Governance$_{i,t}$ is either CGQ (Corporate Governance Quotient) which measures the strength of the firm's corporate governance mechanisms or BoardQ (Board Quotient) which measures the strength of the firm's corporate governance mechanisms or Board Quotient which measures the strength of the board of directors. The control variables are defined as follows: Size is measured as the logarithm of total assets, Capital ratio is the ratio of equity to total assets, Return on assets is the ratio of net income to total assets, Loans to assets is the ratio of net loans to totals assets, Loan growth is the percentage change in loans from year $t-1$ to year *t*, Deposits to assets is the ratio of deposits to total assets, and Non-interest income is the ratio of non-interest income to total income. The *t*-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and within-firm clustering.

* Denote significance at the 0.10 level.
** Denote significance at the 0.05 level.
*** Denote significance at the 0.01 level.

Fourth, in order to examine whether our results are driven by outliers or extreme observations, we winsorize the systemic risk measures at the 5th and 95th percentiles and re-estimate the regressions using these winsorized dependent variables. The estimation results (not tabulated) based on the winsorized systemic risk measures are qualitatively consistent with our main analysis, and thereby suggest that our findings are not caused by outliers. Specifically, the coefficient estimates for CGQ and BoardQ are positive and statistically significant in most of the alternative regressions specifications, indicating that financial institutions with stronger governance mechanisms are associated with higher systemic risk.

Fifth, we investigate the sensitivity of our results to potential firm-size effects. For this purpose, we re-estimate the regressions using two subsamples from which either the largest 10 percent or the smallest 10 percent of the financial institutions have been excluded (not tabulated). The estimation results for the subsample without the smallest institutions are very similar to the results reported in Tables 4 and 5. However, for the subsample from which the largest financial institutions are excluded, the coefficient estimates for CGQ and BoardQ are positive but appear statistically insignificant in most specifications. This suggests that our findings are, at least to some extent, induced by the largest financial institutions in the sample.

Sixth, to examine whether our results are sensitive to the sample period used in the analysis, we re-estimate the regressions using three truncated samples from which the first sample year 2005, the crisis year 2008, or the last sample year 2010 has been excluded. The estimates of the regressions based on the truncated samples (not tabulated) are very similar to our main findings, and once again indicate a strong positive relation between systemic risk and the strength of corporate governance. In the truncated samples without either 2005 or 2010, the coefficient estimates for CGQ and BoardQ are consistently positive and statistically significant in most of the alternative regression specifications. When the crisis year of 2008 is excluded from the sample, the coefficient estimates for CGQ and BoardQ are positive and statistically highly significant in the regressions with SRISK as the dependent variable. However, in the regressions with MES as the dependent variable, the coefficients for CGQ and BoardQ are positive but statistically insignificant, with the only exception being the coefficient for BoardQ which is significant at the 1 percent level in the specification corresponding to Model (4) in Table 5. Overall, the estimates based on the truncated samples suggest that the positive association between corporate governance mechanisms and systemic risk is weaker if the severe financial market turmoil of 2008 is excluded from the sample.

To further examine the potential effects of the financial crisis on our results, we re-estimate the regressions without "troubled" financial institutions. The "troubled" institutions are defined as institutions which either failed or reported losses in excess of two percent of total assets during the crisis. Again, the estimates of these additional regressions (not tabulated) are very similar to our main analysis. Most importantly, the coefficients for CGQ and BoardQ appear positive and statistically significant in most of the alternative model specifications.

Finally, we acknowledge that our sample contains very different types of financial institutions. In order to examine whether our findings are affected by the diversity of the institutions, we re-estimate the regressions using a sample which is constrained to commercial banks and other lending institutions with net loans to totals assets ratio of at least 30 percent. The estimates (not tabulated) based on the restricted sample of financial institutions are similar to the results reported in Tables 4 and 5, and thereby provide further evidence that institutions with stronger corporate governance mechanisms are associated with higher systemic risk. Hence, we conclude that our results are robust to the exclusion of investment banks and non-bank financial services firms from the sample.

5. Conclusions

Corporate governance practices are seen by politicians and regulators as at least partially responsible for the recent financial crisis (see e.g., Kirkpatrick, 2009; Basel Committee on Banking Supervision, 2010; Board of Governors of the Federal Reserve System, 2010; Haldane, 2012). Therefore, we examine the relationship between corporate governance and the systemic risk of financial institutions around the financial crisis of 2008. Systemic risk can be roughly defined as a financial institution's contribution to the overall riskiness of the financial system. During periods of financial turmoil, the failure of one financial institution may more easily affect others and eventually the whole financial system. Thus, systemic risk may be a more appropriate risk measure than stand-alone risk (see e.g., Anginer et al., 2014). In our empirical analysis, we use the systemic risk measures proposed by Acharya et al. (2012) as a proxy for the systemic risk of large, publicly traded U.S. financial institutions and utilize the Corporate Governance Quotient as well as the Board Quotient issued by Institutional Shareholder Services to measure the strength of corporate governance mechanisms and board oversight within financial institutions.

Our empirical findings indicate that financial institutions with stronger corporate governance mechanisms and more shareholder-friendly boards are associated with higher levels of systemic risk. Hence, our results suggest that good corporate governance may encourage rather than constrain excessive risk-taking in the financial industry. We believe that the results reported in this paper offer several important implications. Most importantly, our results demonstrate that "good" corporate governance mechanisms in the financial sector may not be enough to constrain risk-taking and to prevent financial crises in the future. On the contrary, regulators and policy makers who have been charged with implementing reforms of the financial industry should take a more careful approach to corporate governance mechanisms and consider that good governance may potentially have unintended effects on risk-taking of financial institutions. When shaping solutions for influencing the future behavior of banks, it is of importance to acknowledge that shareholder-focused governance structures may create considerable negative externalities on the financial system by increasing the aggregate level of systemic risk.

Overall, our results suggest that banking supervisors and regulators should apply more stringent monitoring to financial institutions with strong, shareholder-oriented corporate governance mechanisms in order to assess their contribution toward systemic risk. More generally, given the negative social consequences that the excessive risk-taking of major financial institutions can have on the global financial and economic conditions, our findings provide grounds for challenging the appropriateness of the traditional shareholder-oriented corporate governance model in the financial industry. Because of the importance of financial institutions for the society, appropriately designed governance mechanisms should ensure that the risk-taking incentives are better aligned with the interests of other stakeholders such as depositors, debt holders, banking supervisors, and the society in general.

There are several limitations in our empirical analysis that should be addressed in future research. First, our sample is relatively small and limited to 71 large U.S. financial institutions and a six-year period around the global financial crisis. The small sample of large, publicly traded U.S. institutions may limit the generalizability of our results. Moreover, we acknowledge that the positive association between corporate governance mechanisms and systemic risk is induced, at least to some extent, by the severe financial market turmoil of 2008. It is possible that the relationship between governance mechanisms and systemic risk is different in more normal financial conditions. Therefore, it would be interesting to extend the analysis to a large sample of international banks and also to utilize a longer sample period. Given that corporate governance structures change rather slowly, a longer sample period would also allow to analyze whether changes in governance mechanisms affect the level of systemic risk. Finally, while our empirical findings demonstrate a strong linkage between two aggregate corporate governance measures and systemic risk, it would be of interest to examine how and through which channels specific governance structures and observable board characteristics influence the systemic risk of financial institutions.

Appendix A.

See Table A1.

Table A1
List of financial institutions.

1	American Express
2	Associated Banc-Corp.
3	Bank of America
4	Bank of Hawaii
5	Bank of New York Mellon
6	BB&T
7	BBVA Compass Bancshares
8	Bear Stearns
9	BGC Partners
10	BOK Financial
11	Capital One Financial
12	Capitol Federal Financial
13	Charles Schwab
14	Citigroup
15	City National
16	Comerica
17	Commerce Bancshares
18	Countrywide
19	Cullen/Frost Bankers
20	East West Bancorp
21	Fannie Mae
22	Fifth Third Bancorp
23	First Citizens BancShares
24	First Horizon National
25	First Niagara Financial
26	Franklin Resources
27	Fulton Financial
28	Goldman Sachs
29	Hancock
30	Hudson City Bancorp
31	Jefferies Group
32	JP Morgan Chase & Co.
33	KeyCorp
34	Legg Mason
35	Lehman Brothers
36	M&T Bank
37	Marshall & Ilsley
38	Merrill Lynch & Co.
39	Metlife
40	Morgan Stanley
41	National City
42	New York Community Bancorp
43	Northern Trust
44	PNC Financial Services
45	Principal Financial Group
46	Prosperity Bancshares
47	Prudential Financial
48	Raymond James Financial
49	Regions Financial
50	SEI Investments
51	Signature Bank
52	Sallie Mae
53	Sovereign Bank
54	State Street
55	Stifel Financial
56	SunTrust
57	SVB Financial
58	Synovus Financial
59	T. Rowe Price Group
60	TCF Financial
61	TD Ameritrade
62	TransAtlantic

Table A1 (*Continued*)

63	UMB Financial
64	UnionBanCal
65	US Bancorp
66	Valley National Bancorp
67	Washington Federal
68	Webster Financial
69	Wells Fargo
70	WMI Holdings
71	Zions Bancorporation

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Corporate Governance and the Insolvency Risk of Financial Institutions☆

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Abstract

We investigate whether corporate governance is related to insolvency risk of financial institutions. Using a large sample of U.S. financial institutions over the 2005–2010 period, we find that corporate governance is positively related with insolvency risk of financial institutions as proxied by Merton's distance to default measure and credit default swap spread. We also find that "stronger" corporate governance increased insolvency risk relatively more for larger financial institutions and during the period of the global financial crisis. Our results hold when we use propensity score matching technique to address the concerns for endogeneity.

JEL classification: G01, G20, G21, G30, G32, G34

Keywords: corporate governance; boards, insolvency risk; bank risk-taking; financial crisis

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☆ We thank Shams Pathan, Steve Swidler, Sami Vähämaa, Qiongbing Wu, Janne Äijö, Björn Rock and participants at the 29th Australasian Finance and Banking Conference, International Finance and Banking Society (IFABS) 2017 Oxford Conference, 2018 Financial Markets & Corporate Governance Conference, and Finance Seminar at University of Vaasa for the valuable comments and suggestions. J. Iqbal gratefully acknowledges the financial support of the Marcus Wallenbergin foundation and Säästöpankkien Tutkimussäätiö for this project. Any errors are our own.

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1. Introduction

"Corporate Governance deals with the ways in which suppliers of finance to corporates assure themselves of getting return on their investment."

(Shleifer and Vishny, 1997, p. 737)

Agency theory posits corporate managers may pursue their own interests rather than maximizing shareholders' value and thus create a conflict of interest. This agency behavior stems from the view that corporate managers may be more risk averse than shareholders because they want to protect their undiversified human capital and investment in the firm. Shareholder-friendly corporate governance mechanisms can influence the behavior of managers and change their willingness to take on more risk.[1] In this regard, John, Litov, and Young (2008) show that the shareholder-friendliness of corporate governance mechanisms encourages risk-taking and promotes the growth of non-financial firms. More recently, in the wake of the financial crisis, several studies have shed light on the role of corporate governance towards risk-taking and financial performance of financial institutions (Adams, 2012; Fahlenbrach and Stulz, 2011; Peni and Vahamaa, 2012). Specifically, several studies focus on risk taking by financial institutions especially during the recent global financial crisis (Pathan, 2009; Laeven and Levine, 2009; Berger, Kick, and Schaeck, 2014; Iqbal, Strobl and Vahamaa, 2015). Overall, these studies suggest more, deemed inappropriate, risk taking by financial institutions during the financial crisis. Thus, stronger corporate governance practices may encourage increased risk-taking in the financial industry (Erkens, et al., 2012: Iqbal et al., 2015) which may lead to the default of financial institution, especially during the periods of financial distress. Therefore, in this paper, we investigate whether the corporate governance affects the insolvency risk of financial institutions.

'Stronger' corporate governance not only affects the performance of the firms, measured by Tobin's Q (Gompers, Ishii, and Metrick, 2003; Brown and Caylor, 2006; Chhaochharia and Laeven, 2009; Ammann et al., 2011) but also encourages

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[1] For instance, shareholder-friendly corporate governance mechanisms can be better investor protection, high number of independent board of directors, separation of the chairman and the CEO, not having poison pill in place etc.
Because shareholders do not internalize the social costs associated with failures of financial institutions, they may find it optimal to increase the level of risk. Furthermore, the shareholders and investors expect the government to bailout the large financial institutions in case of their failures (Acharya, Anginer and Warburton, 2016). However, managers tend to have a lower level of risk than those of the shareholders because of their firm-specific human capital and investment in the firm (Laeven and Levine, 2009; Erkens, Hung and Matos, 2012).

increased risk-taking that results in higher growth of firms (John et al., 2008).[2] However, for financial institutions, the optimal degree of risk taking is higher than for non-financial firms because market expect government support for financial institutions if they become distressed. Implicit and explicit government guarantees encourage financial institutions to take more risks (see Acharya, Anginer and Warburton, 2016).[3] In addition, shareholder-friendly governance mechanisms may further encourage adopting riskier corporate policies (Chava and Purnanadam, 2010) which may, in turn, lead to higher insolvency risk in financial institutions. In contrast to non-financial firms, expectation of government support in times of distress, implicit and explicit government guarantees, provide a unique environment to consider financial institutions separately (Acharya et al., 2016; Zhao, 2018) because stronger corporate governance mechanisms in financial institutions can lead to greater risk taking (Erkens et al., 2012; Anginer, Demirguc-Kunt, Huizinga, and Ma, 2014).[4] Therefore, we hypothesize that strong corporate governance mechanisms are positively associated with insolvency risk of financial institutions.

To test the hypothesis, we utilize the comprehensive data on the U.S. financial institutions from 2005 to 2010, thus including the period of recent financial crisis which previous studies excluded. We use Corporate Governance Quotient and Sub-Quotients (namely Board Quotient, Compensation Quotient, Audit Quotient and Takeover Quotient) issued by Institutional Shareholder Services (ISS) to measure the strength of corporate governance mechanisms. To capture insolvency risk, we use traditional (i.e., distance to default) and innovative market based (i.e., credit default swap (CDS) spread) measures. Recent studies (e.g., Bolton, Mehran, and Shapiro, 2015) utilize CDS spread to proxy insolvency risk and suggest that it is preferable because it also accounts for creditors risk (Colonnello, 2017; Feldhutter, Hotchkiss, and Karakas, 2016).[5] Despite a growing literature on the examination of the role of CDS spreads in understanding corporate finance issues, surprisingly

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[2] Corporate governance mechanisms and the board of directors are considered to be stronger and more shareholder-friendly when they provide effective monitoring and stronger protection of shareholder's interests, and more generally, better alignment of managers' interests with those of the shareholders. Adams (2012) and de Haan and Vlahu (2016) provide comprehensive discussions about the corporate governance of financial institutions and the elements of "good" governance.

[3] Implicit government guarantee is the expectation by market participants that the government may provide bailout (Acharya et al., 2016). It is referred as implicit because government does not explicitly provide commitment to intervene. Implicit government guarantees are not limited to only banks but also for other financial institutions (Zhao, 2018).

[4] For instance, Acharya et al. (2016) find that bondholders of the financial institutions, especially large ones, expect that the government will protect them in case of failure of financial institution.

[5] Blanco, Brennan, and Marsh (2005) and Norden and Weber (2009) find that CDSs are, also, a more accurate and informative measure of credit risk.

little is known about the relationship between corporate governance mechanisms and CDS spreads. We contribute to this literature by empirically examining whether the strength of corporate governance mechanisms affects CDS spreads for financial institutions.

In summary, we find that the insolvency risk of financial institutions, proxied by either its market-based distance to default or CDS spread, is positively associated with the shareholder-friendliness of its corporate governance. Further, this positive association between corporate governance and insolvency risk is more important for larger financial institutions and during the financial crisis. Our findings are broadly consistent with the prior literature on risk-taking by financial institutions (see e.g., Pathan, 2009; Fortin, Goldberg and Roth, 2010; Beltratti and Stulz, 2012; Erkens et al., 2012). These findings suggest that stronger corporate governance mechanisms may encourage more risk-taking in the financial industry. A potential explanation for these results is that shareholder-friendly boards of directors encouraged managers to take more risks to increase shareholder return, prior to the crisis (Laeven and Levine, 2009).[6] According to DeYoung, Peng, and Yan (2013) argue that prior to the global financial crisis (during 2000–2006), CEO compensation in banks was changed which encouraged more risk-taking. Because financial institutions are entering into activities that are more complex and have broadened their scope, this effect may have been amplified in recent years, making it difficult for regulators to keep pace with the changes. Our results are economically significant and robust to several additional analyses, including propensity score matching to mitigate the concerns regarding endogeneity.

Our study is not the first to establish a link between corporate governance and insolvency risk of financial institutions. For instance, Anginer et al. (2014) find that shareholder-friendly corporate governance mechanisms are associated with greater insolvency risk (i.e., lower Z-score and distance to default) for a sample of international banks. However, our study differs from their study in multiple aspects. First, they do not test the impact of global financial crisis on governance–insolvency nexus. Second, their sample only includes large banks and does not consider other types of financial institutions. Third, their measure of insolvency risk does not include credit default swap spread. Some other studies also examine the governance-default linkage but provide contrasting evidence. Using a sample of Canadian financial institutions over the period of 2010 to 2013 (post crisis), Switzer, Wang and Zhang (2016) find that large and more independent boards have higher default risk as measured through distance to default. While in contrast, Switzer and Wang (2013) provide evidence that U.S. commercial banks

[6] Majority of the directors on the shareholder-friendly boards should be independent (Adams and Mehran, 2012).

with larger and more independent boards have lower levels of default risk during the period from 2001 to 2007, that is, prior to the global financial crisis. With these mixed results, the issue of whether the strength of corporate governance mechanisms affects the insolvency risk for financial institutions is still an empirical matter.[7] It is therefore imperative to empirically examine the association between the shareholder-friendliness of corporate governance mechanisms and insolvency risk of financial institutions, especially around the period of the recent global financial crisis.

We contribute to the literature in the following ways. First, we contribute to the literature in corporate finance that relates firm-level characteristics to the failure of financial institutions. Previous contributions to this literature mostly emphasize investigating the influence of accounting variables on financial institutions' failure probabilities. Some of the earliest works in this literature stream are Meyer and Pfifer (1970), Martin (1977), and Whalen and Thomson (1988). These studies mainly find that low capitalization results in poor bank performance and increased failure probability. Furthermore, a few studies investigate the factors that drive bank failures during the global financial crisis (see Aubuchon and Wheelock, 2010; Cole and White, 2012; Berger and Bouwman, 2012; Ng and Roychowdhury, 2014). Aubuchon and Wheelock (2010) show that economic downturns play an important role in bank failures during the crisis period. Cole and White (2012) investigate how accounting-based variables contributed to the bank failures in 2009. Berger and Bouwman (2012) find that bank equity capital is important for the survival of banks (especially smaller banks) during periods of crisis. Ng and Roychowdhury (2014) find that during the period of the recent financial crisis loan loss reserves added back as regulatory capital were positively associated with bank failures. However, studies on the role of corporate governance in the failure of financial institutions are relatively scarce. For instance, Berger, Imbierowicz, and Rauch (2016) investigate the role of bank ownership and compensation structures in bank failures during the recent global financial crisis. We contribute by showing that strength of corporate governance mechanisms plays an important role in the insolvency risk of financial institutions.

Second, we contribute to the literature on the effects of corporate governance on risk taking in financial institutions (see Laeven and Levine, 2009; Pathan, 2009; Fahlenbrach and Stulz, 2011; Beltratti and Stulz, 2012; Erkens et al, 2012; Peni and

[7] Even for non-financial firms, studies find contradictory evidences. For instance, Chiang, Chung and Huang (2015) find that corporate governance is associated with bankruptcy possibility whereas Schultz, Tan and Walsh (2017) find no relationship between probability of default and corporate governance characteristics.

Vahamaa, 2012; Berger et al., 2014; Iqbal et al., 2015).[8] These studies mainly find that shareholder-friendly corporate governance mechanisms encourage more risk-taking in the financial industry. For instance, Pathan (2009) finds that board size can affect the risk-taking in banks and find that banks with larger boards take less risk. Fahlenbrach and Stulz (2011) find that better alignment of bank CEO incentives with the interests of shareholders can negatively affect the bank's performance. Iqbal et al. (2015) find that financial institutions with more shareholder-friendly governance mechanisms are associated with higher levels of systemic risk. Building on these studies, we relate corporate governance to insolvency risk for a large sample of U.S financial institutions.

We particularly focus on the association between corporate governance and insolvency risk amidst the recent financial crisis. As far as we know, this is one of the few studies to show the relevance of corporate governance to a financial institution's insolvency risk especially in the context of the recent global financial crisis. We show that strong governance mechanisms significantly affect the insolvency risk of financial institutions. We also find that strong corporate governance increases insolvency risk especially for the large financial institutions in times of distress that may contribute to the instability in the overall financial system. Then, we show that financial institutions with strong boards have a greater insolvency risk. We believe that connecting board strength to insolvency risk is relevant because the existing literature does not provide a satisfactory answer regarding the role of boards in controlling the agency relationship (see e.g., Adams et al., 2010; de Haan and Vlahu, 2016). Further, most of the previous studies on board effectiveness do not include financial institutions in their sample (see Adams et al., 2010).[9] We also confirm the previous literature (Adams and Mehran, 2012) that in the financial industry, restrictions on board size can be counter-productive. Lastly, building on the earlier contributions, we utilize the market-based CDS spread data to proxy insolvency risk, which also accounts for credit risk.

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[8] Mehran, Morrison and Shapiro (2011) survey studies investigating the relationship between corporate governance and measures of risk.

[9] Most of the studies before GFC excluded financial firms from their sample because they were considered highly regulated. The additional regulatory oversight maybe viewed as a substitute (John, Mehran and Qian, 2010; Adams and Mehran, 2012) for corporate governance in financial institutions. However, governance of financial institutions may be different from that of non-financial firms because of several reasons. For instance, financial institutions have larger number of stakeholders which complicates the governance of financial institutions. Apart from investors and depositors, regulators also have stake in the performance of financial institution because performance of financial institutions can also affect the health of the overall economy (Adams and Mehran, 2012). Implicit and explicit government guarantees provide financial institutions a different risk environment that are not applicable to non-financial firms. Therefore, it is important to consider financial institutions separately.

The remainder of the paper is organized as follows. Section 2 presents the data and explains the variables used in the empirical analysis. Section 3 presents the methods, and reports the empirical findings on the association between corporate governance mechanisms and the insolvency risk of financial institutions. Finally, the last section concludes with policy implications.

2. Data and variables

In this study, we investigate the relationship of corporate governance mechanisms and insolvency risk for a sample of 556 publicly traded U.S. financial institutions over the 2005–2010 period. To empirically examine the relationship between corporate governance mechanisms and insolvency risk, we collect data on corporate governance mechanisms from the Corporate Governance Quotient database developed by Institutional Shareholder Services (ISS). Insolvency risk data is collected from the Credit Research Initiative (CRI) database managed by the Risk Management Institute (RMI) at the National University of Singapore.[10] Lastly, data on financial statement and balance sheet variables is collected from BankScope of Bureau Van Dijk.

Starting from the entire population of U.S. banks and diversified financials (950 financial institutions) in Corporate Governance Quotient database,[11] we first identify the financial institutions for which the insolvency risk data (distance to default and credit default swap spread) is available from the RMI-CRI database. Doing so, we are left with 650 financial institutions. We then eliminate the financial institutions from our sample that have insufficient data on financial statement and balance sheet variables found in BankScope. This leaves us with a final sample of 556 individual financial institutions and an unbalanced panel of 2126 firm-year observations.[12]

[10] RMI-CRI database covers over 60,000 listed firms in Asia Pacific, North America, Europe, Latin America, the Middle East and Africa. The RMI-CRI database provides historical time series of individual distance to default on a monthly frequency at the firm level. Thus, monthly frequency of individual distance to default requires an adjustment to annual frequency to be consistent with other variables.

[11] ISS classification is based on S&P "GICS" (Global Industry Classification System). We download all firm-year observations for banks and diversified financials (GICS code of 4010 and 4020 respectively). These include diversified banks, regional banks, thrifts & mortgage finance, multi-sector holdings, specialized finance, other diversified financial services, consumer finance, asset management & custody banks, investment banking & brokerage, diversified capital markets, financial exchanges & data, and mortgage real estate investment trusts.

Almost 75 percent of these financial institutions are categorized as Banks in Corporate Governance Quotient Database.

[12] Almost 91 percent of the financial institutions are categorized as Banks in the final sample.

2.1. Insolvency risk measures

The dependent variable in our study is the insolvency risk (Insolvency Risk). Since the seminal work of Beaver (1966), a number of accounting and market-based insolvency prediction models have been developed in the literature. The validity of accounting-based models has been questioned due to the backward-looking nature of the financial statements from which these models are derived (Agarwal and Taffler, 2008). Market-based models using the option pricing approach developed by Black and Scholes (1973) and Merton (1974) provide an appealing alternative to the prediction of insolvency conditions of listed firms and have been used in extant empirical studies (e.g., Hillegeist et al., 2004; Bharath and Shumway, 2008; Charitou et al., 2013). Such a methodological approach overcomes the criticisms of accounting-based models through the forward-looking nature of market data. Market data reflect expectations of a firm's future cash flows, and hence should be more appropriate for prediction purposes. Another prevalent feature of such models is their provision of a "finer" volatility assessment that aids in predicting the risk of insolvency (Beaver et al., 2005).[13] Empirical studies such as Hillegeist et al. (2004) recommend that researchers use market-based models of default prediction since these models contain more information about default than accounting-based models. We therefore use the market-based Merton (1974) distance to default (DD) and credit default swap (CDS) spread as measures of insolvency risk (see appendix A: general procedure to calculate DD). Much like typical insurance, CDS is a financial contract.[14]

In a typical CDS contract, the protection seller offers the protection buyer insurance against the default of an underlying bond issued by a certain company (the reference entity). In the event of default by the reference entity, the seller commits to buy the bond for a price equal to its face value from the protection buyer.[15] In exchange for the insurance, the buyer pays a quarterly premium, called the CDS spread, quoted as an annualized percentage of the notional value insured. Therefore, by definition, the CDS spread is the pricing of the insolvency risk (Das et al., 2009). The higher the insolvency risk of the reference entity, the larger is the CDS spread. Tang and Yan (2010) find that the CDS spread captures the major

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[13] Volatility is a critical factor in predicting default risk since it captures the probability that the value of a firm's assets will decrease to such a point that the firm will be unable to repay its debt obligations. Ceteris paribus, the higher the volatility, the higher is the default risk. Depending on asset volatilities, two firms with identical leverage ratios can have substantially different chances of financial distress. Therefore, measures of volatility should be incorporated in financial distress models.

[14] "The contract defines a reference instrument (a bond) issued by some reference entity (the obligor)" (Duan, 2014, p. 51).

[15] In practice, the terms of the *CDS* could involve physical delivery of the defaulted bond or cash settlement.

portion of the firm level determinants of insolvency risk. Thus, the CDS spread should serve as a valid and robust measure of a firm's insolvency conditions.

In this paper, we download the CDS spread data from the "Credit Research Initiative (CRI)" platform of the National University of Singapore (NUS). However, they refer it to as "actuarial spread".[16] Actuarial spread is constructed on the design of traditional CDS but without upfront fee. Further, construction of actuarial spread is based on the assumption that market participants are risk-neutral that is why no upfront fee is initially required. Therefore, actuarial spread has the same features as the standard CDS spread.

2.2. Corporate governance measures

In this paper, we utilize the Corporate Governance Quotient (CGQ) index which measures the strength of corporate governance mechanisms and is issued by Institutional Shareholder Services (ISS).[17] We obtain these data from RiskMetrics Group. *CGQ* is comprehensive corporate governance index comprised of 67 different firm-related characteristics including internal and external governance. The *CGQ* includes information about the board of directors, ownership structure, directors' education, audit committees, executive compensation structure, charter/bylaws, and form of incorporation. This data is obtained from surveys conducted by the ISS, company websites, and public filings. The values of *CGQ* ranges from 0 to 100, with higher values corresponding to stronger, more shareholder-focused corporate governance mechanisms.

In addition to the aggregate governance measure *CGQ*, we use four sub-indices, called board, compensation and ownership, auditing, and takeover that summarize aspects of corporate governance. The takeover sub-index, for instance, has a higher score, if there are fewer corporate governance-related barriers to takeovers. These sub-indices take values from 1 to 5, with higher values representing stronger, more shareholder-friendly mechanisms.

2.3. Control variables

Following prior literature on bank risk-taking (e.g., Pathan, 2009; Fortin et al., 2010; Brunnermeier et al., 2012; Berger et al., 2014; Mayordomo et al., 2014; Iqbal et al., 2015), we control for several institution-specific variables that may influence the insolvency risk of the financial institutions, specifically firm size, profitability,

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[16] This paper uses CDS spread terminology for ease of understanding.

[17] The ISS Corporate Governance Quotient been previously used as a proxy for the strength of corporate governance, for instance, in Chhaochharia and Laeven (2009), Ertugrul and Hegde (2009), and Peni, Smith and Vahamaa (2013).

growth, and the structures of assets and income. When comparing financial institutions, size is the most important control variable. Larger financial institutions may pursue riskier corporate policies (Brunnermeier et al. 2012). The size (*Size*) variable is constructed as the natural logarithm of total assets.

In addition to *Size,* we account for the institution's financial performance, growth, and asset and income structure. We measure financial performance with *Return on assets* which is calculated as the ratio of net income to total assets. *Growth* is measured as the percentage change in the amount of outstanding loans from last year to this year. We control for the institution's business model and asset structure with the ratio of net loans to total assets (*Loans to assets*) and the ratio of deposits to total assets (*Deposits to assets*). Finally, we use the ratio of non-interest income to total income (*Non-interest income*) to control for the level of income diversification and non-traditional banking activities.

In previous literature, capital ratio (or leverage ratio) is used when comparing financial institutions. However, in this study, we do not control for capital ratio as the construction of DD and CDS preclude it.[18] The construction of DD is based on the Merton (1974) model which assumes that firms are financed by equity.[19] Further, CRI computes CDS spread based on the term structure of probabilities of default.[20] CRI adopts the forward intensity approach of Duan, Sun and Wang (2012) to characterize term structure of probabilities of default. Thus, CDS spread is based on a physical probability that makes inclusion of equity, as a control variable, problematic.[21] In addition, capital ratio also serves as a proxy for the insolvency risk (Borisova, Fotak, Holland, Megginson, 2015). For instance, Anginer et al. (2014) do not control for capital ratio when using z-score and DD to proxy insolvency risk. The data on our control variables are obtained from Bureau van Dijk Bankscope. The definitions of variables are summarized in Table 1.

(insert Table 1 about here)

[18] Although our results are robust to inclusion of capital ratio as control variable.
[19] See Duan and Wang (2012) for the detail on measurement of distance to default.
[20] For instance, see Duan (2014) for the detail on construction of CDS
[21] In addition, previous studies (e.g. Baselga-Pascual, Trujillo-Ponce, Cardone-Riportella, 2015) argue that regressing capital ratio on the insolvency risk (measured by Z-score and distance to default) may be problematic because banks can alter their capital if they become more risk.

3. Empirical analysis

3.1. Descriptive statistics and correlations

Table 2 presents the descriptive statistics for the variables used in the empirical analysis. Descriptive statistics show that our sample of financial institutions is quite heterogeneous in terms of corporate governance strength as *CGQ* varies from 0.5 (minimum) to 100 (maximum) and has an average of 53.09. Further, the corporate governance sub-indices, board, compensation, audit, and takeover, also vary from lowest (0) to the highest (5) possible values suggesting that our sample of financial institutions is diverse in terms of the strength of corporate governance mechanisms. In addition to this, our sample is also quite heterogeneous in terms of insolvency risk. *DD* has a minimum value of -2.04 and a maximum value of 11.78. Moreover, *CDS* varies from a minimum of -2.40 to a maximum of 7.89 with a mean value of 3.93. Table 2 also shows that our sample is also quite heterogeneous in terms of control variables. There is considerable variation in size, ranging from 12.7 million to 2.26 trillion USD.

(insert Table 2 about here)

Table 3 shows the pairwise correlations among the variables used in the analysis. It can be noted from the table that *CGQ* and governance sub-indices have a negative correlation with *DD* and a positive correlation with *CDS*,[22] suggesting better governed financial institutions have a greater level of insolvency risk. Moreover, as expected, the two insolvency risk variables, *DD* and *CDS*, are negatively correlated by construction (r=0.93). As the correlation results are not controlled by other factors that affect financial distress, they should be viewed with caution.[23]

(insert Table 3 about here)

3.2. Univariate tests

We start by investigating the association between corporate governance and insolvency of financial institutions in a univariate setting. We do so by dividing our sample of financial institutions into two groups formed on the basis of the strength of corporate governance. The first group comprises financial institutions with stronger corporate governance structures, that is, financial institutions with CGQ values in the top 30 percent. The second group includes financial institutions with

[22] There is a significant negative correlation of CG variables with the components of DD i.e. asset volatility and equity volatility, suggesting that better governed firms are more volatile.
[23] We also observe a significant difference at the 1% level in the insolvency risk measures between the high CGQ firms and the low CGQ firms (results available on request).

weaker corporate governance structures, that is, those with CGQ values in bottom 30 percent. We analyze the significance of the difference in means using two-tailed *t*-tests under the null hypothesis that there are no differences in the means between the financial institutions with stronger and weaker corporate governance structures.

(insert Table 4 about here)

We report the results of this analysis in Table 4. We find that the two groups are significantly different in many respects. First, the difference of means for Distance to Default is negative and statistically significant, and for CDS spread is positive and statistically significant. Thus, the univariate analysis provides evidence that financial institutions with stronger corporate governance mechanisms are associated with a higher level of insolvency risk. Regarding the control variables, the univariate tests in Table 4 indicate that financial institutions with stronger governance structures are significantly larger, and have a lower amount of loans relative to total assets and a higher percentage of non-interest income.

3.3. Regression results

We use panel data where insolvency risk is the dependent variable for the estimation of our model. Our baseline model to examine the association between corporate governance and insolvency risk follows several alternative panel regressions of the equation below:

$$\begin{aligned} InsolvencyRisk_{i,t} &= \alpha + \beta_1 Governance_{i,t} + \beta_2 Size_{i,t} \\ &+ \beta_3 Return\ on\ assets_{i,t} + \beta_4 Loans\ to\ assets_{i,t} \\ &+ \beta_5 Loan\ Growth_{i,t} + \beta_6 Deposits\ to\ assets_{i,t} \\ &+ \beta_7 Non-interest\ income_{i,t} + \sum_{k-1}^{n-1} \alpha_k\, Year_i^y + \varepsilon_{i,t} \end{aligned} \quad (1)$$

where the dependent variable *Insolvency Risk*$_{i,t}$ is one of the two alternative measures of insolvency risk: the distance to default or CDS spread for financial institution *i* at time *t*. The distance to default measures the difference between the asset value of the financial institution and the face value of its debt, scaled by the standard deviation of the asset value (see Campbell, Hilscher and Szilagyi, 2008, p. 2899). Second, the CDS spread is the pricing of the financial distress risk (Das et al., 2009). CDS are credit derivatives that allow the transfer of the firm's default risk between two agents for a predetermined time period. *Governance*$_{j,t}$ is either the *CGQ* which measures the overall strength of the institution's corporate governance mechanisms or *BoardQ* which measures the strength of the board of directors.[24] In order to capture the effect of global financial crisis we also estimate modified versions of Equation (1) where we include the interaction variable *Governance* × *GFC*. Where GFC denotes the crisis year 2008. Further, we use the interaction variable *Governance* × *Size* to investigate the effect of the size of the financial institution.

As discussed earlier, we use several firm-level variables in order to control for the effects of observable characteristics of financial institutions that may impact the insolvency risk. Control variables used in this study are consistent with the previous literature on the determinants of risk-taking in financial institutions (Laeven and Levine, 2009; Beltratti and Stulz, 2012; Bai and Elyasiani, 2013; Ellul and Yerramilli, 2013). Finally, the regressions also include firm and year fixed effects, and errors are clustered at the firm level. We also winsorize all the independent variables at the 1st and 99th percentiles to mitigate potential outlier effects.[25]

Table 5 reports the results for ten alternative versions of Equation (1) with the distance to default (*DD*) as the dependent variable. Models 1 and 6 include only *Size* and *Return on assets* as the control variables for the purpose of parsimony, whereas Models 2 and 7 include the full set of control variables and year fixed-effects, and Models 3 and 8 include both year and firm fixed-effects along with the full set of control variables. Further, Models 4 and 9 include interaction variables *CGQ* × *GFC* and *BoardQ* × *GFC*, respectively to control for the global financial crisis. Lastly, in Models 5 and 10 we include size interaction variables *CGQ* × *Size* and *BoardQ* × *Size*, respectively. The adjusted R^2s of all models are almost 50 percent. The *F*-statistics for all the ten alternative regressions are statistically significant at the 1 percent level.

(insert Table 5 about here)

Table 5 shows that the overall corporate governance index has a negative and statistically significant coefficient in Models 1, 2 and 3. Board index has a negative and statistically significant coefficient in Models 6 and 7. These results suggest that more shareholder-friendly corporate governance and a more shareholder-friendly board increases insolvency risk of financial institutions. In Models 4 and 9, the negative coefficients for interaction variables, *CGQ* × *GFC* and *BoardQ* × *GFC*,

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[24] We further estimate several versions of Equation (1) where $Governance_{j,t}$ is one of the sub-indices namely; board index, compensation and ownership index, auditing index, and takeover index which summarizes information regarding different aspects of corporate governance. These results are reported in Tables 8 and 9.

[25] We follow Ellul and Yerramilli (2013) and winsorize the independent variables. Results are also robust to not winsorizing.

suggest that strong corporate governance and a more shareholder-friendly board is associated with increased insolvency risk during the period of the financial crisis. Hence, the positive association between insolvency risk and strong corporate governance may be driven by the global financial crisis. In Models 5 and 10, the coefficients for the size interaction variables, *CGQ* × *Size* and *BoardQ* × *Size*, are negative and statistically significant suggesting that positive association between strength of corporate governance and insolvency risk is particularly important for larger financial institutions. However, board index in Model 10 is positive and statistically significant suggesting that a more shareholder-friendly board reduces insolvency risk, especially in small financial institutions. This also suggests that larger financial institutions take on more risk as they benefit from a becoming bigger (Acharya et al, 2016; Zhao, 2018).

In summary, Table 5 indicates that financial institutions with stronger, more shareholder-friendly corporate governance mechanisms and boards of directors are associated with greater insolvency risk. Overall the findings reported in Table 5 are broadly consistent with the literature on risk-taking by financial institutions (see e.g., Pathan, 2009; Fortin et al., 2010; de Haan and Vlahu, 2016; Iqbal et al., 2015; Acharya et al., 2016; Zhao, 2018). Our results are also economically significant. For instance, with an increase in CGQ from 25^{th} percentile to 75^{th} percentile is associated with up to a 7.28 percent increase in the insolvency risk of financial institutions (see Table 7) and during the global financial crisis, the increase in insolvency risk rises to 7.81 percent. We gauge the effect of governance on insolvency risk by calculating the marginal effect of an increase of CGQ from the 25th to the 75th percentile and then multiply the difference by the coefficient.[26] We then divide this variation by the average insolvency risk.

(insert Table 6 about here)

Table 6 presents the regression estimates of Equation (1) with credit default swap spread (CDS) as the dependent variable. Regressions in this table are similar to those in Table 5 with estimates of ten alternative versions of Equations (1). Here, the adjusted R^2s of these regressions vary from 45.1 percent to 51.7 percent. The *F*-statistics are significant at the 1 percent level, which indicates a good fit for the estimated models. Again, the *Governance* variable in Models 1–5 is *CGQ* and in Models 6–10 is *BoardQ*. Overall, the regression estimates with *CDS* as dependent variable are similar to the *DD* results reported in Table 5. The coefficient estimates for *CGQ* and *BoardQ* in Table 6 are positively associated with CDS spread

[26] We follow Chung, Elder and Kim (2010) to gauge the economic significance by calculating the marginal effect of an increase in the governance index from the 25th to 75th percentile.

indicating that stronger corporate governance mechanisms and more shareholder-friendly boards of directors are associated with greater insolvency risk. In Models 4 and 9, the positive coefficients for interaction variables, may suggest that the positive association between insolvency risk and strong corporate governance may be driven by the global financial crisis. In Models 5 and 10, the coefficients for the size interaction variables, *CGQ* × *Size* and *BoardQ* × *Size*, are positive and statistically significant, again, suggesting that positive association between strength of corporate governance and insolvency risk is particularly important for larger financial institutions.[27] However, the overall governance index in Model 5 and the board index in Model 10 have negative and statistically significant coefficients suggesting that strong corporate governance and a more shareholder-friendly board reduces insolvency risk, especially in small financial institutions. These findings provide further evidence that insolvency risk of financial institutions is positively associated with shareholder-friendly corporate governance mechanisms. Again, our results are also economically significant. For instance, a change in CGQ from the 25th percentile to the 75th percentile is associated with an up to 3.05 percent increase in insolvency risk of financial institutions as measured by CDS spread (see Table 7) and during the global financial crisis the increase in insolvency risk as measured by CDS spread is up to 3.39 percent.

(insert Table 7 about here)

(insert Table 8 about here)

Table 8 reports the estimates of six alternative versions of Equation (1) with the distance to default (*DD*) as the dependent variable. However, here $Governance_{j,t}$ represents four sub-indices: board, compensation, audit, and takeover. Model 1 only includes size as a control variable and Model 2 includes only *Size* and *Return on assets* as the control variables for parsimony. Whereas, Models 3 and 4 include full set of control variables and year fixed-effect and Model 4 also includes firm fixed-effects along with a full set of control variables. Further, Model 5 includes interaction variables *Governance Indices* × *GFC* for global financial crisis. Lastly, in Model 6 we include the size interaction variables *Governance Indices* × *Size*. The adjusted R^2s of all the models are almost 50 percent except Model 1 where the adjusted R^2s is 34.6 percent. The *F*-statistics for all the six alternative regressions are statistically significant at the 1 percent level.

[27] Bigger financial institutions may be riskier, because they expect a bailout by regulators in case of failure (Acharya et al, 2016).

Table 8 depicts that the overall board index has a negative and statistically significant coefficient in Models 1–3, suggesting that the presence of a more shareholder-friendly and strong board increases insolvency risk of financial institutions. This is consistent with the previous literature finding that strong boards in financial institutions are associated with greater levels of risk (Pathan, 2009). Model 5 shows that the compensation sub-index has a strong negative coefficient suggesting better alignment of interests increases insolvency risk during the period of financial crisis. Lastly, Model 6 shows that larger financial institutions have more insolvency risk.

(insert Table 9 about here)

Table 9 reports the regression estimates of Equation (1) with credit default swap spread (CDS) as the dependent variable. Regressions in this table are similar to those in Table 8 with estimates of six alternative versions of Equations (1). Here, also, $Governance_{j,t}$ represents four sub-indices. The adjusted R^2s of all the models vary from 29 percent to almost 52 percent. The F-statistics for all the six alternative regressions are statistically significant at the 1 percent level. The regression estimates reported in this table are comparable to Table 8 where the board index is positive and statistically significant in Models 1–3 showing that a more shareholder-friendly and strong boards increase insolvency risk of financial institutions. Model 5 shows that the compensation sub-index has strong positive coefficient, suggesting better alignment of interests increases insolvency risk during the period of financial crisis. Lastly, Model 6 shows that shareholder-friendly board in a larger financial institution is associated with greater insolvency risk.

In summary, from the regression results reported in Tables 5, 6, 8, and 9, we find that insolvency risk of a financial institution is positively associated with the shareholder-friendliness of that financial institution's corporate governance especially for large financial institutions and during the period of the global financial crisis. Prior literature (e.g., Mehran et al., 2011; Beltratti and Stulz, 2012; de Haan and Vlahu, 2016) highlights that strong, shareholder-friendly governance practices may encourage more risk-taking in the financial industry in order to increase shareholders' wealth. We provide empirical support for this argument.

3.4. Addressing endogeneity

We recognize that the coefficients reported in Tables 5 and 6 may, to some extent, be biased because corporate governance structure is largely endogenous (Adams et al., 2010). Two important concerns should be addressed, as these can affect the interpretation of our results. First, it could be that we do not actually capture the relationship between insolvency risk and CGQ because of omitted variables. To mitigate this issue, we use firm fixed-effects and try to include different control variables and show that our results hold. Second, it could be that there is reverse causality, that insolvency risk affects CGQ and not the other way around. For instance, the risk preferences of financial institutions can also affect the strength of corporate governance mechanisms. To address this issue, we use lagged CGQ and propensity score matching.

3.4.1 Lagged variables

Although we include both firm fixed-effects and year fixed effects to alleviate the endogeneity concerns, in order to further investigate the predictive ability of corporate governance mechanisms for insolvency risk and also eliminate the concerns regarding reverse causality, we follow Jo and Harjoto (2012) and estimate causal effect of lagged CGQ on insolvency risk measured by distance to default and CDS spread. We also investigate the inverted causal effect of lagged distance to default and CDS spread on CGQ. The regression results (not tabulated) indicate that results are similar to our previous results in Tables 5 and 6 for both first and second lags of corporate governance measures. Furthermore, we also find that the direction of causation is from corporate governance to insolvency risk and not the other way around. These results provide support to our main findings that strong corporate governance mechanisms lead to higher levels of insolvency risk in financial institutions.

3.4.2. Propensity score matching

To further eliminate the endogeneity bias, we conduct propensity score matching where we match firm-years with CGQ index greater than median (treatment group) with firm-years with CGQ index lower than median (control group). Table 10 reports the propensity score matching estimation results and compares the insolvency risk (measured by distance to default and credit default swap (CDS) spread) of financial institutions in the treatment and control groups. First, we estimated the probability that a financial institution has stronger corporate governance mechanisms (i.e. has CGQ index greater than the median). This probability is the propensity score and is the predicted value from a logit regression where the dependent variable is a dummy variable which equals one if CGQ index is greater than the median and zero otherwise. The logit regression results are reported in the pre-match column of Panel A of Table 10 and the same control variables are included as in Table 5 and Table 6. The regression results suggest that financial institutions with stronger corporate governance mechanisms have a lower loans to total assets ratio and lower performance as measured by return on assets ratio.

(insert Table 10 about here)

For this purpose, each financial institution with a CGQ greater than the median is matched to a financial institution with a CGQ lower than the median by the closest propensity score. We employ matching with replacement and allow for the control firms to be matched to multiple treatment firms. We further require that the difference between the propensity score of treatment and matched firms does not exceed 0.5% in absolute value.

In order to ensure that financial institutions in both groups (treatment and control) are almost similar in terms of observable characteristics, we perform two diagnostic tests. In the first test, we re-estimate the logit regression model for the post-match sample. The results of this regression are reported in the post-match column of Panel A of Table 10. All the regression coefficients are statistically insignificant and smaller than those in the column pre-match, suggesting that both groups are almost similar in terms of observable characteristics. Panel B of Table 10 reports the results of the second diagnostic test in which we examine the difference for each control variable between the treated financial institutions and the matched control financial institutions. Again, we find no significant difference in observable characteristics between the two groups. Thus, these results suggest that propensity score matching alleviates the problem of endogeneity and removes other observable differences and increases the probability that any difference in the insolvency risk between the treated and control groups is because of the strength of corporate governance mechanisms.

Lastly, the propensity score matching estimates and the multivariate results using the matched sample are reported in Panel C and Panel D of Table 10, respectively. As it is evident in Panel C of Table 10, we find significant differences in both insolvency risk measures between the treatment and control group. In detail, we find that distance to default is lower and CDS spread is higher in the financial institutions with stronger corporate governance mechanisms than the otherwise indistinguishable financial institutions with relatively weaker corporate governance mechanisms). Likewise, the multivariate results reported in Panel D of Table 10 show that financial institutions with stronger corporate governance have a greater insolvency risk. The results from this analysis suggest that endogeneity bias is not likely to drive our main inference, that is, stronger corporate governance mechanisms is associated with greater insolvency risk in the financial industry.

3.5. Additional analysis

In order to check the robustness of our empirical findings, we perform several additional tests. First, we restrict our sample only to deposit-taking financial institutions, that is, financial institutions with a deposit to asset ratio of at least 10%. We then re-estimate all the regression models in Tables 5 and 6. The regression results (not presented here) are similar to our previous results showing that strong corporate governance mechanisms and more shareholder-friendly boards are associated with a higher level of insolvency risk. This suggests that non-depository financial institutions do not drive our main findings.

Second, in order to examine whether our empirical findings are affected by the diversity of financial institutions, we restrict our sample to lending financial institutions and commercial banks, that is, financial institutions with a loans to asset ratio of at least 30%. We re-estimated all the regression models in Tables 5 and 6 with this restricted sample. The regression results (not presented here) are similar to our previous findings in Tables 5 and 6, thus providing support to our main findings that financial institutions with strong corporate governance mechanisms are associated with a higher level of insolvency risk.

Third, we also examine the potential effect of the size of the financial institution on our results. For this purpose, we divided our sample into two subsamples where we either exclude the smallest 10 percent or the largest 10 percent of financial institutions from the main sample. The re-estimated regression results (not presented here) for the subsample without the smallest 10 percent of financial institutions are quite similar to our main results reported in the Tables 5 and 6, that is, stronger and shareholder-friendly governance provisions are detrimental for the survival of the financial institutions. However, the coefficient estimates for governance (not tabulated) for the subsample where we exclude the largest 10 percent of financial institutions mostly become insignificant although positively related to insolvency risk. These findings provide some evidence that, to some extent, larger financial institutions might be driving our results.

Fourth, we excluded the observations from the year 2008 (the year of the global financial crisis) to preclude the concern of extreme observations. We then re-estimated most of the regression models in Tables 5 and 6 based on this sample. We observe, based on empirical results (not presented here), that our findings that stronger corporate governance mechanisms are associated with a higher level of insolvency risk in financial institutions do not change even when we exclude the extreme observations from 2008.

Fifth, since we utilize CDS spread as a measure for insolvency risk, therefore we also include cost of debt among control variables.[28] We re-estimated most of the regression models in Tables 5 and 6 by adding cost of debt among control variables. Our results (not presented here) are qualitatively similar to our main findings that stronger corporate governance mechanisms are associated with a higher level of insolvency risk in financial institutions. However, the regression coefficients for CGQ become insignificant when we include firm fixed effects. Consistent with previous literature (Borisova et al., 2015), we find that higher cost of debt is associated with higher level of insolvency risk.

Sixth, following Das et al. (2009), we include volatility of equity returns among control variables and re-estimated most of the regression models in Table 6. Our results (not presented here) are qualitatively similar to our main findings that stronger corporate governance mechanisms are associated with a higher level of insolvency risk in financial institutions. The regression coefficients for CGQ are positive and statistically significant. Furthermore, volatility of equity returns is positively associated with insolvency risk, which is consistent with the findings of Das et al. (2009).

Finally, we excluded troubled financial institutions from our sample, that is, those with a return on assets ratio of less than 2%. We did so to examine the effect of the financial crisis on our findings. We re-estimated the regression based on this sample. The additional analysis (not tabulated) reveals that the exclusion of these extreme observations does not have much impact on our main findings. Overall, the additional analysis provides strong evidence that in financial institutions stronger and more shareholder-friendly governance mechanisms can lead to a higher level of insolvency risk.

4. Conclusions

Given the high-profile failures of financial institutions (e.g., Lehman Brothers) during the global financial crisis, investors and regulators are somewhat skeptical of financial market participants. The financial crisis is arguably related to the unethical behavior of corporate executives and failures of corporate governance to curtail increased risk-taking in financial institutions. Our study, therefore, is important to provide insight on the implications of the corporate governance in

[28] "Debt capital can come from private sources (e.g., banks) or from public sources (the debt markets). In either case, the cost of debt is the applicable interest rate" (Sharfman and Fernando, 2008).

financial institutions which can to take on too much risk owing to the different risk environment with incentives and protections. In particular, our study contributes to the ongoing debate on the risk taking implications of shareholder-friendly corporate governance and provides what is to the best of our knowledge the first comprehensive and robust evidence on the relationship between corporate governance and insolvency risk of financial institutions around the global financial crisis.

Based on the sample of 556 US financial institutions over the period from 2005 to 2010 and using two measures of insolvency risk, namely market-based distance to default and innovative credit default swap spread, our results suggest that more shareholder-friendly corporate governance is related to increased insolvency risk of the financial institutions. This empirical relationship is robust against the inclusion of firm specific characteristics, year and firm fixed effects, alternative sample specifications (e.g., excluding troubled financial institutions) and alleviating endogeneity concerns using lagged variable and propensity score matching approaches. Overall, our findings on the positive association between corporate governance and insolvency risk are consistent with the earlier research, on financial institutions and banks, showing that the shareholder-friendly corporate governance encourages corporate executives to take on more risk, which might ultimately lead to increased insolvency risk.

Since the global financial crisis is particularly associated with more level of risk taking by financial institutions, we further explored the interaction effect of shareholder-friendly corporate governance and the global financial crisis on the insolvency risk. As expected, we find that the positive association between corporate governance and insolvency risk is stronger during the period of the financial crisis. This finding corroborates the existing literature showing that the global financial crisis was, at least to some extent, caused by the increased risk taking by financial institutions. We also explored whether the size encourages financial institutions to take more risk. Specifically, our empirical results reveal that the positive linkage between corporate governance and insolvency risk is stronger for larger financial institutions.

Our findings offer important implications for corporate executives, regulators, investors, and researchers. The results could assist managers of financial institutions to control risk-taking behavior by reforming corporate governance mechanisms. Financial regulators could benefit from this study that it could provide a basis from which to enhance economic growth, reduce bankruptcy levels, and add value to the wealth of stockholders by focusing on corporate governance areas. Regulators should pay close attention because strong corporate governance mechanisms in the financial industry can encourage more risk taking during the period of economic turmoil, which can cause instability in the overall financial system.

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Table 1. Variable Definitions and Sources.

Variable name	Definition	Data source
Insolvency Risk Variables		
Distance to default	Annual average of distance to default based on stock based on stock price variability	Obtained from Risk Management Institute at NUS
Credit Default Swap Spread	credit derivatives that allow the transfer of the firm's default risk between two agents for a predetermined time period	Obtained from Risk Management Institute at NUS
Governance variables		
Corporate governance	Overall corporate governance index	ISS
Board	Corporate governance index based on board characteristics	ISS
Compensation and ownership	Corporate governance index based on compensation and ownership characteristics	ISS
Auditing	Corporate governance index based on auditing characteristics	ISS
Takeover	Corporate governance index based on takeover characteristics	ISS
Control variables		
Size	Logarithm of total assets	BankScope
Return on assets	Ratio of net income to total assets	BankScope
Growth	Percentage change in the amount of outstanding loans	BankScope
Loans to total assets	Ratio of net loans to total assets	BankScope
Non-interest income	Ratio of non-interest income to total income	BankScope

Table 2. Descriptive statistics.

Variable	Mean	St.dev	Min	Max	P25	P75	Observations
Dependent variables:							
DD	1.83	1.66	-2.04	11.78	0.65	2.86	1924
CDS	3.93	1.50	-2.40	7.89	2.98	4.88	1914
Corporate governance variables:							
CGQ	53.09	26.75	0.50	100.00	31.15	75.65	1924
BoardQ	3.01	1.32	0.00	5.00	2.00	4.00	1914
Compensation	3.52	1.33	0.00	5.00	2.00	5.00	1924
Audit	3.20	1.52	0.00	5.00	2.00	5.00	1924
Takeover	2.93	1.26	0.00	5.00	2.00	4.00	1924
Control variables:							
Size	14.50	1.68	11.08	21.54	13.47	15.02	1924
Return on assets	0.29	1.59	-11.48	14.39	0.14	1.03	1914
Loans to assets	67.78	14.77	0.99	93.54	61.55	77.18	1924
Loan growth	7.57	25.45	-84.15	704.49	-2.56	13.20	1924
Deposits to assets	0.78	0.13	0.00	0.98	0.74	0.86	1924
Non-interest income	22.73	36.80	-938.37	271.50	13.50	30.21	1924

This table reports the descriptive statistics for the sample. *DD* is the Distance to Default measures the difference between the asset value of the financial institution and the face value of its debt, scaled by the standard deviation of the financial institution's asset value. *CDS* is the credit default swap spread is the pricing of the financial distress risk (Das et al., 2009). *CDS* are credit derivatives that allow the transfer of the firm's default risk between two agents for a predetermined time period. *CGQ* (Corporate Governance Quotient) measures the strength of the firm's corporate governance mechanisms and *BoardQ* (Board Quotient) measures the strength of the board of directors. Compensation index is based on compensation and ownership characteristics of financial institution. Auditing index is based on auditing characteristics. Takeover index is based on takeover characteristics. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Global Financial Crisis* is the dummy variable for global financial crisis, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year t–1 to year t, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income.

Table 3. Correlations.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) DD	1.00												
(2) CDS	-0.96***	1.00											
(3) CGQ	-0.07***	0.07***	1.00										
(4) BoardQ	-0.05**	0.06***	0.83***	1.00									
(5) Compensation	-0.01	0.02	0.42***	0.27***	1.00								
(6) Audit	-0.01	0.02	0.34***	0.25***	0.06***	1.00							
(7) Takeover	0.10***	-0.09***	0.10***	0.04*	-0.10***	0.01	1.00						
(8) Size	0.14***	-0.11***	-0.02	-0.05**	-0.05**	0.13***	0.15***	1.00					
(9) Return on Assets	0.58***	-0.63***	-0.06**	-0.06***	-0.03	-0.04*	0.08***	0.07***	1.00				
(10) Loans to assets	-0.13***	0.14***	-0.04*	-0.01	0.10***	-0.08***	-0.09***	-0.34***	-0.12***	1.00			
(11) Loan growth	0.15***	-0.16***	-0.04*	-0.03	-0.08***	0.00	0.07***	0.02	0.26***	-0.05**	1.00		
(12) Deposits to assets	-0.07***	0.06**	0.02	0.03	0.07***	-0.12***	-0.07***	-0.27***	-0.19***	0.35***	-0.16***	1.00	
(13) Non-interest income	0.11***	-0.11***	0.00	-0.02	-0.06**	0.03	0.04*	0.20***	0.13***	-0.24***	0.04*	-0.18***	1.00

The table reports the pairwise correlations for the variables used in the empirical analysis. *DD* is the Distance to Default measures the difference between the asset value of the financial institution and the face value of its debt, scaled by the standard deviation of the financial institution's asset value. *CDS* is the credit default swap spread is the pricing of the financial distress risk (Das et al., 2009). *CDS* are credit derivatives that allow the transfer of the firm's default risk between two agents for a predetermined time period. *CGQ* (Corporate Governance Quotient) measures the strength of the firm's corporate governance mechanisms and *BoardQ* (Board Quotient) measures the strength of the board of directors. Compensation index is based on compensation and ownership characteristics of financial institution. Auditing index is based on auditing characteristics. Takeover index is based on takeover characteristics. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Global Financial Crisis* is the dummy variable for global financial crisis, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year t–1 to year t, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 4. Univariate tests.

Variable	Strong Governance Mean	Weak Governance Mean	Diff. in Means	
Dependent variables:				
CDS	3.754	3.374	0.3783	***
DD	2.065	2.524	-0.459	***
Explanatory variables:				
CGQ	86.492	14.428	72.064	***
BoardQ	4.385	1.492	2.893	***
Compensation	4.120	2.519	1.601	***
Audit	3.799	2.419	1.380	***
Takeover	3.275	2.942	0.333	***
Control variables:				
Total assets	14.678	14.649	0.030	
Return on assets	0.157	0.526	-0.370	***
Loans to assets	66.513	67.400	-0.888	
Loan growth	5.065	7.970	-2.905	***
Deposits to assets	0.774	0.772	0.003	
Non-interest income	23.352	22.919	0.433	

This table reports the results of two-tailed t-tests under the null hypothesis that there is no difference in the means between financial institutions with stronger and weaker corporate governance mechanisms. The subsample with stronger governance contains financial institutions with CGQ in the top 30% and the subsample of weaker governance contains financial institutions with CGQ in the bottom 30% of the sample. *CDS* is the credit default swap spread is the pricing of the financial distress risk (Das et al., 2009). *CDS* are credit derivatives that allow the transfer of the firm's default risk between two agents for a predetermined time period. *DD* is the Distance to Default measures the difference between the asset value of the financial institution and the face value of its debt, scaled by the standard deviation of the financial institution's asset value. *CGQ* (Corporate Governance Quotient) measures the strength of the firm's corporate governance mechanisms and *BoardQ* (Board Quotient) measures the strength of the board of directors. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Global Financial Crisis* is the dummy variable for global financial crisis, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year *t*–1 to year *t*, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 5. Corporate governance and distance to default (*DD*).

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)
Corporate Governance variables:										
CGQ	-0.004***	-0.003***	-0.003*	-0.001	0.014					
	(-4.09)	(-3.21)	(-1.65)	(-0.92)	(1.63)					
CGQ × GFC				-0.003*						
				(-1.73)						
CGQ × Size					-0.001**					
					(-2.01)					
BoardQ						-0.090***	-0.060***	-0.019	-0.022	0.469***
						(-4.30)	(-3.01)	(-0.60)	(-0.76)	(2.74)
BoardQ × GFC									-0.070*	
									(-1.74)	
BoardQ × Size										-0.036***
										(-3.11)
Control variables:										
Size	0.149***	0.126***	-0.469**	0.127***	0.187***	0.147***	0.125***	-0.462**	0.128***	0.231***
	(9.35)	(7.51)	(-2.52)	(7.56)	(5.43)	(9.27)	(7.44)	(-2.48)	(7.57)	(6.08)
Return on assets	0.284***	0.442***	0.266***	0.440***	0.442***	0.283***	0.441***	0.268***	0.439***	0.441***
	(25.87)	(23.69)	(12.52)	(23.57)	(23.71)	(25.84)	(23.55)	(12.56)	(23.46)	(23.63)
Loans to assets		-0.008***	0.0215***	-0.008***	-0.008***		-0.008***	0.022***	-0.008***	-0.008***
		(-3.85)	(3.98)	(-3.78)	(-4.03)		(-3.82)	(4.06)	(-3.78)	(-4.13)
Loan growth		-0.002	-0.002	-0.002	-0.002		-0.002	-0.002	-0.002	-0.002
		(-1.40)	(-1.65)	(-1.39)	(-1.43)		(-1.36)	(-1.63)	(-1.33)	(-1.39)
Deposits to assets		1.103***	0.460	1.095***	1.053***		1.097***	0.418	1.085***	1.040***
		(4.81)	(0.76)	(4.78)	(4.57)		(4.78)	(0.69)	(4.73)	(4.53)
Non-interest income		0.0001	0.001	0.000	0.000		0.0001	0.001	0.000	0.000
		(0.48)	(0.71)	(0.50)	(0.38)		(0.44)	(0.77)	(0.49)	(0.32)

Table 5. *Continued.*

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	Yes	No	No	No	No	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	50.3%	53.2%	50.6%	53.2%	53.3%	50.3%	53.2%	50.5%	53.2%	53.4%
Observations	2122	1924	1924	1924	1924	2122	1924	1924	1924	1924

The table reports the estimates of ten alternative versions of the following panel regression specification:

$$DD_{i,t} = \alpha + \beta_1 Governance_{i,t} + \beta_2 Size_{i,t} + \beta_3 Return\ on\ assets_{i,t} + \beta_4 Loans\ to\ assets_{i,t} + \beta_5 Loan\ Growth_{i,t} + \beta_6 Deposits\ to\ assets_{i,t} + \beta_7 Non-interest\ income_{i,t} + \sum_{k-1}^{n-1} \alpha_k\, Year_i^y + \varepsilon_{i,t}$$

where the dependent variable $DD_{i,t}$ is the Distance to Default measures the difference between the asset value of the financial institution and the face value of its debt, scaled by the standard deviation of the financial institution's asset value. $Governance_{i,t}$ is either *CGQ* (Corporate Governance Quotient) which measures the strength of the firm's corporate governance mechanisms or *BoardQ* (Board Quotient) which measures the strength of the board of directors. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Global Financial Crisis* is the dummy variable for global financial crisis, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year *t*–1 to year *t*, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. $Firm_i^k$ is a dummy variable for firm i and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and within-firm clustering. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 6. Corporate governance and credit default swap spread (*CDS*).

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)
Corporate Governance variables:										
CGQ	0.004***	0.003***	0.003*	0.001	-0.013*					
	(3.78)	(3.02)	(1.69)	(0.83)	(-1.70)					
CGQ × GFC				0.003*						
				(1.68)						
CGQ × Size					0.001**					
					(2.06)					
BoardQ						0.077***	0.051***	0.019***	0.014	-0.427***
						(4.05)	(2.79)	(0.65)	(0.51)	(-2.71)
BoardQ × GFC									0.069*	
									(1.89)	
BoardQ × Size										0.033***
										(3.05)
Control variables:										
Size	-0.103***	-0.073***	0.734***	-0.0737***	-0.130***	-0.102***	-0.072***	0.728***	-0.075***	-0.168***
	(-7.14)	(-4.74)	(4.30)	(-4.77)	(-4.11)	(-7.06)	(-4.67)	(4.26)	(-4.81)	(-4.80)
Return on assets	-0.250***	-0.483***	-0.351***	-0.481***	-0.483***	-0.250***	-0.482***	-0.353***	-0.481***	-0.482***
	(-25.09)	(-27.87)	(-17.77)	(-27.74)	(-27.89)	(-25.07)	(-27.74)	(-17.79)	(-27.66)	(-27.82)
Loans to assets		0.009***	-0.011**	0.008***	0.009***		0.008***	-0.011**	0.008***	0.009***
		(4.57)	(-2.11)	(4.51)	(4.75)		(4.54)	(-2.20)	(4.49)	(4.84)
Loan growth		0.001	0.001	0.001	0.001		0.001	0.001	0.001	0.001
		(0.87)	(0.77)	(0.87)	(0.90)		(0.84)	(0.76)	(0.81)	(0.87)
Deposits to assets		-1.172***	-0.245	-1.165***	-1.126***		-1.167***	-0.206	-1.155***	-1.117***
		(-5.55)	(-0.43)	(-5.52)	(-5.31)		(-5.53)	(-0.36)	(-5.47)	(-5.29)
Non-interest income		-0.001	-0.001	-0.001	-0.001		-0.001	-0.001	-0.001	-0.001
		(-0.98)	(-1.15)	(-0.99)	(-0.87)		(-0.93)	(-1.20)	(-0.97)	(-0.81)

Table 6. *Continued.*

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	Yes	No	No	No	No	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	45.2%	51.6%	45.9%	51.6%	51.6%	45.2%	51.5%	45.8%	51.6%	51.7%
Observations	2122	1924	1924	1924	1924	2122	1924	1924	1924	1924

The table reports the estimates of six alternative versions of the following panel regression specification:

$$CDS_{i,t} = \alpha + \beta_1 Governance_{i,t} + \beta_2 Size_{i,t} + \beta_3 Return\ on\ assets_{i,t} + \beta_4 Loans\ to\ assets_{i,t} + \beta_5 Loan\ Growth_{i,t} + \beta_6 Deposits\ to\ assets_{i,t}$$
$$+ \beta_7 Non-interest\ income_{i,t} + \sum_{k-1}^{n-1} \alpha_k\ Year_i^y + \varepsilon_{i,t}$$

where the dependent variable $CDS_{i,t}$ is the credit default swap spread is the pricing of the financial distress risk (Das et al., 2009). *CDS* are credit derivatives that allow the transfer of the firm's default risk between two agents for a predetermined time period. $Governance_{i,t}$ is either *CGQ* (Corporate Governance Quotient) which measures the strength of the firm's corporate governance mechanisms or *BoardQ* (Board Quotient) which measures the strength of the board of directors. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Global Financial Crisis* is the dummy variable for global financial crisis, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year *t*–1 to year *t*, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. $Firm_i^k$ is a dummy variable for firm *i* and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and within-firm clustering. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 7. Economic significance analysis.

Insolvency risk proxies	Change in CGQ index from 25th to 75th percentile (1)	Coefficient on CG index (2)	Variation (3=1*2)	Average insolvency risk (4)	Economic significance (%) (3/4*100)
Model 2: year effect					
DD	43.8	-0.0031	-0.1375	1.89	-7.28
CDS	43.8	0.0027	0.1187	3.89	3.05
Model 3: Year + firm effect					
DD	43.8	-0.0027	-0.1169	1.89	-6.19
CDS	43.8	0.0025	0.1108	3.89	2.85
Model 4: Crisis					
DD	43.8	-0.0034	-0.1476	1.89	-7.81
CDS	43.8	0.0030	0.1318	3.89	3.39
Model 5: Size					
DD	43.8	-0.0012	-0.0504	1.89	-2.67
CDS	43.8	0.0011	0.0473	3.89	1.22

Model 2, 3, 4, and 5 of this table report the analysis of economic significance for the relationship between corporate governance and insolvency risk. Change in CGQ refers to the difference between 25th and 75th percentiles on each independent variable.

Table 8. Corporate governance sub-indices and distance to default (*DD*).

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Corporate Governance variables:						
Board	-0.128***	-0.089***	-0.064***	-0.012	-0.044	0.388**
	(-5.00)	(-3.99)	(-2.98)	(-0.37)	(-1.42)	(2.09)
compensation	-0.038	-0.006	0.001	-0.028	0.087***	-0.198
	(-1.56)	(-0.28)	(0.04)	(-1.00)	(2.92)	(-1.12)
Audit	-0.010	-0.001	0.007	-0.002	-0.016	0.293*
	(-0.46)	(-0.06)	(0.40)	(-0.07)	(-0.61)	(1.76)
Takeover	0.057**	0.031	0.033	-0.031	0.060**	0.255
	(2.26)	(1.42)	(1.54)	(-0.86)	(2.06)	(1.37)
Board × GFC					-0.034	
					(-0.80)	
Compensation × GFC					-0.163***	
					(-3.99)	
Audit × GFC					0.035	
					(0.98)	
Takeover × GFC					-0.061	
					(-1.47)	
Board × Size						-0.031**
						(-2.44)
Compensation × Size						0.014
						(1.16)
Audit × Size						-0.020*
						(-1.73)
Takeover × Size						-0.015
						(-1.21)

Table 8. *Continued.*

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Control variables:						
Size	0.137***	0.144***	0.121***	-0.450**	0.126***	0.288***
	(7.33)	(8.86)	(7.10)	(-2.39)	(7.36)	(4.15)
Return on assets		0.282***	0.440***	0.268***	0.439***	0.440***
		(25.69)	(23.49)	(12.54)	(23.50)	(23.53)
Loans to assets			-0.008***	0.022***	-0.008***	-0.008***
			(-3.75)	(4.05)	(-3.91)	(-4.05)
Loan growth			-0.002	-0.002	-0.002	-0.002
			(-1.41)	(-1.60)	(-1.40)	(-1.40)
Deposits to assets			1.106***	0.431	1.127***	1.066***
			(4.80)	(0.71)	(4.90)	(4.61)
Non-interest income			0.000	0.001	0.000	0.000
			(0.44)	(0.74)	(0.45)	(0.43)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	No	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R2	34.6%	50.3%	53.1%	50.5%	53.6%	53.4%
Observations	2126	2122	1924	1924	1924	1924

The table reports the estimates of ten alternative versions of the following panel regression specification:

$$DD_{i,t} = \alpha + \beta_1 Governance_{i,t} + \beta_2 Size_{i,t} + \beta_3 Return\ on\ assets_{i,t} + \beta_4 Loans\ to\ assets_{i,t} + \beta_5 Loan\ Growth_{i,t}$$
$$+ \beta_6 Deposits\ to\ assets_{i,t} + \beta_7 Non-interest\ income_{i,t} + \sum_{k-1}^{n-1} \alpha_k\ Year_i^y + \varepsilon_{i,t}$$

where the dependent variable $DD_{i,t}$ is the Distance to Default measures the difference between the asset value of the financial institution and the face value of its debt, scaled by the standard deviation of the financial institution's asset value. *Governance* $_{i,t}$ represents one of the four sub-indices e.g. Board, Compensation, Audit and Takeover. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Global Financial Crisis* is the dummy variable for global financial crisis, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year t–1 to year t, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. $Firm_i^k$ is a dummy variable for firm i and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The t-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and within-firm clustering. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 9. Corporate governance sub-indices and credit default swap spread (*CDS*).

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Corporate Governance variables:						
Board	0.108***	0.077***	0.057***	0.015	0.035	-0.375**
	(4.73)	(3.81)	(2.91)	(0.49)	(1.22)	(-2.20)
compensation	0.028	-0.000	-0.0061	0.013	-0.087***	0.138
	(1.26)	(-0.01)	(-0.32)	(0.52)	(-3.20)	(0.85)
Audit	0.011	0.003	-0.013	-0.002	0.018	-0.172
	(0.55)	(0.17)	(-0.77)	(-0.11)	(0.73)	(-1.12)
Takeover	-0.054**	-0.031	-0.019	0.054	-0.041	-0.250
	(-2.35)	(-1.53)	(-1.00)	(1.61)	(-1.55)	(-1.46)
Board × GFC					0.040	
					(1.03)	
Compensation × GFC					0.152***	
					(4.07)	
Audit × GFC					-0.047	
					(-1.45)	
Takeover × GFC					0.049	
					(1.29)	
Board × Size						0.030**
						(2.54)
Compensation × Size						-0.010
						(-0.92)
Audit × Size						0.011
						(1.06)
Takeover × Size						0.016
						(1.37)

Table 9. *Continued.*

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Control variables:						
Size	-0.092***	-0.099***	-0.069***	0.702**	-0.0729***	-0.215***
	(-5.46)	(-6.71)	(-4.39)	(4.08)	(-4.65)	(-3.36)
Return on assets		-0.249***	-0.482***	-0.354***	-0.481***	-0.482***
		(-24.92)	(-27.70)	(-17.81)	(-27.73)	(-27.75)
Loans to assets			0.008***	-0.012***	0.009***	0.009***
			(4.50)	(-2.26)	(4.67)	(4.81)
Loan growth			0.001	0.001	0.001	0.001
			(0.85)	(0.70)	(0.84)	(0.84)
Deposits to assets			-1.182***	-0.201	-1.198***	-1.139***
			(-5.57)	(-0.35)	(-5.66)	(-5.35)
Non-interest income			-0.001	-0.001	-0.001	-0.001
			(-0.93)	(-1.19)	(-0.92)	(-0.90)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	No	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R2	29.1%	45.2%	51.5%	45.8%	52.0%	51.7%
Observations	2126	2122	1924	1924	1924	1924

The table reports the estimates of six alternative versions of the following panel regression specification:

$$CDS_{i,t} = \alpha + \beta_1 Governance_{i,t} + \beta_2 Size_{i,t} + \beta_3 Return\ on\ assets_{i,t} + \beta_4 Loans\ to\ assets_{i,t} + \beta_5 Loan\ Growth_{i,t}$$
$$+ \beta_6 Deposits\ to\ assets_{i,t} + \beta_7 Non-interest\ income_{i,t} + \sum_{k-1}^{n-1} \alpha_k\, Year_i^y + \varepsilon_{i,t}$$

where the dependent variable $CDS_{i,t}$ is the credit default swap spread is the pricing of the financial distress risk (Das et al., 2009). *CDS* are credit derivatives that allow the transfer of the firm's default risk between two agents for a predetermined time period. $Governance_{i,t}$ represents one of the four sub-indices e.g Board, Compensation, Audit and Takeover. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Global Financial Crisis* is the dummy variable for global financial crisis, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year *t*–1 to year *t*, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. $Firm_i^k$ is a dummy variable for firm *i* and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and within-firm clustering. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 10. Propensity score matching estimator.

Panel A: Pre-match propensity score regression and post-match diagnostic regression

	Dependent Variable: Equals 1 if CGQ is greater than median and 0 otherwise	
	Pre-match	Post-match
Size	0.007	0.001
	(0.23)	(0.03)
Return on assets	-0.062**	0.027
	(-1.99)	(0.52)
Loans to assets	-0.009***	-0.001
	(-2.75)	(-0.13)
Loan growth	-0.002	-0.004
	(-1.25)	(-1.11)
Deposits to assets	0.290	0.008
	(0.76)	(0.01)
Non-interest income	0.001	0.001
	(0.94)	(0.30)
Year effect	Yes	Yes
Constant	0.560	0.070
	(0.91)	(0.06)
Observations	2131	2082
Pseudo R2	0.0069	0.0023

Panel B: Differences in firm characteristics

Variable	Treated group	Control group	Difference	*t*-stat
Size	14.455	14.433	0.022	0.30
Return on assets	0.240	0.240	0.000	0.01
Loans to assets	67.204	67.546	-0.342	-0.53
Loan growth	6.351	7.525	-1.174	-1.50
Deposits to assets	0.782	0.784	-0.002	-0.24
Non-interest income	23.885	23.113	0.772	0.59

Panel C: Propensity score matching estimator

Variable	Firm year obs. with high CGQ	Firm year obs. With low CGQ	Difference	T-stat
DTD	1.769	1.942	-0.173*	-1.65
CDS	3.978	3.814	0.164*	1.77

Table 10. Propensity score matching estimator (*continued*).

Panel D: Regression analysis based on treatment and control group	DD - regression	CDS - regression
Index dummy	-0.135***	0.062**
	(-2.72)	(2.45)
Size	0.149***	-0.027***
	(9.17)	(-3.24)
Return on assets	0.442***	-0.323***
	(24.61)	(-34.78)
Loans to assets	-0.005***	0.003***
	(-2.75)	(3.15)
Loan growth	-0.004***	0.001*
	(-2.81)	(1.65)
Deposits to assets	0.857***	-0.594***
	(3.67)	(-5.00)
Non-interest income	0.001	-0.001***
	(1.22)	(-2.94)
Year effect	Yes	Yes
Constant	0.143	4.751***
	(0.41)	(26.65)
Observations	2082	2070
Adjusted R-squared	0.541	0.505
F-Statistics	205.036	176.802

This table reports the results of propensity score matching estimation. Panel A reports the logit regression results. Here the dependent variable is a dummy variable which equals one if CGQ index is greater than the median and zero otherwise. Panel B reports the results of the second diagnostic test in which we examine the difference for each control variable between the treated financial institutions (financial institutions with stronger corporate governance mechanisms) and the matched control financial institutions (financial institutions with CGQ lower than median). Panels C and D report the propensity score matching estimates and the multivariate results using the matched sample. Independent variables are following. *Size* is measured as the logarithm of total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year t–1 to year t, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. Year fixed-effects are included in all regressions. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Appendix A: General procedure to calculate distance to default (DD)

The Merton (1974) model views the firm's equity value as a European call option on the firm's assets, with a strike price equal to the face value of the firm's liabilities. This is because of the shareholders' limited liability and their residual claim on the firm's assets. If the firm's value exceeds the level of liabilities (strike price) at the time of maturity, when the value of the equity is positive, shareholders exercise their option and the firm survives. If the firm's value falls below the level of liabilities (strike price) at the time of maturity, when the value of equity becomes zero, the model assumes shareholders do not exercise their option and the firm defaults. Thus, the larger the positive distance between firm value and firm liabilities, the lower is the probability of financial distress.

Value of firm (V_A) = value of equity (V_e) + Value of debt (X)

Value of equity (V_e) = Value of firm (V_A) – Value of debt (X)

Value of firm (V_A) > Value of debt (X) ➔ Value of equity (V_e) is positive (firm survives)

Value of firm (V_A) < Value of debt (X) ➔ Value of equity (V_e) is zero (firm defaults)

The Merton (1974) model has two important assumptions for the calculation of DD. First, it assumes that the value of the firm follows the geometric Brownian motion that is expressed as follows:

$$d\,V_A = \mu\,V_A\,dt + \sigma_A V_A dW \qquad \text{(A.1)}$$

where V_A denotes the value of firm's assets, μ represents expected continuously compounded returns on the firm's assets, σ_A indicates instantaneous volatility of the firm's assets, and dW is a standard Wiener process.

Second, the model assumes that the firm has only two securities outstanding; namely, common stock and a zero coupon bond maturing at time (T).

Based on these two assumptions, the equity of the firm can be viewed as a call option on the value of the firm's assets, with a strike price equal to face value of the debt maturing at time T. Therefore, the market value of equity as a function of the total value of the firm's assets can be expressed by using Black and Scholes' (1973) formula for call options:

$$V_e = V_A N(d_1) - X\,e^{-rT} N\,(d_2) \qquad \text{(A.2)}$$

where V_e is the market value of the firm's equity, X is the face value of the debt, r is the risk-free rate, T is the time horizon for the maturity of debt, N symbolizes the function of the cumulative standard normal distribution, and d_1 and d_2 are given by the following formulas:

$$d_1 = \frac{ln\left(\frac{V_A}{X}\right)+\left(r+\frac{1}{2}\sigma_A^2\right)T}{\sigma_A\sqrt{T}}, \quad d_2 = d_1 - \sigma_A\sqrt{T} \qquad \text{(A.3)}$$

In Eq. (A.2), V_e, X, r, and T are readily observable and known factors, whereas V_A and σ_A are difficult to observe and are unknown factors. This means there are two unknowns in one equation, so a unique solution to Eq. (A.2) is not available. Thus, another equation involving one of the two unknown factors is required.

As in the Merton (1974) model, it is assumed that the value of the firm's equity is a function of the value of its assets and time, so the second equation that relates the volatility of the firm's equity to the volatility of the firm's assets can be written as:

$$\sigma_e = \left(\frac{V_A}{V_e}\right)\frac{\partial V_e}{\partial V_A}\sigma_A \quad \text{(A.4)}$$

According to the Black-Scholes-Merton model, the term $\frac{\partial V_e}{\partial V_A}$ in Eq. (4) is equal to $N(d_1)$, and can be rewritten as follows:

$$\sigma_e = \left(\frac{V_A}{V_e}\right) N(d_1)\sigma_A \quad \text{(A.5)}$$

Now, Eq. (A.2) and (A.5) can be solved simultaneously for the values of V_A and σ_A, and DD can be calculated by using the following equation:

$$DD = \frac{ln\left(\frac{V_A}{X}\right)+\left(\mu-\frac{1}{2}\sigma_A^2\right)T}{\sigma_A\sqrt{T}} \quad \text{(A.6)}$$

The probability of default (PD) is calculated as follows:

$$PD = N(-DD) \quad \text{(A.7)}$$

In a nutshell, for the calculation of DD, the following steps are required:

1) Estimating the volatility of the firm's equity (σ_e) through historical stock price data or option-implied volatility data. Historical stock price data to estimate the volatility of the firm's equity is easily available. Following the Hull (2009) methodology, equity volatility can be calculated as:
   $$R_i = \text{Ln}(pr_t - pr_{t-1}) \quad \text{(A.8)}$$
   where R_i is the daily stock returns, Ln is the natural logarithm, pr_t is the stock price at the end of the day and pr_{t-1} is the stock price at the end of the previous day: i =1, 2, 3...n.
   Annualized volatility is then estimated as:
   $$\sigma_e = \frac{1}{\sqrt{\frac{1}{n}}}\sqrt{\frac{1}{n-1\sum_{i=1}^{n}R_i^2} - \frac{1}{n(n-1)}\left(\sum_{i=1}^{n}R_i\right)^2} \quad \text{(A.9)}$$
   where n denotes the number of observations in one year i.e., number of trading days.
2) Selecting the forecasting horizon (T). Generally, the forecast horizon is one year (T=1).
3) Measuring the face value of the debt (X). Generally, current liabilities plus half of the non-current liabilities are used to proxy the face value of debt, as also advised by Moody's KMV.

4) Collecting the risk-free rate (r). 3-month bank accepted bill or T-bills can be used to proxy risk-free rate.
5) Measuring the market value of equity (V_e). It is calculated as the number of outstanding shares multiplied by market price per share.

Solving Eq. (A.2) and (A.5) simultaneously for the values of (V_A) and(σ_e), and then calculate the DD using Eq. (A.6) and PD using Eq. (A.7).

Managerial Risk-Taking Incentives and the Systemic Risk of Financial Institutions☆

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Abstract

This paper examines whether the systemic risk of financial institutions is associated with the risk-taking incentives generated by executive compensation. We measure managerial risk-taking incentives with the sensitivities of chief executive officer (CEO) and chief financial officer (CFO) compensation to changes in stock prices and stock return volatility. Using data on large U.S. financial institutions, we document a negative association between systemic risk and the sensitivities of CEO and CFO compensation to stock return volatility. However, our results also demonstrate that financial institutions with greater managerial risk-taking incentives were associated with significantly higher levels of systemic risk during the financial crisis in 2008.

JEL classification: G01, G20, G21, G30, G32, G34

Keywords: executive compensation; risk-taking incentives; delta; vega; systemic risk; bank risk-taking; financial crisis

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☆ We would like to thank Miguel García-Cestona, Denis Davydov, Iftekhar Hasan, Jana Ohls, Laura Rondi, Jukka Sihvonen, and conference and seminar participants at the 30th Australasian Finance and Banking Conference, the 19th Corporate Governance and Investment Workshop, the Hanken School of Economics Workshop on Corporate Governance, the University of Vaasa Banking Research Workshop, and the University of Vaasa for helpful comments and suggestions. J. Iqbal gratefully acknowledges the support of the Marcus Wallenberg Foundation and the Finnish Cultural Foundation. S. Vähämaa gratefully acknowledges the support of the OP Group Research Foundation and the Finnish Savings Banks Research Foundation.

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1. Introduction

"Compensation practices at some banking organizations have led to misaligned incentives and excessive risk-taking, contributing to bank losses and financial instability."

Chairman Ben S. Bernanke (Board of Governors of the Federal Reserve System, 2009a)

This paper examines whether the systemic risk of financial institutions is associated with the compensation-based risk-taking incentives of the top executives. In the aftermath of the global financial crisis of 2008-2009, policy makers, regulators, and bank supervision authorities have alleged that the risk-taking incentives generated by executive compensation policies at banking organizations were among the key factors contributing to the development of the crisis (see e.g., Kirkpatrick, 2009; Basel Committee on Banking Supervision, 2010; Board of Governors of the Federal Reserve System, 2009b, 2010; Mehran, Morrison and Shapiro, 2011). Furthermore, the financial crisis revealed the distinct adverse consequences of bank risk-taking and systemic risk on global financial stability, economic growth, and societal well-being. Given that the compensation policies of top executives are generally designed to mitigate agency problems and to maximize shareholder value, the incentives generated by executive compensation may encourage excessive risk-taking in the financial industry (e.g., e.g., Palia and Porter, 2004; Chen, Steiner and Whyte, 2006; Bebchuk, Cohen and Spamann, 2010; Bebchuk and Spamann, 2010; Bai and Elyasiani, 2013).

Do compensation-based risk-taking incentives of the top executives increase the riskiness of financial institutions and the level of systemic risk? In this paper, we aim to address this question by empirically examining the linkage between systemic risk and the sensitivities of chief executive officer (CEO) and chief financial officer (CFO) compensation to changes in stock prices and stock return volatility.[1] Using data on large, publicly traded U.S. financial institutions, we find ambiguous evidence on the association between managerial risk-taking incentives and the systemic risk of financial institutions. Our results indicate that the sensitivities of top executive compensation to volatility are negatively related to systemic risk. However, our empirical findings also demonstrate that financial institutions with greater managerial risk-taking incentives were associated with

[1] Following Chava and Purnanadam (2010), we examine the effects of risk-taking incentives of both CEOs and CFOs. Chava and Purnanadam (2010) document that CFO incentives may have a stronger role than those of the CEO's on corporate financial policies.

significantly higher levels of systemic risk in 2008, during the peak of the global financial crisis.

Our analysis is closely related to prior literature addressing the effects of managerial compensation structures on bank performance and risk-taking. [2] Previous studies have examined how different elements of top executive compensation and the incentives generated by managerial compensation structures are reflected in the riskiness of financial institutions. Using data on U.S. commercial banks, Chen et al. (2006) document that option-based compensation and the option-based wealth of bank CEOs induce greater risk-taking. DeYoung, Peng and Yan (2013) document that the compensation structures of CEOs are important determinants of bank business policies and risk-taking. Their findings also suggest that banks with higher CEO compensation sensitivities to volatility are associated with higher levels of systematic and idiosyncratic risk and are more involved with non-traditional banking activities. Guo, Jalal and Khaksari (2015) examine the relationship between CEO compensation structure and bank risk-taking, and find that a higher proportion of incentive compensation increases default risk and stock return volatility. Perhaps the study most related to our analysis is that of Bai and Elyasiani (2013), which examines the linkage between bank stability and CEO's compensation-based risk-taking incentives. They find that higher sensitivity of CEO compensation to stock return volatility induces risk-taking and leads to greater bank instability.

The linkages between executive compensation structures and bank performance and riskiness during the global financial crisis have been previously examined in Bebchuk et al. (2010), Fortin, Goldberg and Roth (2010), Fahlebrach and Stulz (2011), and Bhagat and Bolton (2014). These studies provide somewhat mixed evidence about the effects of managerial compensation incentives on bank outcomes amidst the recent crisis. Bebchuk et al. (2010) investigate the compensation structures of the top executives in Bear Stearns and Lehman Brothers, and conclude that the compensation arrangements in those banks may have provided more risk-taking incentives for the top executives. Fortin, Goldberg and Roth (2010) examine the determinants of bank risk-taking at the onset of the global financial crisis. Their empirical findings indicate that banks with higher CEO option-based compensation and bonuses were associated with greater risk-taking. Fahlebrach and Stulz (2011) investigate the influence of CEO compensation on the stock returns and profitability of U.S. banks during the financial crisis. In contrast to the view that managerial compensation incentives encouraged higher

[2] Mehran, Morrison and Shapiro (2011) and de Haan and Vlahu (2016) provide comprehensive reviews of the link between executive compensation of risk-taking in the financial industry.

risk-taking, Fahlebrach and Stulz (2011) document that option-based compensation incentives and cash bonuses were unrelated to bank performance during the crisis. Finally, using data on 14 of the largest U.S. financial institutions, Bhagat and Bolton (2014) find evidence that the incentives generated by executive compensation led to more bank risk-taking and contributed to the outbreak of the financial crisis.

Our study builds upon the prior literature by empirically examining whether the systemic risk of financial institutions is associated with the compensation-based risk-taking incentives of their top executives. The Financial Stability Board (2009) defines systemic risk as "a risk of disruption to financial services that is (i) caused by an impairment of all or parts of the financial system and (ii) has the potential to have serious negative consequences for the real economy". In this regard, Acharya, Pedersen, Philippon and Richardson (2017) show that undercapitalization of the financial sector is damaging to the real economy because financial institutions are highly interconnected. They define the systemic risk of an individual financial institution as "its propensity to be undercapitalized when the system as a whole is undercapitalized" and propose a market-based measure for estimating the systemic risk of individual financial institutions.[3] As argued by Engle, Jondeau and Rockinger (2015), the undercapitalization of individual financial institutions during a crisis period is the externality that generates systemic risk. Thus, individual financial institutions and their interdependencies contribute to the overall riskiness of the financial system (Anginer, Demirguc-Kunt and Zhu, 2014; Acharya et al., 2017).

Based on the findings documented in the prior literature, we presume in this paper that managerial risk-taking incentives may influence the level of systemic risk. The risk-taking incentives generated by executive compensation are generally designed to maximize shareholder value by decreasing managerial risk aversion so that managers undertake riskier but value enhancing and growth oriented investments (John, Litov and Yeung, 2008). As noted by Fahlebrach and Stulz (2011) among others, greater alignment of incentives between executives and shareholders in the financial industry may create a conflict between shareholder orientation and financial stability. Opportunistic managers may take more risks to pursue performance-based compensation benefits and this increased risk-taking may increase the downside risk of their institutions, especially during the periods of financial turmoil (e.g., Ang, Chen and Xing, 2006; Bai and Elyasiani, 2013; Ellul

[3] All types of financial intermediaries can be considered systemically important (Financial Stability Board, 2009). Acharya (2011) notes that "for the purposes of systemic regulation, one should think of a 'financial firm' as not just the commercial bank taking deposits and making loans, but also include investment banks, money-market funds, insurance firms, and potentially even hedge funds and private equity funds".

and Yerramilli, 2013; Poletti-Hughes and Ozkan, 2014).[4] Because financial institutions are highly interconnected and are prone to contagion (Allen and Carletti, 2013), the downside risk of a single financial institution can contribute to the overall riskiness of the financial system (Anginer, et al., 2014). We therefore hypothesize that managerial risk-taking incentives are positively associated with systemic risk.

Over the past few years, a growing body of literature has examined how certain firm-specific attributes are related to the systemic risk of financial institutions. Studies by Brunnermeier, Dong and Palia (2012), Pais and Stork (2013), Mayordomo, Rodriguez-Moreno and Peña (2014), Calluzzo and Dong (2015), and Acharya and Thakor (2016), among others, have documented that the size of the institution, the amount of equity capital, and the extent of lending activities are important factors for explaining the cross-sectional variation in systemic risk. These studies indicate larger institutions with lower capital ratios and greater involvement in nontraditional banking activities are associated with higher levels of systemic risk. Closely related to our analysis, Iqbal, Strobl and Vähämaa (2015) and Battaglia and Gallo (2017) examine the relationship between shareholder-focused corporate governance structures and systemic risk. Their empirical findings suggest that financial institutions with more shareholder-oriented corporate governance mechanisms and boards of directors have greater systemic risk. In this paper, we aim to extend the prior systemic risk literature by examining the linkage between systemic risk and the compensation-based risk-taking incentives of the top executives.

In our empirical analysis, we use data on 71 large U.S. financial institutions over the period 2005-2010. Following the prior literature (e.g., Chava and Purnandam, 2010; Fahlebrach and Stulz, 2011; Bai and Elyasiani, 2013; DeYoung et al., 2013), we measure the risk-taking incentives of the CEOs and CFOs with the sensitivities of their personal compensation to changes in the stock price and stock return volatility of their institutions. These two compensation sensitivities are commonly known as delta and vega. Delta is a relatively direct proxy for pay-performance sensitivity and it provides a broad measure for how well top executive incentives are aligned with shareholder interests (e.g., Fahlenbrach and Stulz 2011). As noted for example by Bai and Elyasiani (2013), vega provides an explicit measure of the risk-sensitivity of executive compensation. We measure the systemic risk of individual financial institutions with the market-based approach proposed by

[4] Although systemic risk (the danger of a breakdown of the financial system) and systematic risk (the exposure of individual firms to common risk factors) are conceptually different risk measures, a greater amount of the systematic risk can increase systemic risk (Löffler and Raupach, 2018).

Acharya, Engle and Richardson (2012), Acharya et al. (2017), and Brownlees and Engle (2017).[5] Specifically, we use the marginal expected shortfall (*MES*) and systemic risk (*SRISK*) to gauge systemic risk. *MES* measures the decline of a financial institution's equity capital when the market drops more than two percent and *SRISK* is the expected capital shortage of an institution during a financial crisis. Essentially, *MES* and *SRISK* aim to measure how exposed a given financial institution is to aggregate tail shocks in the financial system.[6]

The empirical findings reported in this paper indicate that the relationship between managerial risk-taking incentives and systemic risk is ambiguous. The results show that the sensitivities of top executive compensation to volatility (i.e., the CEO and CFO vegas), are generally negatively associated with systemic risk, while there is essentially no relationship between pay-performance sensitivity (i.e., the delta) and systemic risk. Our regressions indicate that one standard deviation increases in CEO and CFO vegas are associated with approximately six percent reductions in *SRISK*. These findings are in stark contrast with the hypothesis that greater managerial risk-taking incentives would increase the level of systemic risk.

On the other hand, our empirical results indicate that financial institutions with greater managerial risk-taking incentives were associated with significantly higher levels of systemic risk in 2008, during the peak of the global financial crisis. The positive association between the pre-crisis deltas and vegas of the top executives and systemic risk during the crisis is economically significant; our estimates indicate that a one standard deviation increase in deltas and vegas increases *MES* by about 25-40 basis points during the crisis. The documented positive association between CEO and CFO risk-taking incentives and systemic risk during the severe market turmoil in 2008 may indicate that financial institutions with greater compensation-based managerial risk-taking incentives were taking more risk before the crisis in order to maximize shareholder wealth, and that these risks were then materialized and exposed during the financial crisis (e.g., Erkens, Hung and Matos, 2012). This interpretation of our results is broadly consistent with the previous studies which suggest that banks with more shareholder-focused corporate governance structures were taking more risk before the crisis (e.g., Fortin et al., 2010; Erkens et al., 2012; Peni and Vähämaa, 2012).

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[5] Several alternative approaches for measuring systemic risk have been proposed in the literature in the aftermath of the global financial crisis. Different approaches are discussed and compared, for instance, in Bisias, Flood, Lo, and Valavanis (2012), Hattori, Kikuchi, Niwa and Uchida (2014), and Kleinow, Moreira, Strobl and Vahamaa (2017).

[6] *MES* and *SRISK* are market-based measures of capital shortage during severe market turmoil. A firm is considered to be as systemically risky if it is likely to face a capital shortage during the periods of financial turmoil (Acharya et al., 2017). This capital shortage can be damaging to the real economy because the failure of a systemically risky firm will have effects throughout the financial industry (Acharya et al., 2017).

The remainder of the paper proceeds as follows. Section 2 describes the data and introduces the variables used in our empirical analysis. Section 3 presents the methods and reports our empirical findings on the association between managerial risk-taking incentives and the systemic risk of financial institutions. The final section summarizes the findings and concludes the paper.

2. Data and variables

We use data on 71 large, publicly traded U.S. financial institutions spanning the period 2005-2010. The data on CEO and CFO compensation, systemic risk, and financial statement and balance sheet variables of the financial institutions are obtained from S&P Capital IQ's ExecuComp, the V-Lab of the Stern School of Business of New York University, and the Bureau van Dijk Bankscope, respectively. Our initial sample consists of the 98 financial institutions examined in Fahlenbrach and Stulz (2011) and we eliminate from this initial sample the institutions with missing or insufficient executive compensation and systemic risk data on Execucomp and/or V-Lab. This leaves us with a sample of 71 individual financial institutions and an unbalanced panel of 332 firm-year observations.[7] The sample includes commercial banks, investment banks, non-bank lending institutions, and financial services firms. The list of financial institutions included in the sample is presented in Appendix 1.

2.1. Systemic risk

Our dependent variable is the systemic risk of individual financial institutions. Systemic risk of a financial institution can be broadly defined as a measure of how much an individual institution contributes to the tail of the system's loss distribution (see e.g., Acharya et al., 2012; Anginer et al., 2014; Acharya et al., 2017). The global financial crisis prompted considerable interest in the measurement of systemic risk and several alternative risk metrics have been proposed in the literature in recent years (for surveys, see e.g. Bisias et al., 2012 and Hattori et al., 2014). These alternative approaches to measuring systemic risk can be classified into accounting-based and market-based risk measures. The accounting-based systemic risk measures are estimated from balance sheet variables and are by construction backward-looking, while the market-based measures utilize financial market data and can thereby provide a timelier estimate of systemic risk.

[7] Several recent studies have used relatively small samples of financial institutions (see e.g., Chen et al., 2006; Fortin et al., 2010; Fahlenbrach and Stultz, 2011; Adams and Mehran, 2012; Peni and Vähämaa, 2012; Peni, Smith and Vähämaa, 2013; Mayordomo et al., 2014; Iqbal et al., 2015).

In our empirical analysis, we apply the market-based approach developed by Acharya et al. (2012), Acharya et al. (2017), and Brownlees and Engle (2017) to gauge systemic risk. Specifically, we utilize the marginal expected shortfall (*MES*) and systemic risk (*SRISK*) obtained from the NYU Stern's V-Lab to measure the systemic risk of individual financial institutions. These two systemic risk metrics are estimated from stock market data and attempt to capture the capital shortfall of an institution during periods of market stress based on its stock return volatility and correlation with the market. Essentially, *MES* and *SRISK* measure how exposed a given financial institution is to aggregate tail shocks in the stock markets. We use the year-end (December) estimates of *MES* and *SRISK* as the dependent variable in our analysis.

SRISK can be defined as the amount of "capital that a firm is expected to need if we have another financial crisis" (Acharya et al., 2012). Formally, *SRISK* for a financial institution *i* at time *t* can be expressed as:

$$SRISK_{i,t} = E_{i,t}\left(Capital\ Shortfall_i \middle| Crisis\right) \tag{1}$$

Capital Shortfall in Equation (1) is determined under the assumption that the book value of debt of a financial institution would remain relatively unchanged if a crisis occurred within the next six months whereas the value of equity would decline. The computation of *SRISK* is based on *MES* which measures the expected loss of equity capital during periods of market stress. *MES* can be broadly interpreted as the marginal contribution of an individual financial institution to the overall systemic risk, with higher *MES* reflecting a greater contribution of the institution to the aggregate level of systemic risk. If a financial institution has high levels of *MES*, most of the institution's equity capital will be depleted during a financial crisis, and hence, the institution will be in danger of failure. This also implies that undercapitalization of financial institutions contributes positively to the overall systemic risk in the financial system (Engle et al. 2015; Acharya et al., 2017; Brownlees and Engle, 2017).

Acharya et al. (2012) define *MES* as the expected daily percentage decrease in the value of equity of an individual financial institution when the aggregate stock market declines by more than two percent. By extrapolating *MES* to a longer and more severe period of market stress, Acharya et al. (2012) obtain the long run marginal expected shortfall (*LRMES*) which can be approximated as:

$$LRMES_{i,t} = 1 - \exp\left(-18 \times MES_{i,t}\right) \tag{2}$$

Based on *LRMES*, Acharya et al. (2012) estimate *SRISK* of financial institution *i* at time *t* as follows:

$$SRISK_{i,t} = E_{i,t}\left[k\left(Debt_{i,t} + Equity_{i,t}\right) - Equity_{i,t} \middle| Crisis\right] \quad (3)$$

$$SRISK_{i,t} = k\left(Debt_{i,t}\right) - \left(1-k\right)\left(1 - LRMES_{i,t}\right)Equity_{i,t} \quad (4)$$

where *k* denotes the prudential capital ratio which is taken to be eight percent, *LRMES* is the long run marginal expected shortfall, *Equity* is the market value of equity, and *Debt* is the market value of debt. Hence, *SRISK* is the amount of equity capital needed by a financial institution in a severe crisis in which the current equity value falls according to the *LRMES* and the level of debt stays constant.

MES and *SRISK* are estimated from historical stock price data. First, *MES*, or the expected daily decrease in equity value of a financial institution when the aggregate stock markets declines by more than two percent is calculated based on the institution's stock return volatility, correlation with the aggregate market, and extreme stock price movements. Then, these *MES* estimates are extrapolated to a financial crisis. Based on these extrapolated decreases in equity value, and under the assumption that a financial institution needs at least eight percent of equity capital relative to the value of assets, *SRISK* is computed as the expected amount of equity capital that the institution would need to raise during a severe financial crisis. A more detailed description of the estimation of *MES* and *SRISK* can be found in Acharya et al. (2012), Acharya et al. (2017), and Brownlees and Engle (2017).

2.2. CEO and CFO risk-taking incentives

The main independent variables in our empirical analysis are measures of risk-taking incentives generated by executive compensation. Following the prior literature on compensation-based incentives (see e.g., Chava and Purnandam, 2010; Fahlenbrach and Stulz, 2011; Kini and Williams, 2012), we measure the risk-taking incentives of the CEOs and CFOs with the sensitivities of their personal compensation to changes in the stock price and stock return volatility of their institutions. More specifically, we utilize the delta and vega of the stock option holdings of individual executives as proxies for the compensation-based risk-taking incentives of the top executives.

CEO delta and *CFO delta* measure the dollar gain or loss in personal executive wealth for a one percent change in the stock price of the financial institution. [8] Consequently, delta is a relatively direct proxy for pay-performance sensitivity and it provides a broad measure of how well managerial incentives are aligned with shareholder interests (e.g., Fahlenbrach and Stulz 2011). The delta also provides an indirect measure of managerial risk-taking incentives because in order to increase shareholder wealth and their own compensation, the top executives are incentivized to take risks that ultimately increase the overall risk exposure of the firm (Chava and Purnanadam, 2010; Kini and Williams, 2012). *CEO vega* and *CFO vega* measure the dollar gain or loss in personal executive wealth for a one percentage point change in the stock return volatility of the financial institution. As discussed by Bai and Elyasiani (2013), vega is an explicit measure of risk-sensitivity of executive compensation, and thereby it provides a direct proxy for the compensation-based risk-taking incentives of the top executives.

We follow the approach of Core and Guay (2002) and Fahlenbrach and Stulz (2011) to calculate the deltas and vegas for the top executives in each financial institution. Specifically, we collect data on the components of CEO and CFO compensation from ExecuComp.[9] The deltas and vegas are calculated based on the Black-Scholes option valuation model using detailed information on fiscal year-end outstanding option grants awarded to the CEOs and CFOs.[10] For each option grant, we obtain the strike prices and expiration dates from ExecuComp. We use the fiscal year-end stock price and stock return volatility over the previous three years as the Black-Scholes inputs for stock price and volatility, and the 10-year Treasury rate is used as a proxy for the risk-free interest rate. With these inputs, the deltas and vegas can be computed as the first partial derivatives of the Black-Scholes model with respect to stock price and volatility, respectively. By aggregating the deltas and vegas on each option grant for each executive, we are able to measure the changes in personal executive wealth associated with changes in stock price and stock return volatility.

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[8] Following Chava and Purnanandam (2010) and Fahlenbrach and Stulz (2011), we use dollar gain or loss to compute deltas and vegas.

[9] We identify CEO and CFO of each financial institution from the "CEOANN" and "CFOANN" variables, respectively. Because of missing information for CFOs in ExecuComp database, the number of observations is lower for CFO delta and vega. To ensure that we have the correct CEOs and especially CFOs, we manually match the names of the CEOs and CFOs from the proxy statements of the financial institutions.

[10] In 2004, the Financial Accounting Standards Board (FASB) issued FAS 123R and the Securities and Exchange Commission (SEC) adopted new disclosure requirements for executive compensation that require firms to report detailed information on the compensation of at least five highest-paid executives. Given these disclosure requirements, firms have to report outstanding equity awards at fiscal year-end by providing detailed information about outstanding option grants, including the exercise prices and expiration dates of the options.

2.3. Control variables

We employ a number of control variables in our empirical analysis to account for the potentially confounding effects of institution-specific factors on the level of systemic risk. Previous studies have documented that the riskiness of financial institutions is related to variables such as size, capital ratio, profitability, growth, and asset and income structure (see e.g., Pathan, 2009; Fortin et al., 2010; Brunnermeier et al., 2012; Bai and Elyasiani, 2013; Iqbal et al, 2015; Berger, Roman and Sedunov, 2016).

Firm size is often considered the most important control variable when comparing financial institutions because different sized organizations may have very different characteristics, business strategies, governance mechanisms, and product compositions (Peni et al., 2013, Palvia et al., 2015). Moreover, larger institutions are likely to have greater systemic importance. Following the prior banking literature (e.g., Laeven and Levine, 2009; Beltratti and Stulz, 2012; DeYoung et al., 2013; Ellul and Yerramilli, 2013), we measure the size of the financial institutions (*Size*) by the natural logarithm of total assets. With respect to systemic risk, Brunnermeier et al. (2012), Pais and Stork (2013), and Iqbal et al. (2015) document that larger financial institutions are associated with higher levels of systemic risk, while Mayordomo et al. (2014) do not find any significant relation between systemic risk and bank size.

The second important variable that needs to be controlled for when comparing financial institutions is the amount of equity capital. The capital ratio is the main variable of interest for banking supervisors and regulators. The amount of equity capital is the predominant factor in reducing insolvency risk and capital ratio can be considered as a proxy for the soundness and financial health of the institution. We measure *Capital ratio* as the ratio of equity capital to total assets. Brownlees and Engle (2017) posit that the degree of undercapitalization of financial institutions can impose significant negative externalities on the real economy and reflects the level of systemic risk when the entire financial system is undercapitalized. Moreover, Acharya and Thakor (2016), Brunnermeier et al. (2012), and Mayordomo et al. (2014) have documented that capital ratio is an important factor for explaining the systemic risk of individual financial institutions.[11]

[11] The systemic risk of an individual financial institution is the contribution of an individual financial institution to the downside risk of the whole financial system (Anginer et al. 2014). Acharya et al. (2017) define systemic risk of an individual financial institution as “its propensity to be undercapitalized when the system as a whole is undercapitalized”.

Furthermore, following the prior bank risk-taking literature, we control for the financial performance, growth, and asset and income structure of the financial institutions. We measure profitability of the institutions with *Return on assets* which is computed as the ratio of net income to total assets. Profitability can be seen as a crude proxy of management quality and more profitable institutions may be in better positions to build capital buffers and to reduce systemic risk. Previous studies have documented a negative association between profitability and systemic risk (Iqbal et al., 2015; Berger et al., 2016). We use the annual percentage change in the amount of outstanding loans as a proxy for the growth of the institutions (*Growth*). The growth rate is an important determinant of the riskiness of financial institutions (Foos, Norden, and Weber, 2010). We utilize the ratio of net loans to total assets (*Loans to assets*) and total deposits divided by total assets (*Deposits to assets*) to control for the asset and liability structures of the financial institutions. These variables reflect the lending and funding risks of the institutions. Finally, we use the ratio of non-interest income to total income (*Non-interest income*) to control for the level of income diversification and the differences in business models across institutions. The balance sheet and income statement data for our control variables are collected from the Bureau van Dijk Bankscope.

3. Empirical analysis

3.1. Descriptive statistics and correlations

Table 1 reports the descriptive statistics for the variables used in our empirical analysis. The table illustrates that the financial institutions in our sample are very heterogeneous in terms of the compensation-based risk-taking incentives of their top executives. *CEO delta* takes values from a minimum of about USD 700 to a maximum of USD 53.1 million, while CFO delta takes varies between USD 50 and USD 38.2 million. The mean *CEO delta* of USD 1.6 million is about four times larger than the mean *CFO delta* of USD 400,000, as is the mean *CEO vega* of USD 320,000 compared to the mean *CFO vega* of USD 81,000. The mean and median values of the CEO deltas and CEO vegas over the sample period are plotted in Figure 1. Regarding the systemic risk measures, Table 1 shows that our sample contains financial institutions associated with very different levels of systemic risk. *MES* varies from a minimum of 0.8 percent to a maximum of 8.7 percent with a mean of 2.1 percent, while *SRISK* ranges from –67.7 billion to 136.5 billion with a mean value of 4.1 billion USD.

(insert Table 1 about here)

The descriptive statistics for the control variables in Table 1 demonstrate that our sample comprises very divergent types of financial institutions. Although all firms in our sample are large, publicly traded financial institutions, the amount of total assets (*Size*) varies substantially from about USD 540 million to USD 3.2 trillion. The inclusion of commercial banks as well as other types of financial institutions (investment banks, non-bank lending institutions, and financial services firms) in our sample is manifested in the considerable variation of the asset and income structure variables (*Loans to assets*, *Deposits to assets*, and *Non-interest income*). Overall, it can be concluded from the descriptive statistics that our empirical analysis is based on a heterogeneous sample of financial institutions.

(insert Figure 1 about here)

Pairwise correlations between the two systemic risk measures, managerial risk-taking incentives, and the control variables are presented in Table 2. The strong positive correlations between the systemic risk measures and the deltas and vegas of the top executives suggest that financial institutions with greater managerial risk-taking incentives are generally associated with higher levels of systemic risk. Thus, the correlations provide support for the view that compensation-based risk-taking incentives of the top executives encourage risk-taking in the financial industry. The correlations in Table 2 also demonstrate that *MES* and *SRISK* are strongly positively correlated with each other (0.74), and furthermore, that the risk-taking incentives of the CEOs and CFOs are strongly positively correlated.[12] Given the high correlations between *CEO delta* and *CFO delta* (0.93) and *CEO vega* and *CFO vega* (0.99), we estimate separate regression models for CEO and CFO risk-taking incentives.

(insert Table 2 about here)

With respect to the control variables, it can be noted from Table 2 that the risk-taking incentives of the CEOs and CFOs as well as the two systemic risk measures are positively correlated with the *Size*. Hence, these correlations indicate that larger financial institutions are associated with higher levels of systemic risk and that the top executives of larger institutions have stronger personal incentives to increase firm-level risk-taking. Our systemic risk measures *MES* and *SRISK* also appear to be strongly negatively correlated with *Loans to assets* and positively correlated with *Non-interest income*, suggesting that financial institutions that are more involved with traditional banking activities are associated with lower systemic risk. Finally, it is worth noting from Table 2 that several of our control variables are relatively highly correlated with each other.[13] The strongest

[12] We conduct additional tests to ensure that our findings are not affected by the strong correlations between the deltas and vegas.

[13] Given these correlations, we perform several robustness checks to ascertain that our results are not affected by multicollinearity.

correlations observed among the control variables are those between *Capital ratio* and *Return on assets* (0.55) and *Loans to assets and Non-interest income* (-0.65).

3.2. Univariate tests

We first examine the relationship between managerial risk-incentives and systemic risk in a univariate setting. For this purpose, we divide the financial institutions into two subsamples based on the level of systemic risk. The first subsample consists of firm-year observations with *MES* in the top quartile (high systemic risk) and the second subsample comprises firm-year observations with *MES* in the bottom quartile (low systemic risk). Table 3 reports the results of two-tailed *t*-tests with the null hypothesis that there are no differences in the means of the top executive deltas and vegas and the control variables between the high and low systemic risk subsamples.[14] Interestingly, the *t*-tests indicate that there are no statistically significant differences in the CEO and CFO risk-taking incentives between the financial institutions associated with high and low systemic risk. Thus, in contrast to our expectations, the univariate tests do not provide support for the view that greater managerial risk-taking incentives would contribute positively to the level of systemic risk.

(insert Table 3 about here)

Regarding the control variables, it can be noted from Table 3 that the high systemic risk institutions are very different from the low systemic risk institutions. Specifically, the univariate tests show that financial institutions associated with higher systemic risk are significantly larger and have higher capital ratios. Moreover, the statistically significant differences between the two subsamples in terms of *Loans to assets*, *Deposits to assets*, and *Non-interest income* suggest that the high systemic risk institutions are more involved in non-traditional banking activities.

3.3. Regression results

We examine the association between managerial risk-taking incentives and systemic by estimating alternative versions of the following panel regressions specification:

[14] We also perform the Wilcoxon/Mann-Whitney median tests to examine differences between the high and low systemic risk subsamples. The results are consistent with the *t*-tests reported in Table 3.

$$
\begin{aligned}
Risk_{i,t} = {} & \alpha + \beta_1 Delta_{i,t-1} + \beta_2 Vega_{i,t-1} + \beta_3 Size_{i,t-1} + \beta_4 Capital\ ratio_{i,t-1} \\
& + \beta_5 Return\ on\ assets_{i,t-1} + \beta_6 Loans\ to\ assets_{i,t-1} + \beta_7 Loan\ growth_{i,t-1} \\
& + \beta_8 Deposits\ to\ assets_{i,t-1} + \beta_9 Non\text{-}interest\ income_{i,t-1} \\
& + \sum_{k=1}^{n-1} \alpha_k Bank-type_i^k + \sum_{y=2006}^{2010} \omega_y Year_i^y + \varepsilon_{i,t}
\end{aligned}
\tag{5}
$$

where the dependent variable $Risk_{i,t}$ is one of the two alternative systemic risk measures for financial institution *i* at time *t*. The first risk measure is the marginal expected shortfall, *MES*, calculated as the expected daily decrease in equity value of a financial institution when the aggregate stock market falls more than two percent. The second risk measure is systemic risk, *SRISK*, defined as the expected capital shortfall of a financial institution in a crisis scenario. *Delta* and *Vega* measure the compensation-based risk-taking incentives of the CEOs and CFOs. *Delta* is the sensitivity of executive compensation to changes in stock price, while *Vega* is the sensitivity of executive compensation to changes in stock return volatility. In the regressions, we use natural logarithms of *MES*, *SRISK*, *Delta*, and *Vega*. Given the high correlations between CEO and CFO risk-taking incentives, we do not include the deltas and vegas of the CEOs and CFOs simultaneously in the regressions. In addition to the baseline specification, we also estimate modified versions of Equation (5) in which we interact the deltas and vegas with a dummy variable for year 2008. With these additional specifications, we aim to assess the potential effects of the financial crisis on the relation between managerial risk-taking incentives and systemic risk.

The control variables in Equation (5) are defined as follows: *Size* is measured as the logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year *t*–1 to year *t*, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. Following the prior literature, all the independent variables are lagged by one year. Our regressions include year fixed-effects (*Year*) to control for time-specific unobservable factors which may influence systemic risk and we also include bank-type fixed-effects (*Bank-type*) for different types of financial institutions based on SIC codes to control for potentially omitted variables and unobserved heterogeneity. Throughout the regressions, we use robust standard errors which are adjusted for heteroskedasticity and clustered by firm to account for the potential correlation across observations of the same financial institution over time.

The regression results with marginal expected shortfall, *MES*, as the dependent variable are reported in Table 4. CEO risk-taking incentives are used as the independent variables of interest in Models 1-3 and CFO incentives in Models 4-6. For both CEO and CFO risk-taking incentives, we first estimate the regressions by including *Delta* and *Vega* in the same regression with all of the control variables (Models 1 and 4). We then estimate four alternative interaction specifications in which the CEO and CFO deltas are interacted with a dummy variable for the crisis year 2008 (Models 2 and 5) and in which the CEO and CFO vegas are interacted with the same dummy (Models 3 and 6). As can be seen from Table 4, the adjusted R^2s of our alternative regression specifications vary between 64 and 72 percent and the *F*-statistics are all statistically significant at the 1 percent level, indicating a good fit of the models.[15]

(insert Table 4 about here)

The main variables of interest in our regressions are *Delta* and *Vega* and the two interaction variables $Delta \times Year^{2008}$ and $Vega \times Year^{2008}$. As can be noted from Table 4, the coefficient estimates for *CEO delta* and *CEO vega* in Model 1 are statistically insignificant, suggesting that *MES* is not affected by CEO risk-taking incentives. However, after the inclusion of the crisis interactions in Models 2 and 3, the coefficient estimate for *CEO vega* is negative and statistically significant and the coefficients for the both interaction variables *CEO delta* $\times$ $Year^{2008}$ and *CEO vega* $\times$ $Year^{2008}$ are positive and highly significant. Accordingly, our estimates indicate that financial institutions led by CEOs with greater compensation-based risk-taking incentives were associated with significantly higher *MES* in the midst of the global financial crisis in 2008.

In Models 4-6 with CFO risk-taking incentives as the variables of interest, the coefficients for *CFO delta* are negative and statistically significant, suggesting that *MES* is lower for institutions with greater CFO pay-performance sensitivity. This finding is inconsistent with the view that compensation-based managerial incentives encourage greater risk-taking. Nevertheless, similar to the CEO incentive regressions, the coefficient estimates for both interaction variables *CFO delta* $\times$ $Year^{2008}$ and *CFO vega* $\times$ $Year^{2008}$ are positive and statistically significant at the 1 percent level in Models 5 and 6. Since delta and vega are proxies of managerial risk-taking incentives, the interaction regressions in Table 4 suggest that financial institutions with greater compensation-based risk-taking incentives

[15] The adjusted R^2 is 26 percent when only the control variables are used as the independent variables. After the inclusion of bank-type and year fixed-effects, the adjusted R^2 is about 58 percent.

of the top executives at the onset of the financial crisis were associated with higher levels of systemic risk during the severe financial market turmoil in 2008.

In addition to being statistically significant, the coefficients for the interaction variables in Table 4 can also be considered economically significant. The coefficient estimate for *CEO delta* × $Year^{2008}$ in Model 2 suggests that a one standard deviation increase in the pre-crisis *CEO delta* would be associated with a 30 basis point increase in *MES* in the year 2008. Similarly, the magnitudes of the statistically significant coefficients for *CEO vega* and *CEO vega* × $Year^{2008}$ in Model 3 jointly imply that a one standard deviation increase in pre-crisis vega of the CEO increases *MES* by approximately 40 basis points during the financial crisis. Consistent with Models 2 and 3, the estimates for the CFO risk-taking incentives in Models 5 and 6 indicate that one standard deviation increases in *CFO delta* and *CFO vega* are associated with about 25 basis point increase in *MES* amidst the crisis. Given that the average book value of equity for the financial institutions in our sample is about USD 16 billion, these 25-40 basis point increases in *MES* are economically highly significant.

With respect to the control variables, the regression results in Table 4 show that systemic risk as measured by *MES* is statistically significantly positively associated with *Size* and *Non-interest income* and negatively associated with *Return on assets*. Thus, our estimates suggest that larger financial institutions which are more involved in non-traditional banking activities and institutions with weaker financial performance are associated with higher levels of systemic risk.

(insert Table 5 about here)

Table 5 reports the regression results with systemic risk, *SRISK*, as the dependent variable. Similar to Table 4, CEO risk-taking incentives are used as the independent variables of interest in Models 1-3, while CFO incentives are used in Models 4-6. As can be noted from Table 5, the *F*-statistics for all six model specifications are statistically significant at the 1 percent level and the adjusted R^2s of the estimated regressions range from 31 percent to 57 percent.

Overall, the estimates of the *SRISK* regressions in Table 5 are very similar to the *MES* regressions reported in Table 4. The most notable differences between the two sets of results are the statistically significant coefficients for *CEO vega* in Model 1 and *CFO vega* in Model 4. These negative and highly significant coefficients indicate that financial institutions with greater risk-sensitivities of the top executives are generally associated with lower levels of systemic risk. The coefficient estimates indicate that a 10 percent increase in *CEO vega* would decrease *SRISK* by 0.7 percent, while a corresponding increase in *CFO vega* is associated with a 1.2 percent decrease in *SRISK*. Furthermore, one standard deviation increases in *CEO vega* and *CFO vega* would decrease *SRISK* by approximately 6.0 percent. The average *SRISK* for the institutions included in our sample is about USD 4.1 billion, and therefore, these reductions in *SRISK* can be considered economically significant. The documented negative linkage between CEO and CFO vegas and *SRISK* contrasts with the hypothesis that higher managerial risk-taking incentives would contribute positively to the level of systemic risk. Consistent with the agency theory (Jensen and Meckling, 1976), this negative association between vegas and systemic risk may suggest that the top executives of financial institutions tend to be risk averse.

Similar to Table 4, the coefficient estimates for the interaction variables $Delta \times Year^{2008}$ and $Vega \times Year^{2008}$ are positive and statistically significant at the 1 percent level in all four interaction regressions. Thus, consistent with our *MES* regressions, the regressions in Table 5 suggest that financial institutions with greater risk-taking incentives of the top executives prior the financial crisis were associated with higher levels of systemic risk during the crisis. Nevertheless, the magnitudes of the coefficients indicate that the positive association between managerial risk-taking incentives and *SRISK* in the midst of the financial crisis is rather marginal. The estimates of Models 2 and 3 imply that a 10 percent increase in pre-crisis *CEO delta* and *CEO vega* would increase *SRISK* by less than 0.10 percent during the financial crisis. With respect to CFO incentives, the estimates of Model 5 and 6 suggest that 10 percent increases (one standard deviation increases) in pre-crisis *CFO delta* and *CFO vega* are associated with 0.6 percent (4.7 percent) and 0.3 percent (1.4 percent) increases in *SRISK*, respectively. With average *SRISK* of about USD 4.1 billion, these increases in *SRISK* during the crisis can be considered economically significant.

The coefficient estimates for the control variables in Table 5 indicate that systemic risk is significantly negatively related to *Return on assets*, *Loans to assets*, and *Non-interest income*, while being positively associated with *Size*. This suggests that systemically more risky financial institutions are larger and have lower profitability, lower amounts of outstanding loans, and less income diversification.

In general, the regression results reported in Tables 4 and 5 provide mixed evidence about the linkage between top executive risk-taking incentives and the systemic risk of financial institutions. On the one hand, our results indicate that the sensitivities of CEO and CFO compensation to stock return volatility are negatively associated with the systemic risk of financial institutions over our sample period 2005-2010. This finding is in stark contrast with the hypothesis that higher managerial risk-taking incentives would increase the level of systemic risk.

On the other hand, our regressions demonstrate that financial institutions with greater managerial risk-taking incentives were associated with significantly higher levels of *MES* and *SRISK* in the midst of the global financial crisis in 2008. Nevertheless, taken as a whole, the regressions in Tables 4 and 5 together with the univariate tests in Table 3 do not provide strong support for the view that the risk-taking incentives of the top executives contribute positively to the level of systemic risk.

3.4. Robustness checks

We perform several additional tests to investigate the robustness of our findings. First, in order to ensure that the high correlations between the managerial risk-taking incentive variables do not affect our results, we re-estimate Models 1 and 4 in Tables 4 and 5 using only one incentive variable at a time (not tabulated). Similar to Model 1 in Table 4, the coefficients for *CEO delta* and *CEO vega* with *MES* as the dependent variable are statistically insignificant even when these variables are not used simultaneously in the regression. In contrast to our main analysis, the coefficient estimates for *CFO delta* and *CFO vega* are negative and statistically significant in the *MES* regressions (Model 4 in Table 4) and the coefficients for *CEO delta* and *CFO delta* are negative and significant at the 1 percent level in the *SRISK* regressions (Models 1 and 4 in Table 5). The coefficients for *CEO vega* and *CFO vega* in the regressions with *SRISK* as the dependent variable are negative and highly significant consistent with Models 1 and 4 in Table 5. Thus, these additional regressions strongly suggest that financial institutions with greater compensation-based managerial risk-taking incentives are generally associated with lower systemic risk.

Second, following Fahlenbrach and Stulz (2011), we re-estimate all our regression specifications by using the sums of CEO and CFO deltas and CEO and CFO vegas as the incentive variables. Fahlebrach and Stulz (2011) use the combined incentives of the top five highest-paid executives, whereas we only combine the deltas and vegas of the CEOs and CFOs. The estimates of these additional regressions (not tabulated) are very similar to the estimates reported in Table 4 and 5. The coefficients for the combined deltas and vegas as well as for the interaction variables have the same signs and also largely the same significance levels as in our main analysis.

Third, we winsorize all the variables at the 2.5^{th} and 97.5^{th} percentiles to examine whether our findings are affected by outliers or extreme observations. When the regressions are re-estimated with the winsorized variables (not tabulated), the coefficients for the risk-taking incentive variables remain virtually unchanged. Once again, the estimates indicate that *CEO vega* and *CFO vega* are significantly negatively associated with *SRISK*, and the positive and significant coefficients for the interaction variables demonstrate that financial institutions with greater managerial risk-taking incentives in 2007 were associated with higher *MES* and *SRISK* amidst the financial crisis in 2008.We therefore conclude that our empirical findings are not driven by outliers.

Fourth, we re-estimate the regressions by using firm fixed-effects instead of bank-type fixed-effects to control for omitted variables and unobserved heterogeneity. The estimation results with firm fixed-effects (not tabulated) are broadly consistent with our main regressions. Specifically, the coefficient estimates for the interaction variables $Delta \times Year^{2008}$ and $Vega \times Year^{2008}$ are always positive and statistically significant, and therefore suggest that the level of systemic risk during the financial crisis was higher for financial institutions with greater managerial risk-taking incentives.

Fifth, we estimate parsimonious versions of the regressions with *Size*, *Capital ratio*, and *Return on assets* as the only control variables to ascertain that our findings are not driven by spurious correlations between the variables used in the regressions. Again, the coefficients for the variables of interest (not tabulated) are consistent with our main analysis. Our parsimonious regressions indicate that managerial risk-taking incentives are generally negatively associated with systemic risk, while being significantly positively associated with the level of risk during the severe financial market turmoil in 2008.

Sixth, we investigate whether our findings are affected by firm-size effects. For this purpose, we divide our sample into two subsamples based on firm-size and then re-estimate the regressions (not tabulated). We exclude either the largest 10 percent or the smallest 10 percent of the financial institutions from the sample. The regressions results based on these two subsamples are very similar to the results reported in Tables 4 and 5 and the coefficients for the deltas and vegas as well as for the crisis interaction variables have the same signs and mostly the same significance levels as in our main regressions. This suggests that our empirical findings are not driven by the largest or the smallest institutions included in the sample.

Seventh, we examine the sensitivity of our results to the sample period used in the regressions. Specifically, we re-estimate the regressions using three different truncated subsamples (not tabulated). The first truncated subsample excludes the first sample year 2005, the second subsample excludes the crisis year 2008, and the third excludes the last sample year 2010. When either year 2005 or 2010 is excluded, the results are broadly consistent with the estimates reported in Table 4 and 5, and indicate that financial institutions with greater managerial risk-taking at the onset of the financial crisis incentives were associated with higher *MES* and *SRISK* during the crisis in 2008. When we exclude the crisis year 2008 from the sample, the coefficient estimates for *CEO vega* and *CFO vega* are negative and statistically highly significant both in the *MES* and *SRISK* regressions, and the coefficients for *CEO delta* and *CFO delta* are statistically insignificant. This provides additional evidence that the sensitivities of top executive compensation to stock return volatility are negatively associated with the systemic risk of financial institutions, at least outside crisis periods.

Eighth, in order to further examine the effects of the financial crisis on our findings, we exclude "troubled" financial institutions from the sample and then re-estimate the regressions (not tabulated). We define "troubled" financial institutions as those institutions that either failed or reported losses in excess of two percent of total assets during the crisis. The regression results without the "troubled" institutions are very similar to the estimates reported in Tables 4 and 5. The overall association between managerial risk-taking incentives and systemic risk is negative, and the positive and statistically significant coefficients for *Delta* $\times$ $Year^{2008}$ and *Vega* $\times$ $Year^{2008}$ indicate that financial institutions with greater managerial risk-taking incentives were positively associated with systemic risk amidst the crisis in 2008.

Finally, given that our sample contains different types of financial institutions, we examine the robustness of our results by restricting the sample to commercial banks and other lending institutions with a net loans to total assets ratio of at least 30 percent. When the regressions are re-estimated with this restricted sample (not tabulated), the results are similar to our main analysis. Once again, the coefficients for the interaction variables *Delta* $\times$ $Year^{2008}$ and *Vega* $\times$ $Year^{2008}$ are positive and statistically significant both in the *MES* and *SRISK* regressions, and therefore suggest that the pre-crisis risk-taking incentives of the top executives are positively association with systemic risk during the crisis. Thus, we conclude that our results are robust to the exclusion of investment banks and non-bank financial services firms from the sample.

4. Conclusions

Politicians, regulators, and bank supervision authorities have emphasized the focal role of executive compensation policies at banking organizations in the development of the global financial crisis of 2008-2009. Moreover, the financial crisis highlighted the importance of systemic risk and the fact that risk-taking of individual institutions may create substantial negative externalities on the financial system. In this paper, we examine the linkage between systemic risk and compensation-based risk-taking incentives of the top executives. The risk-taking incentives generated by executive compensation programs are generally designed to maximize shareholder value by mitigating managerial risk aversion. However, given the unique risk environment where financial institutions are protected by implicit and explicit government guarantees (Acharya, 2009, 2011; Acharya, Anginer and Warburton, 2016), a greater alignment of incentives between executives and shareholders may encourage excessive risk-taking in the financial industry.

In our empirical analysis, we use data on large, publicly traded U.S. financial institutions to empirically examine whether systemic risk is associated with the risk-taking incentives generated by executive compensation. We measure the risk-taking incentives of CEOs and CFOs with the sensitivities of their personal compensation to changes in the stock price and stock return volatility of their institutions. Furthermore, we use the marginal expected shortfall (*MES*) and systemic risk (*SRISK*) proposed by Acharya et al. (2012), Acharya et al. (2017), and Brownlees and Engle (2017) to gauge the systemic risk of individual financial institutions. *MES* and *SRISK* provide a measure of the exposure of a given financial institution to aggregate tail shocks in the financial system.

We find an ambiguous relationship between managerial risk-taking incentives and systemic risk. Our empirical findings indicate that the sensitivities of top executive compensation to volatility are generally negatively associated with systemic risk, while the relation between executive pay-performance sensitivity and systemic risk is virtually nonexistent. These findings are in stark contrast with the hypothesis that greater compensation-based managerial risk-taking incentives would increase the level of systemic risk. However, our empirical findings also demonstrate that financial institutions with greater managerial risk-taking incentives were associated with significantly higher levels of systemic risk in 2008 during the global financial crisis. Our estimates suggest that one standard deviation increases in the pre-crisis risk-taking incentives increase *MES* by about 25-40 basis points and *SRISK* by several percentage points during the crisis. This positive association between CEO and CFO risk-taking incentives and systemic risk during the severe market turmoil in 2008 may indicate that financial institutions with greater compensation-based risk-taking incentives were taking more risk before the crisis in order to maximize shareholder wealth, and that these risks were then materialized and exposed during the financial crisis.

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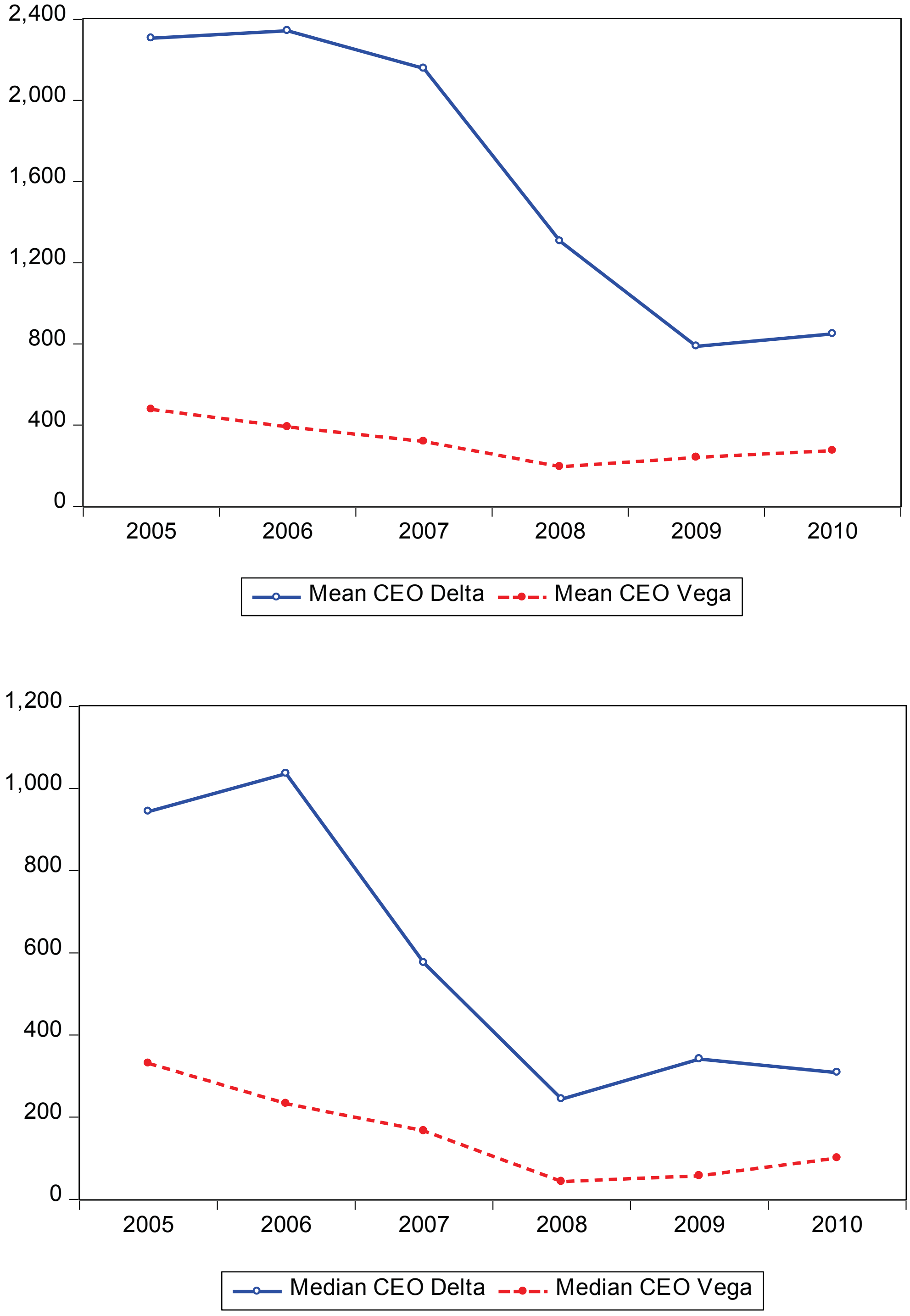
Figure 1. CEO deltas and vegas.



The figures plot the mean and median values of CEO Delta and CEO Vega.

Table 1. Descriptive statistics.

Variable	Mean	Median	St.dev.	Min	Max	P25	P75	No. of obs
Dependent variables:								
Marginal Expected Shortfall (%)	2.51	2.34	1.10	0.84	8.65	1.66	3.11	332
Systemic Risk ($ billions)	4.10	-0.44	20.90	-67.66	136.47	-1.83	2.33	332
Managerial Risk-taking Incentives:								
CEO Delta ($ Thousands)	1642.42	526.56	4735.40	0.69	53121.09	181.33	1621.78	336
CEO Vega ($ Thousands)	320.14	154.90	476.14	1.59E-25	3032.25	34.79	424.24	347
CFO Delta ($ Thousands)	403.64	61.60	3051.02	0.05	38202.76	22.48	166.82	285
CFO Vega ($ Thousands)	80.92	31.65	135.91	7.73E-14	859.53	9.07	94.35	285
Control variables:								
Size	257.41	57.21	481.59	0.54	3221.97	15.94	193.32	367
Capital ratio	12.68	9.88	13.73	-3.60	90.51	7.91	12.02	367
Return on assets	1.12	0.97	3.08	-18.42	22.57	0.46	1.39	367
Loans-to-assets	50.70	60.26	24.63	0.00	90.74	34.83	69.50	338
Loan growth	14.64	6.99	58.46	-72.26	704.49	-1.47	17.10	310
Deposits to assets	61.77	69.43	24.27	0.05	89.95	50.07	80.20	362
Non-interest income	49.94	43.58	31.55	-76.02	175.13	30.02	74.15	367

The table reports the descriptive statistics for the sample. The sample consists of 71 publicly traded U.S. financial institutions. Systemic risk is measured with the following two variables: (i) *Marginal Expected Shortfall* (*MES*) is the expected daily percentage decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent and (ii) *Systemic Risk* (*SRISK*) is the expected capital shortfall (in $ billions) of a financial institution in a crisis scenario. Managerial Incentives (in $ Thousands) are defined as: *Delta* is the sensitivity of manager's portfolio to stock price and measures the dollar gain or loss in manager's wealth if the firm's stock price changes and *Vega* is the sensitivity of manager's portfolio to changes in equity volatility. The control variables are defined as follows: *Size* is measured as the total assets (in $ billions), *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year t–1 to year t, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income.

Table 2. Correlations.

Correlation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) CEO Delta												
(2) CEO Vega	0.634											
(3) CFO Delta	0.928	0.611										
(4) CFO Vega	0.625	0.992	0.616									
(5) Marginal Expected Shortfall	0.668	0.617	0.454	0.569								
(6) Systemic Risk	0.559	0.881	0.472	0.830	0.738							
(7) Total assets	0.266	0.526	0.245	0.513	0.331	0.510						
(8) Capital ratio	-0.027	-0.203	0.005	-0.185	-0.071	-0.177	-0.396					
(9) Return on assets	0.411	0.162	0.431	0.177	0.175	0.101	-0.128	0.554				
(10) Loans to assets	-0.333	-0.141	-0.304	-0.138	-0.345	-0.158	-0.228	-0.069	-0.240			
(11) Loan growth	0.008	-0.054	-0.098	-0.044	0.046	-0.035	-0.013	0.094	0.092	-0.036		
(12) Deposits to assets	-0.134	-0.031	-0.080	-0.043	-0.108	0.008	-0.140	-0.219	-0.334	0.378	-0.320	
(13) Non-interest income	0.324	0.227	0.315	0.226	0.288	0.235	0.185	0.106	0.307	-0.652	0.057	-0.330

The table reports pairwise correlations for the variables used in the empirical analysis. *Marginal Expected Shortfall* is the expected daily percentage decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent, *Systemic Risk* is the expected capital shortfall of a financial institution in a crisis scenario, *Delta* is the sensitivity of manager's portfolio to stock price and measures the dollar gain or loss in manager's wealth if the firm's stock price changes, *Vega* is the sensitivity of manager's portfolio to changes in equity volatility, *Size* is measured as the logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year t–1 to year t, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income.

Table 3. Univariate tests

	High systemic risk	Low systemic risk	Difference in means	*t*-stat
Risk-taking incentives:				
CEO delta	6.086	6.122	-0.036	-0.19
CEO vega	5.502	5.623	-0.121	-1.22
CFO delta	5.326	5.269	0.057	0.65
CFO vega	5.038	5.051	-0.013	-0.22
Control variables:				
Size	18.155	17.499	0.657	3.17 ***
Capital ratio	16.078	10.129	5.950	3.71 ***
Return on assets	1.230	0.998	0.231	0.65
Loans-to-assets	40.314	59.512	-19.198	-6.98 ***
Loan growth	15.773	9.640	6.132	0.95
Depostis to assets	93.477	97.697	-4.220	-4.63 ***
Non-interest income	61.886	37.960	23.926	7.43 ***

The table reports the results of two-tailed *t*-tests under the null hypothesis that there is no difference in the means between financial institutions having higher level of systemic risk and financial institutions having lower level of systemic risk. We divide our sample into two subsamples. The first subsample contains the financial institutions with higher level of systemic risk (financial institutions having systemic risk values in 3rd quartile) and the second subsample contains institutions with lower level of systemic risk (financial institutions having systemic risk values in 1st quartile). *Marginal Expected Shortfall* is the expected daily decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent, *Systemic Risk* is the expected capital shortfall (measured in billion dollars) of a financial institution in a crisis scenario, *Delta* is the sensitivity of manager's portfolio to stock price and measures the dollar gain or loss in manager's wealth if the firm's stock price changes and *Vega* is the sensitivity of manager's portfolio to changes in equity volatility, *Size* is measured as the logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans-to-assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year t–1 to year t, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 4. Managerial Incentives and Marginal Expected Shortfall (*MES*).

	CEO Incentives			CFO Incentives		
Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Risk-taking Incentives						
Delta	-0.013	-0.028		-0.072 *	-0.090 ***	
	(-0.59)	(-1.45)		(-1.81)	(-3.23)	
Delta × $Year^{2008}$		0.049 ***			0.179 ***	
		(2.53)			(3.06)	
Vega	-0.012		-0.056 **	-0.002		-0.108 ***
	(-0.40)		(-2.28)	(-0.28)		(-3.23)
Vega × $Year^{2008}$			0.111 ***			0.193 ***
			(3.24)			(3.27)
Control variables:						
Size	0.063 ***	0.061 ***	0.064 ***	0.077 ***	0.072 ***	0.074 ***
	(3.92)	(3.73)	(3.99)	(4.54)	(4.41)	(4.39)
Capital ratio	0.005	0.004	0.003	0.003	0.003	0.002
	(0.62)	(0.57)	(0.45)	(0.40)	(0.38)	(0.29)
Return on assets	-0.076 ***	-0.078 ***	-0.080 ***	-0.080 ***	-0.077 ***	-0.079 ***
	(-3.28)	(-3.45)	(-3.54)	(-3.46)	(-3.53)	(-3.27)
Loans to assets	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(-0.80)	(-0.68)	(-0.78)	(-0.93)	(-0.72)	(-0.77)
Loan growth	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(-1.26)	(-1.12)	(-0.35)	(-0.49)	(-0.98)	(-0.14)
Deposits to assets	1.862	1.792	1.884	1.630	1.583	1.584
	(1.25)	(1.18)	(1.27)	(1.46)	(1.1)	(1.08)
Non-interest income	0.004 ***	0.004 ***	0.004 ***	0.003 *	0.003 *	0.003 *
	(2.75)	(2.84)	(2.77)	(1.91)	(1.93)	(1.92)

Table 4. *Continued.*

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Bank-type fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	69.27%	69.94%	71.55%	63.81%	64.97%	64.25%
F-stat.	29.88 ***	30.81 ***	34.17 ***	20.99 ***	22.02 ***	21.37 ***

The table reports the estimates of six alternative versions of the following panel regression specification:

$$MES_{i,t} = \alpha_0 + \beta_1 Incentives_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 \text{Capital ratio}_{i,t-1} + \beta_4 \text{Return on assets}_{i,t-1} + \beta_5 \text{Loans to assets}_{i,t-1}$$
$$+ \beta_6 \text{Loan growth}_{i,t-1} + \beta_7 \text{Deposits to assets}_{i,t-1} + \beta_8 \text{Non - interest income}_{i,t-1} + \sum_{k=1}^{n-1} \alpha_k Bank-Type_i^k + \sum_{y=2006}^{2010} \omega_y Year_i^y + \varepsilon_{i,t}$$

where the dependent variable $MES_{i,t}$ is the Marginal Expected Shortfall (*MES*) for firm *i* at time *t* calculated as the expected daily percentage decrease in equity value of a financial institution when the aggregate stock market falls more than 2 percent. $Incentives_{j,t}$ is either the *Delta* which is the sensitivity of manager's portfolio to stock price and measures the dollar gain or loss in manager's wealth if the firm's stock price changes or *Vega* which the sensitivity of manager's portfolio to changes in equity volatility. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year *t*–1 to year *t*, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. $Bank-Type_i^k$ is a dummy variable for type of financial institution *i* and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and within-firm clustering. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 5. Managerial Incentives and Systemic Risk (*SRISK*).

	CEO Incentives			CFO Incentives		
Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Risk-taking Incentives						
Delta	0.002	-0.028 ***		0.011	-0.067 **	
	(0.16)	(-2.98)		(0.53)	(-2.25)	
Delta × Year^{2008}		0.035 ***			0.128 ***	
		(2.55)			(2.49)	
Vega	-0.072 ***		-0.098 ***	-0.124 ***		-0.144 ***
	(-2.54)		(-3.33)	(-2.66)		(-4.06)
Vega × Year^{2008}			0.107 ***			0.171 **
			(2.51)			(2.45)
Control variables:						
Size	0.060 ***	0.045 ***	0.061 ***	0.080 ***	0.067 ***	0.077 ***
	(4.67)	(3.46)	(5.02)	(4.87)	(4.16)	(4.84)
Capital ratio	-0.001	-0.002	-0.002	0.003	0.003	0.002
	(-0.15)	(-0.51)	(-0.59)	(0.52)	(0.53)	(0.46)
Return on assets	-0.020 *	-0.024 *	-0.020 *	-0.014	-0.017	-0.012
	(-1.80)	(-1.75)	(-1.63)	(-1.17)	(-1.19)	(-0.99)
Loans to assets	-0.001 *	-0.002 *	-0.002 *	-0.002 *	-0.002 *	-0.002 *
	(-1.66)	(-1.63)	(-1.68)	(-1.90)	(-1.82)	(-1.91)
Loan growth	0.000	0.000	0.000 *	0.000	0.000	0.000 *
	(-0.87)	(0.93)	(1.80)	(1.20)	(0.72)	(1.81)
Deposits to assets	0.253	0.152	0.405	1.059	0.974	1.106
	(0.54)	(0.38)	(0.81)	(1.40)	(1.24)	(1.42)
Non-interest income	-0.001 **	-0.002 ***	-0.001 **	-0.002 ***	-0.002 ***	-0.002 ***
	(-2.28)	(-2.61)	(-2.19)	(-2.60)	(-2.65)	(-2.58)

Table 5. *Continued.*

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Bank-type fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	33.54%	30.54%	41.02%	53.49%	52.24%	56.82%
F-stat.	7.47 ***	6.63 ***	10.17 ***	14.03 ***	13.4 ***	15.91 ***

The table reports the estimates of six alternative versions of the following panel regression specification:

$$SRISK_{i,t} = \alpha_0 + \beta_1 Incentives_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 \text{Capital ratio}_{i,t-1} + \beta_4 \text{Return on assets}_{i,t-1} + \beta_5 \text{Loans to assets}_{i,t-1}$$

$$+ \beta_6 \text{Loan growth}_{i,t-1} + \beta_7 \text{Deposits to assets}_{i,t-1} + \beta_8 \text{Non - interest income}_{i,t-1} + \sum_{k=1}^{n-1} \alpha_k Bank-Type_i^k + \sum_{y=2006}^{2010} \omega_y Year_i^y + \varepsilon_{i,t}$$

where the dependent variable $SRISK_{i,t}$ is the *Systemic Risk* for firm *i* at time *t* calculated as the is the expected capital shortfall in a crisis scenario. $Incentives_{j,t}$ is either the *Delta* which is the sensitivity of manager's portfolio to stock price and measures the dollar gain or loss in manager's wealth if the firm's stock price changes or *Vega* which the sensitivity of manager's portfolio to changes in equity volatility. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Loan growth* is the percentage change in loans from year *t*–1 to year *t*, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. $Bank-Type_i^k$ is a dummy variable for type of financial institution *i* and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors which are adjusted for heteroskedasticity and within-firm clustering. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Appendix 1.

List of financial institutions.

1	American Express	39	Metlife
2	Associated Banc-Corp.	40	Morgan Stanley
3	Bank of America	41	National City
4	Bank of Hawaii	42	New York Community Bancorp
5	Bank of New York Mellon	43	Northern Trust
6	BB&T	44	PNC Financial Services
7	BBVA Compass Bancshares	45	Principal Financial Group
8	Bear Stearns	46	Prosperity Bancshares
9	BGC Partners	47	Prudential Financial
10	BOK Financial	48	Raymond James Financial
11	Capital One Financial	49	Regions Financial
12	Capitol Federal Financial	50	SEI Investments
13	Charles Schwab	51	Signature Bank
14	Citigroup	52	Sallie Mae
15	City National	53	Sovereign Bank
16	Comerica	54	State Street
17	Commerce Bancshares	55	Stifel Financial
18	Countrywide	56	SunTrust
19	Cullen/Frost Bankers	57	SVB Financial
20	East West Bancorp	58	Synovus Financial
21	Fannie Mae	59	T. Rowe Price Group
22	Fifth Third Bancorp	60	TCF Financial
23	First Citizens BancShares	61	TD Ameritrade
24	First Horizon National	62	TransAtlantic
25	First Niagara Financial	63	UMB Financial
26	Franklin Resources	64	UnionBanCal
27	Fulton Financial	65	US Bancorp
28	Goldman Sachs	66	Valley National Bancorp
29	Hancock	67	Washington Federal
30	Hudson City Bancorp	68	Webster Financial
31	Jefferies Group	69	Wells Fargo
32	JP Morgan Chase & Co.	70	WMI Holdings
33	KeyCorp	71	Zions Bancorporation
34	Legg Mason		
35	Lehman Brothers		
36	M&T Bank		
37	Marshall & Ilsley		
38	Merrill Lynch & Co.		

CEO Pay-Share and Risk-Taking in Large Bank Holding Companies☆

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Abstract

This study investigates the relationship between CEO pay-share (pay inequality between the CEO and the other top executives) and risk-taking in large bank holding companies (BHCs) over the period 1992–2016. We find that greater CEO pay-share is associated with lower BHC risk. The results provide support for the CEO power hypothesis which argues that CEOs may reduce the riskiness of their firms to protect their own financial wealth and human capital invested in the firm.

JEL classification: G01, G20, G21, G30, G34

Keywords: Corporate governance; Executive compensation; CEO pay-share; Bank holding company risk; CEO power

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☆ I would like to thank Sami Vähämaa, Klaus Grobys, Jukka Sihvonen, Denis Davydov, Seppo Pynnönen, Erik Mäkelä, Yi Zhang, and conference and seminar participants at the 57th Annual Meeting of Southwestern Finance Association, the 2018 Annual Meeting of Finnish Economic Association, the 19th Corporate Governance and Investment Workshop, and the University of Vaasa for valuable comments and suggestions. I gratefully acknowledge the financial support from Suomen Kulttuurirahasto for this project. Any errors are my own.

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1. Introduction

Does executive compensation influence corporate strategies and organizational performance? If so, in what ways? Does executive compensation stimulate risky and novel corporate strategies through higher tournament incentives (Kini and Williams, 2012)? Alternatively, does executive compensation lead to more calculative and conservative corporate actions by making CEOs more powerful (Bebchuk, Cremers and Peyer, 2011)? These questions continue to attract scholarly, practitioner, and regulatory attention. So far, growing empirical evidence exists on the influence of executive compensation (including the CEO and the other senior executives) on the corporate risk-taking propensity for both non-financial (Chava and Purnanandam, 2010; Kini and Williams, 2012) and financial firms (Fahlenbrach and Stulz, 2011; Bai and Elyasiani, 2013).[1] Despite the evidence on the effect of executive compensation on firm performance, the role of pay inequality between the CEO and other executives (CEO pay-share) in bank risk-taking is less clear.[2]

Among several explanations offered for the collapse of the stock market capitalization of the banking industry during the global financial crisis (GFC), one is that executive compensation structures prompted inappropriate risk-taking, which ultimately contributed, at least to some extent, to the crisis (Bebchuk and Spamann, 2010; Bebchuk, Cohen and Spamann, 2010; Fahlenbrach and Stulz, 2011; Bolton, Mehran and Shapiro, 2015; Guo, Jala and Khaksari, 2015). For instance, according to the Financial Stability Forum (2009),

> *"Compensation practices at large financial institutions are one factor among many that contributed to the financial crisis that began in 2007. High short-term profits led to generous bonus payments to employees without adequate regard to the longer-term risks they imposed on their firms. These perverse incentives amplified the excessive risk-taking that severely threatened the global financial system and left firms with fewer resources to absorb losses as risks materialized. The lack of attention to risk also contributed to the large, in some cases extreme absolute level of compensation in the industry."*

1 Several studies relate managerial compensation to the firm-risk and choice of risky projects (see Stulz, 1984; Smith and Stulz, 1985; Core and Guay, 1999; Guay, 1999; Coles, Daniel, and Naveen, 2006). For detailed review of literature on executive compensation, and risk-taking in banks, see de Haan and Vlahu (2016).
2 CEO pay-share is defined as "the fraction of the aggregate compensation of the firm's top-five executive team captured by the CEO" (Bebchuk et al., 2011, p 200).

Importantly, the top executives, in the banking industry, play an important role in decision making regarding "tail risk" which may lead to failure of the bank (Bai and Elyasiani, 2013). Therefore, it is important to understand the relationship between the compensation of top executives and risk-taking in the banking industry.

In this paper, we examine whether CEO pay-share (pay inequality between the CEO and the other top executives) is associated with risk-taking among large bank holding companies (BHCs).[3] Our main hypothesis is that BHCs with greater CEO pay-share should have higher risk (default risk and tail risk). This is because, according to tournament theory, an executive's rank in the firm determines his/her compensation (Lazear and Rosen, 1981). Ang, Lauterbach, and Schreiber (2002) argue that greater CEO pay is justified because CEOs have a greater responsibility towards the firm and also they are more competent. However, tournament theory provides different arguments for this view and argues how the CEO's compensation can be several times greater than those of the other executives.[4] In this regard, Lazear and Rosen (1981) propose a tournament model where workers in the firm are compensated based on their ranks. In this way, not only monitoring costs are reduced, but it also gives workers an incentive to win the tournament and receive the prize. In the case of executives, the CEO's share of pay is the prize because that is substantially greater than those of the other executives. Greater CEO pay motivates the other top executives to be the next CEO and win the tournament (Ang et al., 2002). To achieve this, top executives adopt riskier policies to increase their performance (Kini and Williams, 2012). So, greater pay inequality would also result in the better performance of the firm (Lin et al., 2013). However, to achieve a higher level of performance executives will take on more risks in the presence of tournament incentives (Goel and Thakor, 2008).[5] In doing so, the executives will increase the overall risk of the firm. In the banking industry, the pay inequality between the CEO and the other top executives is even larger (Ang et al., 2002) and this larger pay inequality may result in increased risk-taking in the banking industry.

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[3] Bebchuk et al., (2011), Kini and Williams (2012), and Bai and Elyasiani (2013) use CEO pay-share as a measure of the CEO power and risk incentive measures of the CEO compensation.
The regulatory burden under the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank) generally depends on bank size. BHCs with assets above USD 10 billion are subject to greater oversight than banks with less than USD 10 billion in assets. Therefore, this study considers BHCs as large if the book value of their assets is greater than USD 10 billion in 2010 constant dollars.

[4] Ang et al. (2002) report that bank CEOs, on average, earn 1.8 times more than the next most highly paid executive in the bank, and 2.6 times more than the fifth most highly paid executive.

[5] For a detailed discussion and arguments around why every executive will take on riskier projects see the theoretical model of Goel and Thakor (2008).

In contrast to the tournament theory, Bebchuk et al. (2011) argue that firms might differ regarding tournament incentives for senior executives, and thus CEO pay-share level might differ in the firms. Because the CEO has power over the decision-making in the firm, the CEO might affect the level of pay-share. Therefore, a high CEO pay-share might indicate governance problems in the firm where CEO can extract a greater pay. The ability to extract greater pay can also refer to the additional information that other CEO power proxies (e.g., the CEO is also the founder and CEO duality) may not capture.[6] With more power, CEO can run the firm for his/her own benefits at the expense of the shareholders (Adams, Almeida, and Ferreira, 2005). Thus, greater CEO power may result in lower firm value (Bebchuk, Cohen, and Ferrel, 2009) and lower credit rating (Ashbaugh-Skaife, Collins, and Lafond, 2006). In banks, CEO power is also associated with less bank risk (Pathan, 2009). This might be because; managers are risk-averse (Jensen and Meckling, 1976) and therefore adopt safer policies to protect their own investment in the firm (Pathan, 2009). Furthermore, the higher risk would also increase the probability of default by increasing the bankruptcy costs (Parrino et al., 2005). Therefore, unlike other senior executives, CEOs do not have strong incentives to adopt riskier policies rather CEOs are the most influential persons in decision-making and with increased bank risk the probability of failure would increase and the probability to lose CEO title. Consistent with these arguments, our main alternative hypothesis is that BHCs with greater CEO pay-share should be less risky.

We use CEO pay-share for two reasons. First, it is a risk incentive measure of CEO compensation (Kini and Williams, 2012).[7] Managerial risk-taking incentives generated by compensation also enhance managerial risk-taking in a firm (Coles, Daniel, and Naveen, 2006; Chava and Purnanandam, 2010; Kini and Williams, 2012) and greater CEO pay gives other executives option-like incentives to increase firm risk in an attempt to be promoted as CEO. Second, CEO pay-share can capture CEO power because it captures many observable and unobservable dimensions of the top executive team in a firm. Therefore, it can also capture CEO's role and relative centrality in the top executive team (Bebchuk et al., 2011). In this study, CEO pay-share is measured as the ratio of the CEO's total annual compensation to the total annual compensation of the CEO and the next four most highly-paid executives in the BHC (Bebchuk et al., 2011; Bai and Elyasiani, 2013). We use the

[6] CEO Power is "the power the CEO has over the board and other top executives" (Adams, Almeida, and Ferreira, 2005, p 1408).
[7] We also use Vega, of CEO option holdings, which measures the CEO personal wealth sensitivity to stock return volatility (risk-sensitivity) as risk incentive measure of CEO compensation in additional analysis for robustness.

publically available consolidated BHC data from FRY-9C reports from 1991.[8] We use four different measures as proxies of BHC risk: first, following Laeven and Levine (2009), the *z*-score, return on assets plus equity to assets ratio divided by standard deviation of return on assets; second, the market-based Merton (1974) distance to default (DD);[9] third, again following Laeven and Levine (2009) and Bai and Elyasiani (2013), the total risk measured as the volatility of stock returns (annualized volatility of daily stock returns); fourth tail-risk, following Ellul and Yerramilli (2013), which is the negative of the average of the bank's stock returns over the 5% of worst return days in the year.

Using an unbalanced panel dataset of 122 large and economically significant U.S. BHCs (those with assets greater than USD 10 billion in 2010 constant dollars),[10] this study finds that greater CEO pay-share is associated with lower BHC risk. These findings are consistent with the alternative hypothesis (CEO power argument) suggesting that powerful CEOs reduce the overall risk exposure of the BHC to protect their own human capital and financial wealth. These results are robust against a number of alternative estimation methods, different sample periods (before GFC, and after Dodd-Frank), and even against tests for addressing endogeneity where CEO pay-share is instrumented with industry median pay-share. These results may suggest that when CEO pay-share rises, CEOs become more risk-averse and powerful, and thus implement less risk business policies.

This study makes several important contributions to the existing literature and recent policy debate regarding the CEO compensation in large BHCs. First, this study, broadly, contributes to the bank risk-taking literature (Laeven and Levine 2009; Pathan 2009; Fortin et al., 2010; Beltratti and Stulz 2012; Ellul and Yerramilli 2013; Berger et al., 2014; Cheng, Hong and Scheinkman, 2015).[11] Second, this study contributes to the bank compensation literature (Fahlenbrach and Stulz, 2011; Bai and Elyasiani, 2013). Third, this study contributes to the CEO pay-share literature (Bebchuk et al., 2011; Kini and Williams, 2012; Bai and Elyasiani, 2013). Bebchuk et al. (2011) find that CEO pay-share is negatively associated with firm value as measured by Tobin's Q. On the other hand, Kini and Williams (2012) find that CEO pay-share is positively associated with firm risk as

[8] Although the data has been available since 1986, the compensation data has been available only since 1992.

[9] Both z-score and DD measure the default risk. Higher the z-score and the DD, the lower is the default risk i.e. more firm stability. For simplicity, negative of z-score and DD are used as dependent variables in regressions i.e. higher z-score and DD mean higher default risk.

[10] We use Consumer Price Index data from Federal Reserve Bank of St. Louis to calculate constant dollars (base year 2010).

[11] For detailed review of literature on executive compensation and risk-taking in banks, see de Haan and Vlahu (2016).

measured by cash flow volatility and return volatility. Kini and Williams (2012) regard CEO pay-share as a tournament incentive that drives top executives to compete for the position of CEO. However, the above studies exclude the banking sector from their samples.[12] Among banking studies, this study is closely related to that of Bai and Elyasiani (2013) who investigate whether CEO pay-share is related to the stability of BHC. They find that greater CEO pay-share ratio is related to greater stability among BHCs as measured by the *z*-score. However, the sample is based on data from 1992 to 2008, and therefore before the advent of Dodd-Frank. Our study uses comprehensive data on BHCs from 1992 to 2016, including the post Dodd-Frank years and using the sample of only economically significant BHCs (those having assets greater than $10 billion in 2010 constant dollars).

The findings of this study have important implications for researchers, the board of directors, shareholders and regulators. Most of the previous studies focused on the composition of CEO pay. This study highlights the importance of inequality of compensation amongst the top executive team. The inverse relationship between CEO pay-share and BHC risk supports the view of possible risk aversion i.e., CEOs with greater pay-share might pursue less risky strategies. The findings caution researchers against considering powerful CEOs as only risk-seekers. Moreover, the results indicate shareholders and boards of directors could influence CEO pay share to alter the risk-taking propensity of the management. The findings also have implications for regulations altering the relative CEO pay by imposing differential limits on the total compensations of CEOs and other executives. BHCs play an important role in the financial system and therefore are heavily protected and regulated. Thus, implicit and explicit guarantees provide financial institutions a different risk environment that is not applicable to non-financial firms. This highlights the importance to consider banks and BHCs separately in empirical analysis and policy development.

The remainder of the paper proceeds as follows. Section 2 describes the data and introduces the variables used in the empirical analysis. Section 3 presents the methods and reports empirical findings on the association between CEO pay-share and the risk-taking among BHCs. The last section summarizes the findings and concludes the paper.

[12] Most of the studies before GFC excluded financial firms from their sample because they were considered highly regulated. However, governance of financial institutions may be different from that of non-financial firms because of several reasons. For instance, financial institutions have larger number of stakeholders which complicates the governance of financial institutions. Apart from investors and depositors, regulators also have stake in the performance of financial institution because performance of financial institutions can also affect the health of the overall economy (Adams and Mehran, 2012).

2. Data and variables

Following previous studies on U.S. BHCs, the initial sample of this study consists of large publicly traded BHCs.[13] All BHCs having assets of more than USD 500 million file a FRY-9C report quarterly. Therefore, we collect the financial information of BHCs from the FRY-9C reports of the last quarter of each year, which are available from the Federal Reserve Bank of Chicago's website for the period from 1992 to 2016. We start from 1992 because this is the first year when compensation data is available on executive compensation. The data on executive compensation is gathered from the ExecuComp database by COMPUSTAT. Following Minton, Stulz and Taboada (2017), the BHCs with missing data on total assets are dropped and further the sample is restricted to the BHCs those with assets greater than USD 10 billion constant in 2010.[14] We use this threshold to focus on economically significant BHCs with activities comparable to those of large banks (according to Dodd-Frank). Matching FRY-9C data with compensation data yields a sample of 134 BHCs.

The data on distance to default (default risk) was collected from the website of Credit Research Initiative of National University of Singapore. After merging with default risk data, the sample was further reduced to 124 BHCs. Stock price and return data is collected from DataStream, reducing the final sample to 122 BHCs.[15] In the robustness checks, the observations from the years (2007, 2008, and 2009) are excluded to avoid the GFC effect.[16] The study sample includes high percentage of largest BHCs (having assets greater than USD 50 billion in 2010 constant dollars – Largest BHCs according to the Dodd-Frank) and it is argued that banks and BHCs benefit from becoming bigger. Largest BHCs can have access to stronger regulatory safety net (Minton et al., 2017) and thus reap the benefits of implicit and explicit guarantees granted to largest financial institutions (International Monetary Fund, 2014).[17] Therefore, we perform additional analyses to pay attention to largest BHCs.

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[13] For instance, Adams and Mehran (2012), Bai and Elyasiani (2013), Ellul and Yerramilli (2013), Erel, Nadauld, and Stulz (2014), Khan, Scheule, and Wu (2017) etc. use bank holding companies' data publically available at Federal Reserve Bank of Chicago's website.
[14] We use prior year assets to classify banks therefore we download the data starting from fourth quarter of 1991.
[15] Based on the availability of default risk and stock price data the sample is reduced to 122 BHCs.
[16] Fahlenbrach and Stulz (2011) show that banks with CEOs having better aligned incentives performed worse during the period of the GFC and consequently suffered decline in their stock-based wealth. This could alter the sensitivity to risk and return (DeYoung, Peng, and Yan, 2013).
[17] "Banks may also seek to grow faster and larger than justified by economies of scale and scope to reap the benefits of the implicit funding subsidy granted to TITF (too important to fail) institutions" IMF (2014).

(insert Table 1 about here)

Table 1 reports the descriptive statistics by year for the full sample used in this study and for the largest BHCs. The number of BHCs is different each year and it ranges from 54 in 2008 to 71 in 2016. For the whole sample, mean assets (mean BHC size) increases over the years from almost USD 57 billion to USD 195 billion in 2010 constant dollars and the median of BHCs remains almost similar from beginning to end. As of December 2016, the BHCs included in this study account for 91.19% of total banking system assets.[18]

2.1. Measures of BHC risk

In line with established banking literature, four measures for BHC risk are used in this study. First, following Laeven and Levine (2009) for each BHC we calculate the z-score which is equal to return on assets plus the equity to assets ratio divided by standard deviation of return on assets:[19]

$$Z - Score = \frac{Return\ on\ Assets\ (ROA) + (Equity\ to\ assets)}{Standard\ Deviation\ of\ ROA} \tag{1}$$

ROA is the ratio of net income to total assets and Equity to assets is the ratio of equity to total assets. The *z*-score measures default risk or distance to default for each BHC. So, a higher *z*-score is associated with a more stable BHC (one with less default risk). We take the natural logarithm of the *z*-score for normal distribution and then the negative of the natural logarithm so that the inverse relation between CEO pay-share and BHC risk is direct.[20] Second proxy for BHC risk is the distance-to-default (DD), a concept originating from the structural credit risk model of Merton (1974). DD is a popular measure for gauging how far away a limited-liability firm is from default (e.g., Duan, Sun, & Wang, 2012; Duan & Wang, 2012). The higher the DD, the lower the default risk.[21] Similar to z-score, the negative of the natural logarithm of DD is used.

Third, following Laeven and Levine (2009) and Bai and Elyasiani (2013), total risk measured as the volatility of stock returns to proxy for the BHC market risk.

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[18] Here total banking system assets as of December 2016 are $16,780.224 billion representing the total assets of the 5,913 FDIC-insured commercial banks and savings institutions in the U.S. (FDIC Quarterly banking profile).
[19] Following Minton et al. (2017), the standard deviation of ROA is estimated using data from the three previous years.
[20] Since the z-score is highly skewed in the sample, we use the natural logarithm of z-score by following Laeven and Levine (2009), Beltratti and Stulz (2012) and Bai and Elyasiani (2013) and call it z-score.
[21] The calculation of DD is explained in Appendix. For methodological details on estimating distance to default see Duan et al. (2012).

Volatility of stock returns is the annualized volatility of daily stock returns in a year. Data for stock returns are collected from DataStream and we use a total return index that accounts for dividends. Fourth, following Ellul and Yerramilli (2013), BHC tail risk which is the negative of the average of a BHC's stock returns over the 5% of worst return days in the year.[22] Tail risk is an important measure of BHC risk because high-powered executive compensation schemes can encourage managers to increase tail risks (Ellul and Yerramilli, 2013). For risk, daily stock price data is gathered from DataStream.

2.2. CEO pay-share

Following previous studies (Bebchuk et al., 2011; Kini and Williams, 2012; Bai and Elyasiani, 2013), CEO pay-share variable is used to measure the compensation inequality between the CEO and other executives. CEO pay-share is calculated as:

$$CEOpayShare_{i,t} = \frac{Total\ CEO\ Compensation_{i,t}}{Total\ Compensation\ of\ top\ five\ executives\ (including\ CEO)_{i,t}} \quad (2)$$

Total compensation data is taken from the ExecuComp database. Here total compensation includes salary, bonus, value of restricted stock grants, long term incentive pay, value of option grants and other annual pay. Only those banks are included in the sample where the total compensation for the CEO and the next four most highly-paid executives is available.

2.3. Control variables

In order to control for potential omitted variable bias (Gujarati 2003; Wooldridge 2010), in the regressions, we account for various institution-specific characteristics to examine the association of CEO pay-share and BHC risk. The control variables used in this paper are determined by following the prior bank risk-taking literature (e.g., Pathan, 2009; Fortin et al., 2010; Brunnermeier et al., 2012; Berger et al., 2014; Mayordomo et al., 2014) and, to some extent, by data availability. We control for firm size, capital ratio, profitability, growth, and the structure of assets and income. Although only economically significant and large BHCs are included in this study, consistent with previous studies, we control for the BHC size because business strategies, product compositions, and the corporate governance structures of a BHC are affected by the BHC's size. Consistent with the

[22] Tail risk is based on the expected shortfall (ES) measure. Tail risk is widely used within financial firms to measure expected loss conditional on returns (Ellul and Yerramilli, 2013; Acharya, Pedersen, Philippon, Richardson, 2017). For robustness, we also confirm our results by tail risk measured as the negative of a bank's average stock returns over the 5% of worst return days of the S&P500.

literature, BHC size is measured (*Size*) by the logarithm of total assets. Secondly, we control for BHC's capital ratio (or leverage ratio) as the ratio of equity to total assets.[23]

In addition to *Size* and *Capital ratio*, we account for the BHC's financial performance, growth, and asset and income structure. Financial performance is measured by *Return on assets* which is computed as the ratio of net income to total assets. *Growth* is measured as the annual percentage change in the amount of outstanding loans. We also control for the BHC's business model and structure of the assets and liabilities with the ratio of net loans divided by total assets (*Loans to assets*) and the ratio of deposits to total assets (*Deposits to assets*). Finally, the ratio of non-interest income to total income (*Non-interest income*) is used to control for the level of income diversification and non-traditional banking activities. The data on these control variables are obtained from FRY-9C reports.

3. Empirical analysis

3.1. Descriptive statistics and correlations

Table 2 reports the descriptive statistics for the data used in this study. With regard to CEO pay-share, the mean pay-share of 0.37 indicates that the average amount a CEO earns annually is 37% of what is paid to the top five executives in the BHC. This amount is comparable to the mean value of 35.7% found in Bebchuk et al. (2011) for non-bank sample. With regard to BHC risk proxies, the z-score is an average 3.15 which is consistent with and comparable to previous studies on banks (Laeven and Levine 2009; Bai and Elyasiani 2013) and distance to default has mean value of 2.59. Mean equity volatility is 4.02 and mean tail-risk is 4.26, which is comparable to Ellul and Yerramilli (2013) who report 4.7.

In terms of BHC specific variables, the median asset value is $32.83 billion, and the mean asset value is $138.77 billion which is higher than $15.5 billion (median) and $129.3 billion (mean) found in Fahlenbrach and Stulz (2011). The return over assets is 0.03 which is higher than 0.01 and 0.018 found in Fahlenbrach and Stulz (2011) and Bai and Elyasiani (2013), respectively. The loans to assets ratio is 0.60 and deposits to asset ratio is 0.53. Finally, on average, the non-interest income is 0.29 and capital ratio is 0.10 which are slightly higher than 0.25 and 0.81 found in

[23] We perform additional analysis where we exclude capital ratio from the control variables. Our results are robust to the exclusion of capital ratio among control variables. Previous studies (e.g. Baselga-Pascual, Trujillo-Ponce, Cardone-Riportella, 2015) argue that regressing capital ratio on the insolvency risk (measured by Z-score and distance to default) may be problematic because banks can alter their capital if they become more risky. Secondly, because of the construction of z-score and DD it may be problematic to include capital ratio as a control variables.

Bai and Elyasiani (2013). Overall, these statistics are not surprising because we only focus on large BHCs and over the large sample period (1992 to 2016).

(insert Table 2 about here)

Table 3 reports the pairwise correlations among the variables used in the empirical analysis. Table 3 shows that both measures of default risk (z-score and distance to default) are positively correlated to the CEO pay-share and both measures of market risk (equity volatility and tail risk) are negatively correlated to the CEO pay-share. These results provide some preliminary support to our alternative hypothesis (CEO power hypothesis) and suggest that CEO pay-share is associated with less BHC risk. However, the correlation analysis does not control other factors that affect BHC risk, so the results should be viewed with caution. The correlation analysis also indicates that collinearity is generally moderate between the explanatory variables. The highest correlation coefficient is between non-interest income and loans to assets of -0.64. Thus, multicollinearity may not be an issue in our analysis.

(insert Table 3 about here)

3.2. Univariate tests

Table 4 reports the results of univariate tests. We divide the whole sample into two sub-samples based on CEO pay-share. The first sub-sample contains the BHCs with greater CEO pay-share (CEO pay-share in the top 25%) and the second sub-sample contains the BHCs with lower CEO pay-share (CEO pay-share values in the bottom 25%). After dividing the sample into these sub-samples, we perform the two-tailed *t*-tests and Wilcoxon/Mann-Whitney median tests with the null hypothesis that there are no differences in the means and medians between the BHCs with greater CEO pay-share and BHCs with lower CEO pay-share.

(insert Table 4 about here)

Table 4 shows that, except the z-score, the means and medians of all other BHC risk measures (distance to default, equity volatility, and tail-risk) between both groups are significantly different. BHCs with low CEO pay-share have higher risk levels than BHCs with greater CEO pay-share, which suggests that, in general, greater CEO pay-share is associated with less BHC risk. These results again provide support to the alternative hypothesis (CEO power hypothesis) that BHCs with greater CEO pay-share should be less risky. Lastly, results show that BHCs with high CEO pay-share have high loans and deposits but less non-interest income.

3.3. Regression results

The following formal equation (3) is the baseline model to empirically test the relationship between CEO pay-share and BHC risk:

$$\begin{aligned} Risk_{i,t} = \alpha + \ & \beta_1 CEOpayShare_{i,t} + \beta_2 Size_{i,t} + \beta_3 Capital\ ratio_{i,t} \\ & + \beta_4 Return\ on\ assets_{i,t} + \beta_5 Loans\ to\ assets_{i,t} \\ & + \beta_6 Deposits\ to\ assets_{i,t} + \beta_7 NoninterestIncome_{i,t} \\ & + \sum_{k=1}^{n-1} \alpha_k BHC_i^k + \sum_{y=1992}^{2016} \omega_y Year_i^y + \varepsilon_{i,t} \end{aligned} \quad (3)$$

Several alternative versions of equation (3) are estimated where the dependent variable *Riski,t* is proxied by four alternative measure of BHC risk.[24] As discussed above, several BHC-specific financial variables that may affect the level of BHC risk are included. We use year fixed-effects to eliminate common business cycle effects across all BHCs and firm fixed-effects to examine the relationship between CEO pay-share and risk within BHCs. In all regressions, standard errors are clustered by BHC.[25]

(insert Table 5 about here)

Table 5 reports the results for equation (3). For each BHC risk measure, four estimations approaches are used. First, only year fixed effects are included in the regressions and second, in addition to year fixed effects, firm fixed effects are included. Third (not tabulated), we use lagged control variables by one year,[26] and fourth (not tabulated), we estimate modified versions of equation (3) to include an interaction variable *CEO pay-share* × *Largest BHC*, for BHCs with total assets exceeding USD 50 billion.[27]

The coefficient of CEO pay-share is negative for distance to default, equity volatility, and tail risk suggesting that CEO pay-share is negatively associated with BHC default risk, BHC market risk, and BHC tail risk. These results provide support to the alternative hypothesis that CEO pay-share is associated with less

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[24] Negative of natural logarithm of z-score and distance to default, equity volatility, and tail risk.
[25] When using panel data, including year fixed effects and clustering standard errors is a common approach (Petersen, 2009).
[26] Previous studies (Coles et al., 2006; DeYoung et al., 2013) also use lagged explanatory variables. Following Bai and Elyasiani (2013), we use contemporaneous explanatory variables. We also select large BHC based on their prior year-end assets. However, in our study, the results are qualitatively similar when explanatory variables are lagged one year.
[27] *Largest BHC* is a dummy variable which takes the value of 1 if the assets of the BHC are greater than 50 billion measured in 2010 constant US dollars and 0 otherwise.

BHC risk.[28] These results are also economically significant and our sample also consists of large and economically significant BHCs. For instance, one standard deviation increase in CEO pay-share is associated with a 6.64% decrease in default risk (compared to the sample mean distance to default of 2.59) based on the coefficient in model (4). Similarly, one standard deviation increase in CEO pay-share is associated with a 3.04% decrease in equity volatility based on model (6) and a 2.79% decrease in tail risk based on model (8). Overall, the results are consistent across alternative estimation approaches (i.e., contemporaneous variables, lagged variables, year fixed effects and bank fixed effects), suggesting that our inference (i.e., the BHC with greater CEO pay-share have less risk) is less likely to be biased due to omitted variables and reverse causality issues. These results provide support to the CEO power hypothesis (Pathan, 2009; Bebchuk et al., 2011), that is, greater CEO pay-share reduces BHC risk.

3.4. Addressing reverse causality

In this study, we find that BHCs with a higher CEO pay-share have lower BHC risk. There are two important concerns about the empirical results that must be addressed. First, it could be that the relationship between CEO pay-share and BHC risk is not captured because of omitted variables. To address this concern, we use firm fixed effects and BHC level control variables, as used in previous literature. Second, it could be that the relationship is endogenous and there is reverse causality, that BHC risk affects CEO pay-share and not the other way around (Coles et al. 2006; Bebchuk et al. 2011; Bai and Elyasiani 2013; Ellul and Yerramilli 2013). Previous studies show that boards of directors adjust CEO compensation based on the risk the firm carries (Coles et al. 2006). To address this issue, we estimate the regressions using instrumental variables for CEO pay-share. We follow Bebchuk et al. (2011) and Kini and Williams (2012) and use three variables as the instruments for CEO pay-share: industry median pay-share, number of vice presidents (VPs) in the top five executives and lastly whether the CFO is vice president (VP). Industry median pay-share is calculated each year for each BHC by excluding the respective BHC. The data informing these variables are collected from the ExecuComp database.

(insert Table 6 about here)

[28] Additionally, in unreported results, the coefficients for CEO pay-share with the Largest BHC interaction term are positive for all risk measures and statistically significant for all except the z-score. These results further suggest that CEO pay-share is associated with lower risk, even in, largest BHCs as the sum of the coefficients on CEO pay-share and CEO pay-share × Largest BHC is negative.

The results in Table 6 show that the CEO pay-share is negatively associated with BHC risk even after addressing endogeneity. The results show that when CEO pay-share is instrumented the coefficients are negative and highly significant except the *z*-score. These results are consistent with previous regression results showing that greater CEO pay-share is associated with less BHC risk.

3.5. BHC activities and CEO pay-share

Large BHC companies engage in several different activities than smaller BHCs and banks. Therefore, we investigate whether these different activities can help us understand why CEO pay-share reduces risk-taking in large BHCs. Following prior studies (Bai and Elyasiani, 2013; Ellul and Yerramilli, 2013; Erel et al., 2014; Minton et al., 2017), we identify important BHC activities than could potentially affect the association between CEO pay-share and BHC risk. Following Bai and Elyasiani (2013), the model is described as:

$$BHC\ activity_{i,t} = \alpha + \beta_1 CEO\ pay - share_{i,t} + \beta_2 Size_{i,t} + \beta_3 Capital\ ratio_{i,t} + \beta_4 Loan\ loss\ provisions_{i,t} + \beta_5 Asset\ concentration_{i,t} + \sum_{k=1}^{n-1} \alpha_k BHC_i^k + \sum_{y=1992}^{2016} \omega_y Year_i^y + \varepsilon_{i,t} \quad (4)$$

Several alternative versions of equation (3) are estimated where the dependent variable *BHC activity*, is proxied by six alternative BHC activities: 1) *Non-interest income* which is the ratio of non-interest income to total income; 2) *Deposits to assets* is the ratio of deposits to total assets; 3) *RE loans to assets* which the ratio of real estate loans to total assets; 4) *CI loans to assets* which is the ratio of commercial and industrial loans to total assets; 5) *Securities to assets* which is the ratio of total securities to total assets, and 6) *Trading to assets* which is the ratio of total trading assets to total assets. Following Bai and Elyasiani (2013), we also control for BHC-specific characteristics that may affect the different BHC activities. These include: *Size* which is the natural logarithm of total assets, *Capital ratio* which is the ratio of equity to total assets, *Loan loss provisions* which is the ratio of the BHC's loan loss reserve to total assets, and *Asset concentration* which is the Herfindahl-Hirschman index (HHI) of BHC loans. HHI measures the concentration of BHC assets across different categories of loan. We include both year fixed-effects and firm-fixed effects. The standard errors are clustered at the BHC level.

(insert Table 7 about here)

Table 7 reports the results for BHC activities. The results suggest that CEO pay-share affects the business activities in large BHCs. The CEO pay-share is negatively associated with *Non-interest income* suggesting greater CEO pay-share reduces the level of non-traditional BHC activities. These results are consistent with the view that CEO pay-share affects the CEO's risk preference and thus engage in a greater levels of traditional activities i.e. through less risky deposits (Bai and Elyasiani, 2013; Ellul and Yerramilli, 2013).[29] The CEO pay-share is positively associated with *RE loans to assets* and *CI loans to assets*. Overall, the results suggest that greater CEO pay-share makes CEO more risk-averse and provides incentive to implement less risky investment policies.

3.6. Additional robustness tests

We perform several robustness tests to make sure that the findings are reliable and robust to additional analysis. First, to make sure that the results are not affected by the outliers in the sample, we winsorize all the independent variables at the 1 percent and 99 percent levels and re-estimate all the models in Tables 5 with these winsorized variables. The regression results (not tabulated) are similar to the models in Tables 5, suggesting that the BHCs with greater CEO pay-share are associated with lower BHC risk. These findings suggest that the results are not driven by outliers.

Second, in order to make sure that we only consider deposit-taking BHCs, we re-estimate the regression models in Tables 5 by restricting the sample to the banks having a deposits to assets ratio of at least 10% in the previous year (Minton et al. 2017).[30] The regression results (not tabulated) are similar to the OLS results presented in Tables 5. The regression coefficients for CEO pay-share are negatively and mostly statistically significant, indicating a negative association between CEO pay-share and BHC risk. The coefficients are not significant for the *z*-score as a dependent variable, which is consistent with full-sample results.

Third, we exclude GFC years (2007, 2008, and 2009) from the sample and re-estimate the regression models in Tables 5. The results for these analyses (not tabulated) are consistent with the main findings of this paper in that CEO pay-share is negatively associated with BHC risk. Most of the coefficients are statistically significant for CEO pay-share, which suggests that the results would remain qualitatively similar even when the crisis period is excluded from the sample.

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[29] Following Beltratti and Stulz (2012), we also use deposit funding and find (results unreported) that CEO pay-share is positively associated with *Deposits to assets* which further lends support to this argument.

[30] This restricted sample contains 118 BHCs.

Fourth, for parsimony, we re-estimate several models in Tables 5 to include only three control variables: size, capital ratio, and return on assets. The regression coefficients (not tabulated here) for CEO pay-share are negative and statically significant for all the BHC risk proxies except the *z*-score. These findings are consistent with the main regression findings that show that BHC with greater CEO pay-share are associated with lower BHC risk.

Fifth, following Kini and Williams (2012) and Bai and Elyasiani (2013), we control for risk-taking managerial incentives and include *vega* (CEO compensation sensitivity to risk) in the regressions. Then we re-estimate the models in Tables 5 (results not tabulated) and find that *vega* is positively related to BHC risk. However, the coefficients for CEO pay-share remain negative and statistically significant. These results suggest that even when controlling for option-based managerial risk-taking incentives, the relationship between CEO pay-share remains consistent with the main regression results.

4. Conclusions

This study investigates whether CEO pay-share (pay inequality between the CEO and the other top executives) is associated with risk-taking in large BHCs. Using a comprehensive dataset on large U.S. BHCs, we contribute to the previous bank and BHC risk literature by documenting that CEO pay-share is associated with lower levels of risk in large BHCs. These findings are consistent with previous literature on CEO pay-share (Bebchuk et al., 2011; Bai and Elyasian, 2013) that greater CEO pay-share represents CEO power, and powerful CEOs will protect their human and financial investment in a BHC by lowering the BHC risk levels. Additional tests show that CEO pay-share is negatively associated with non-traditional and risky BHC activities (e.g., non-interest income, trading) suggesting that greater CEO pay-share makes CEO more risk-averse and provides an incentive to implement less risky investment policies.

The findings reported in this study have important implications. Previous studies, mostly, focus on the composition of CEO pay. This study also highlights the importance of the spread of compensation among the top executive team. Our results indicate that CEO pay-share is negatively associated with risky business policies, so the board of directors could adjust CEO pay-share to alter the risk-taking propensity of the management.

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Table 1. Yearly Sample Description

		Total Assets in Constant USD Billion				
		Full Sample		Largest BHCs (>$50B)		% of Largest BHCs
Year	BHCs	Mean	Median	Mean	Median	
1992	55	56.99	36.34	120.01	79.52	34.55
1993	58	60.42	33.03	122.76	84.56	37.93
1994	58	65.63	34.01	134.36	97.46	37.93
1995	58	70.68	29.59	142.32	105.30	39.66
1996	56	76.05	30.99	156.08	106.25	39.29
1997	55	85.65	40.90	173.74	109.55	40.00
1998	54	99.24	42.91	210.39	118.34	38.89
1999	60	109.07	39.09	227.52	108.86	41.67
2000	60	116.90	40.37	254.75	107.46	40.00
2001	62	122.87	40.17	267.54	100.70	40.32
2002	70	120.68	40.53	273.39	104.04	38.57
2003	68	134.56	42.08	266.23	108.33	45.59
2004	61	162.97	46.77	308.35	109.21	49.18
2005	63	150.52	51.52	275.10	106.20	50.79
2006	56	180.76	50.09	338.64	124.15	50.00
2007	55	191.89	46.31	372.01	144.91	49.09
2008	54	212.31	38.94	420.42	155.54	48.15
2009	56	201.09	34.27	412.59	148.86	46.43
2010	59	228.60	51.04	419.14	145.65	52.54
2011	58	231.06	47.75	442.89	169.39	50.00
2012	58	224.03	42.03	442.66	155.89	48.28
2013	71	189.96	35.36	408.37	134.92	43.66
2014	70	198.50	36.35	419.92	144.29	44.29
2015	71	191.63	36.03	423.09	140.09	42.25
2016	71	195.69	35.10	420.11	136.21	43.66

This table reports the yearly sample of publicly traded BHCs from 1992 to 2016. The BHC is only included in the sample if its assets are greater than $10 billion in 2010 constant dollars (the minimum threshold for greater oversight under Dodd-Frank). This table also reports the percentage of largest BHCs defined as BHCs having assets greater than $50 billion in 2010 constant dollars (the threshold for enhanced supervision under Dodd-Frank) in the sample.

Table 2. Descriptive Statistics

Variable	Mean	Median	St.dev.	Min	Max	P25	P75	No. of obs
Dependent Variables								
Z-score	3.15	3.19	0.27	2.26	3.99	2.90	3.37	1517
Distance-to-default	2.59	2.58	0.13	2.12	3.10	2.47	2.66	1308
Equity volatility	4.02	3.99	0.38	1.95	5.89	3.75	4.29	1204
Tail risk	4.26	3.51	2.77	0.20	23.40	2.69	4.72	1354
Main variable								
CEO pay-share	0.37	0.37	0.10	3.31E-08	0.77	0.32	0.43	1274
Control variables:								
Size (log. Assets)	3.78	3.49	1.30	1.77	7.85	2.75	4.50	1517
Assets ($Billion)	138.77	32.83	345.54	5.88	2572.77	15.62	90.19	1517
Capital ratio	0.10	0.09	0.04	0.03	0.79	0.08	0.77	1517
Return on assets	0.03	0.03	0.02	-0.06	0.20	0.02	0.04	1517
Loans-to-assets	0.60	0.65	0.17	0.01	0.96	0.56	0.71	1517
Deposits to assets	0.53	0.55	0.13	0.001	0.88	0.48	0.61	1509
Non-interest income	0.29	0.26	0.17	-0.11	0.99	0.18	0.36	1517
Additional test variables								
RE loans to assets	0.32	0.33	0.16	0.00	0.79	0.23	0.44	1517
CI loans to assets	0.14	0.13	0.08	0.00	0.51	0.09	0.18	1517
Securities to assets	0.20	0.18	0.11	0.00	0.94	0.13	0.25	1404
Trading to assets	0.03	0.00	0.06	0.00	0.49	0.001	0.02	1404
Loan loss provisions	0.01	0.00	0.01	-0.01	0.09	0.002	0.01	1517
Asset concentration	0.46	0.42	0.16	0.24	1.00	0.34	0.52	1517
Industry Median CEO Pay-share	0.37	0.37	0.01	0.34	0.40	0.36	0.38	1274
Number of VPs	1.91	2.00	1.46	0.00	5.00	0.00	3.00	1322
CFO is VP	0.73	1.00	0.44	0.00	1.00	0.00	1.00	772
Largest BHC	0.44	0.00	0.50	0.00	1.00	0.00	1.00	1517
CEO Vega ($1000)	223.01	78.89	384.20	0.00	3768.64	24.23	235.80	1117

This table reports the descriptive statistics for the variables used in this study. The sample consists of 122 large and economically significant BHCs (those having assets of at least $10 billion in 2010 constant dollars) from 1992 to 2016. Here the dependent variable is BHC risk which is proxied by four alternative measure of risk: 1) the *z*-score measured by the sum of return on assets and equity to assets divided by standard deviation of return on assets; 2) distance-to-default calculated based on credit risk model of Merton (1974); 3) equity volatility measured as the annualized standard deviation of daily stock returns, and 4) tail risk measured as the negative of a BHC's average stock return over the worst 5% of return days in a year. CEO pay-share is the ratio of the CEO's annual total compensation to the total compensation of CEO and next four highly paid executives in the same BHC. The control variables are defined as follows: *Size* is measured as the natural logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. Additional test variables are: RE loans to assets which the ratio of real estate loans to total assets, *CI loans to assets* which is the ratio of commercial and industrial loans to total assets, *Securities to assets* which is the ratio of total securities to total assets, *Trading to assets* which is the ratio of total trading assets to total assets, *Loan loss provisions* which is the ratio of the BHC's loan loss reserve to total assets, *Asset concentration* which is the Herfindahl-Hirschman index (HHI) of BHC loans, *Industry median pay-share* which is calculated for each year for each BHC by excluding the respective BHC, *Number of VPs* is the number of vice presidents among the top five executives, *CFO is VP* is a dummy variable which equals 1 if the CFO is also a vice president, *Largest BHC* is a dummy variable which equals 1 if the total assets of BHC exceed $50 billion in 2010 constant dollars and zero otherwise, and *CEO Vega* is CEO compensation sensitivity to risk.

Table 3. Correlation

Correlation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Z-score	1.00										
(2) Distance-to-default	0.09*	1.00									
(3) Equity volatility	-0.17*	-0.57*	1.00								
(4) Tail risk	-0.22*	-0.55*	0.90*	1.00							
(5) CEO pay-share	0.01	0.08*	-0.07*	-0.09*	1.00						
(6) Size	-0.12*	-0.02	0.02	0.02	-0.29*	1.00					
(7) Capital ratio	0.22*	0.32*	-0.02	0.00	-0.03	-0.06*	1.00				
(8) Return on assets	0.54*	-0.16*	0.01	-0.04	0.00	-0.15*	0.10*	1.00			
(9) Loans to assets	0.22*	0.02	-0.12*	-0.11*	0.20*	-0.36*	-0.03	0.14*	1.00		
(10) Deposits to assets	0.05*	0.04	-0.10*	-0.08*	0.22*	-0.51*	-0.11*	-0.02	0.47*	1.00	
(11) Non-interest income	-0.08*	0.15*	0.05*	0.06*	-0.24*	0.38*	0.17*	-0.05*	-0.64*	-0.52*	1.00

This table reports the pairwise correlation among the variables used in this study. Here BHC risk which is proxied by four alternative measure of risk: 1) the z-score measured by the sum of return on assets and equity to assets divided by standard deviation of return on assets; 2) distance-to-default calculated based on credit risk model of Merton (1974); 3) equity volatility measured as the annualized standard deviation of daily stock returns, and 4) tail risk measured as the negative of a BHC's average stock return over the worst 5% of return days in a year. CEO pay-share is the ratio of the CEO's annual total compensation to the total compensation of CEO and the next four most highly-paid executives in the same BHC. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. * denotes significance at the 0.10 level.

Table 4. Univariate tests.

Variable	Low CEO pay-share Mean	Low CEO pay-share Median	High CEO pay-share Mean	High CEO pay-share Median	Test of Differences Mean		Test of Differences Median	
Dependent variables:								
Z-score (Natural Logarithm)	3.12	3.16	3.15	3.18	0.03		0.02	
Distance to default	2.55	2.55	2.60	2.60	0.05	***	0.05	***
Equity volatility	4.11	4.07	4.01	3.99	-0.10	***	-0.08	***
Tail-risk	4.97	4.01	4.29	3.55	-0.68	***	-0.46	***
Main Variable								
CEO pay-share	0.24	0.26	0.50	0.47	0.26	***	0.22	***
Control variables:								
Size	4.40	4.02	3.49	3.26	-0.91	***	-0.76	***
Capital ratio	0.10	0.09	0.10	0.09	0.00		0.00	
Return on assets	0.03	0.03	0.03	0.03	0.00		0.00	
Loans to assets	0.53	0.62	0.63	0.66	0.10	***	0.04	***
Deposits to assets	0.46	0.49	0.55	0.57	0.09	***	0.08	***
Non-interest income	0.36	0.31	0.27	0.25	-0.09	***	-0.06	***

This table reports the results for two-tailed t-tests and Wilcoxon rank tests of differences in the mean and median between the BHCs with high CEO pay-share (those having a pay-share in the top 25%) and BHCs with low CEO pay-share (those having a pay-share in the bottom 25%). Here the dependent variable is BHC risk which is proxied by four alternative measures of risk: 1) the z-score measured by the sum of return on assets and equity to assets divided by standard deviation of return on assets; 2) distance-to-default calculated based on credit risk model of Merton (1974); 3) equity volatility measured as the annualized standard deviation of daily stock returns, and 4) tail risk measured as the negative of a BHC's average stock return over the worst 5% of return days in a year. CEO pay-share is the ratio of the CEO's annual total compensation to the total compensation of CEO and the next four most highly-paid executives in the same BHC. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. *** denotes significance at the 0.01 level.

Table 5. CEO pay-share and BHC risk

Variable	Z-score		Distance to default		Equity volatility		Tail risk	
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
CEO pay-share	0.0198	0.0258	-0.0670***	-0.0863***	-0.1946**	-0.1156*	-1.2335**	-0.7725*
	(1.24)	(1.64)	(-2.92)	(-3.47)	(-2.22)	(-1.64)	(-2.37)	(-1.96)
Size	-0.0043***	-0.0099**	0.0037	0.0160	-0.0157	-0.0841***	-0.0092	-0.1163
	(3.85)	(-2.44)	(1.21)	(1.30)	(-1.52)	(-4.91)	(-0.13)	(-0.76)
Capital ratio	-2.2151***	-3.4162***	-0.2533*	-0.2220	-0.2551	0.9720*	5.0475	0.1104
	(-8.86)	(-10.83)	(-1.79)	(-1.07)	(-0.60)	(1.66)	(1.28)	(0.04)
Return on assets	-2.0994***	-2.8587***	-1.3273**	-2.4368***	0.0490	-2.8924	-34.0068	-66.7319***
	(-5.39)	(-11.78)	(-2.23)	(-4.88)	(0.02)	(-1.46)	(-1.64)	(-3.66)
Loans to assets	-0.1584***	-0.0210	-0.0549***	0.0237	-0.2062**	0.2995**	-0.0986	0.9222
	(-11.89)	(-1.13)	(-2.59)	(0.71)	(-1.98)	(2.47)	(-0.20)	(1.08)
Deposits to assets	-0.0819***	0.0059	-0.1281***	-0.0666*	-0.1885***	-0.1846*	-0.8267*	-0.7145
	(-5.24)	(0.36)	(-7.88)	(-1.66)	(-3.14)	(-1.70)	(-1.95)	(-0.93)
Non-interest income	-0.0494***	-0.0496***	-0.1186***	-0.0795*	-0.0699	-0.1460	-0.2314	-0.3162
	(-4.01)	(-2.69)	(-4.93)	(-1.75)	(-0.77)	(-1.45)	(-0.62)	(-0.35)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BHC fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.9594	0.9879	0.5884	0.7152	0.6189	0.8196	0.7676	0.8680
F-stat.	942.43***	550.60***	52.99***	16.73***	60.43***	28.09	126.29***	45.33***
#BHCs/observations	134/1268	134/1268	124/1181	124/1181	122/1071	122/1071	124/1217	124/1217

Table 5. *Continued.*

The table reports the estimates of eight alternative versions of the following panel regression specification:

$$Risk_{i,t} = \alpha + \beta_1 CEOpayShare_{i,t} + \beta_2 Size_{i,t} + \beta_3 Capital\ ratio_{i,t} + \beta_4 Return\ on\ assets_{i,t} + \beta_5 Loans\ to\ assets_{i,t} + \beta_6 Deposits\ to\ assets_{i,t}$$
$$+ \beta_7 NoninterestIncome_{i,t} + \sum_{k=1}^{n-1} \alpha_k BHC_i^k + \sum_{y=1992}^{2016} \omega_y Year_i^y + \varepsilon_{i,t}$$

where the dependent variable $Risk_{i,t}$ is proxied by four alternative measures of risk: 1) the z-score measured by the sum of return on assets and equity to assets divided by standard deviation of return on assets; 2) distance-to-default calculated based on credit risk model of Merton (1974); 3) equity volatility measured as the annualized standard deviation of daily stock returns, and 4) tail risk measured as the negative of a BHC's average stock return over the worst 5% of return days in a year. CEO pay-share is the ratio of the CEO's annual total compensation to the total compensation of CEO and the next four most highly-paid executives in the same BHC. The control variables are defined as follows: *Size* is measured as the logarithm of total assets, *Capital ratio* is the ratio of equity to total assets, *Return on assets* is the ratio of net income to total assets, *Loans to assets* is the ratio of net loans to totals assets, *Deposits to assets* is the ratio of deposits to total assets, and *Non-interest income* is the ratio of non-interest income to total income. BHC_i^k is a dummy variable for BHC *i* and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and clustered at bank level. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 6. Regressions with CEO pay-share instrumented

	CEO pay-share	Z-score	Distance to default	Equity volatility	Tail-risk
Variable	First Stage	Model (1)	Model (2)	Model (3)	Model (4)
CEO pay-share - IV		0.0724	-0.1786 **	-0.5737 ***	-0.6300 ***
		(1.07)	(-2.46)	(-3.81)	(-4.60)
Instrument Variables					
Median pay-share	-14.4791 ***				
	(-2.72)				
Number of VPs	0.0092 ***				
	(2.97)				
CFO is VP	-0.0086				
	(-0.99)				
Full control variables	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Year & BHC	Year & BHC	Year & BHC	Year & BHC	Year & BHC
Adjusted R^2	0.6001	0.9898	0.7850	0.5904	0.6543
F-stat.	6.30 ***	414.08 ***	15.33 ***	32.04 ***	42.37 ***
#BHCs/observations	115/750	115/750	108/705	106/593	106/594

This table reports the results from 2SLS regression. Models 1 to 4 report the second stage results. Here I use three instruments: 1) Industry median pay-share – calculated for each year for each BHC by excluding the respective BHC, Number of VPs – number of vice presidents among the top five executives, and CFO is VP – a dummy variable which equals 1 if the CFO is also a vice president. In each regression, a full set of control variables, year fixed effects and bank fixed effects are used. The t-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and clustered at bank level. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 7. CEO pay-share and BHC policies

	Non-interest income		Deposits to assets		RE loans to assets		CI loans to assets		Securities to assets		Trading to assets	
	Model	Model	Model	Model	Model	Model	Model	Model	Model	Model	Model	Model
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
CEO pay-share	-0.185***	-0.063*	0.162***	0.038**	0.157***	0.032*	0.016	0.0257**	0.033	-0.038**	-0.096***	-0.004
	(-3.33)	(-1.88)	(3.74)	(2.19)	(3.42)	(1.94)	(0.93)	(2.34)	(1.58)	(-2.37)	(-4.76)	(-0.61)
Size	0.049***	-0.006	-0.057***	-0.023***	-0.051***	-0.006	-0.019***	-0.002	-0.013***	0.001	0.029***	0.003
	(19.89)	(-0.61)	(-19.05)	(-4.88)	(-20.10)	(-1.22)	(-9.67)	(-0.34)	(-4.66)	(0.16)	(17.12)	(1.26)
Capital ratio	0.969***	0.583***	-0.660***	-0.508***	-0.407***	-0.040	-0.142***	0.265***	-0.199	-0.960***	0.029	-0.204***
	(9.43)	(5.10)	(-5.78)	(-3.85)	(-3.66)	(-0.52)	(-2.83)	(3.65)	(-1.62)	(-4.72)	(0.48)	(-4.71)
Loan loss provision	-2.767***	-1.122***	2.082***	0.282	-0.448	0.882***	0.287*	0.398**	-2.544***	-1.377***	-0.687**	0.040
	(-4.08)	(-2.67)	(4.65)	(1.42)	(-0.39)	(4.96)	(1.77)	(2.48)	(-7.12)	(-4.05)	(-2.51)	(0.53)
Asset concentration	-0.013	0.044	-0.053**	0.066*	0.158***	0.396***	-0.299***	-0.233***	0.043**	0.056	0.012	-0.020**
	(-0.35)	(1.13)	(-2.24)	(1.74)	(5.72)	(11.82)	(-27.12)	(-10.41)	(2.10)	(1.27)	(1.32)	(-2.29)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BHC fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R2	0.2617	0.9050	0.3546	0.8501	0.3084	0.9429	0.3320	0.8736	0.0826	0.7794	0.3644	0.9615
F-stat.	14.76	64.15	22.77	37.97	18.57	111.18	20.71	46.54	4.91	23.01	24.31	162.72
#BHCs/obs.	132/1238	132/1238	132/1238	132/1238	132/1238	132/1238	132/1238	132/1238	130/1173	130/1173	130/1173	130/1173

Table 7 reports the estimates of twelve alternative versions of the following panel regression specification:

$$BHC\ activity_{i,t} = \alpha + \beta_1 CEO\ pay - share_{i,t} + \beta_2 Size_{i,t} + \beta_3 Capital\ ratio_{i,t} + \beta_4 Loan\ loss\ provisions_{i,t} + \beta_5 Asset\ concentration_{i,t} + \sum_{k=1}^{n-1} \alpha_k BHC_i^k + \sum_{y=1992}^{2016} \omega_y Year_i^y + \varepsilon_{i,t}$$

where the dependent variable *BHC activity*, is proxied by alternative BHC activities: 1) *Non-interest income* which is the ratio of non-interest income to total income; 2) *Deposits to assets* is the ratio of deposits to total assets; 3) *RE loans to assets* which the ratio of real estate loans to total assets; 4) *CI loans to assets* which is the ratio of commercial and industrial loans to total assets; 5) *Securities to assets* which is the ratio of total securities to total assets, and 6) *Trading to assets* which is the ratio of total trading assets to total assets. The control variables include: *Size* which is the natural logarithm of total assets, *Capital ratio* which is the ratio of equity to total assets, *Loan loss provisions* which is the ratio of the BHC's loan loss reserve to total assets, and *Asset concentration* which is the Herfindahl-Hirschman index (HHI) of BHC loans. BHC_i^k is a dummy variable for BHC i and $Year_i^y$ is a dummy variable for fiscal years. The reported adjusted R^2s are the overall R^2s which account for the explanatory power of the firm and year fixed-effects. The *t*-statistics (reported in parentheses) are based on robust standard errors, which are adjusted for heteroskedasticity and clustered at bank level. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Appendix 1. General procedure to calculate distance to default (DD)

The Merton (1974) model views the firm's equity value as a European call option on the firm's assets, with a strike price equal to the face value of the firm's liabilities. This is because of the shareholders' limited liability and their residual claim on the firm's assets. If the firm's value exceeds the level of liabilities (strike price) at the time of maturity, when the value of the equity is positive, shareholders exercise their option and the firm survives. If the firm's value falls below the level of liabilities (strike price) at the time of maturity, when the value of equity becomes zero, the model assumes shareholders do not exercise their option and the firm defaults. Thus, the larger the positive distance between firm value and firm liabilities, the lower is the probability of financial distress.

Value of firm (V_A) = value of equity (V_e) + Value of debt (X)

Value of equity (V_e) = Value of firm (V_A) – Value of debt (X)

Value of firm (V_A) > Value of debt (X) ➔ Value of equity (V_e) is positive (firm survives)

Value of firm (V_A) < Value of debt (X) ➔ Value of equity (V_e) is zero (firm defaults)

The Merton (1974) model has two important assumptions for the calculation of DD. First, it assumes that the value of the firm follows the geometric Brownian motion that is expressed as follows:

$$d\,V_A = \mu\, V_A dt + \sigma_A V_A dW \tag{A.1}$$

where V_A denotes the value of firm's assets, μ represents expected continuously compounded returns on the firm's assets, σ_A indicates instantaneous volatility of the firm's assets, and dW is a standard Wiener process.

Second, the model assumes that the firm has only two securities outstanding; namely, common stock and a zero coupon bond maturing at time (T).

Based on these two assumptions, the equity of the firm can be viewed as a call option on the value of the firm's assets, with a strike price equal to face value of the debt maturing at time T. Therefore, the market value of equity as a function of the total value of the firm's assets can be expressed by using Black and Scholes' (1973) formula for call options:

$$V_e = V_A N(d_1) - X\, e^{-rT} N\,(d_2) \tag{A.2}$$

where V_e is the market value of the firm's equity, X is the face value of the debt, r is the risk-free rate, T is the time horizon for the maturity of debt, N symbolizes the function of the cumulative standard normal distribution, and d_1 and d_2 are given by the following formulas:

$$d_1 = \frac{ln\left(\frac{V_A}{X}\right)+\left(r+\frac{1}{2}\sigma_A^2\right)T}{\sigma_A\sqrt{T}}, \qquad d_2 = d_1 - \sigma_A\sqrt{T} \qquad \text{(A.3)}$$

In Eq. (A.2), V_e, X, r, and T are readily observable and known factors, whereas V_A and σ_A are difficult to observe and are unknown factors. This means there are two unknowns in one equation, so a unique solution to Eq. (A.2) is not available. Thus, another equation involving one of the two unknown factors is required.

As in the Merton (1974) model, it is assumed that the value of the firm's equity is a function of the value of its assets and time, so the second equation that relates the volatility of the firm's equity to the volatility of the firm's assets can be written as:

$$\sigma_e = \left(\frac{V_A}{V_e}\right)\frac{\partial V_e}{\partial V_A}\sigma_A \qquad \text{(A.4)}$$

According to the Black-Scholes-Merton model, the term $\frac{\partial V_e}{\partial V_A}$ in Eq. (4) is equal to $N(d_1)$, and can be rewritten as follows:

$$\sigma_e = \left(\frac{V_A}{V_e}\right) N(d_1)\sigma_A \qquad \text{(A.5)}$$

Now, Eq. (A.2) and (A.5) can be solved simultaneously for the values of V_A and σ_A, and DD can be calculated by using the following equation:

$$DD = \frac{ln\left(\frac{V_A}{X}\right)+\left(\mu-\frac{1}{2}\sigma_A^2\right)T}{\sigma_A\sqrt{T}} \qquad \text{(A.6)}$$

The probability of default (PD) is calculated as follows:

$$PD = N(-DD) \qquad \text{(A.7)}$$

In a nutshell, for the calculation of DD, the following steps are required:

Estimating the volatility of the firm's equity (σ_e) through historical stock price data or option-implied volatility data. Historical stock price data to estimate the volatility of the firm's equity is easily available. Following the Hull (2009) methodology, equity volatility can be calculated as:

$$R_i = \text{Ln}(pr_t - pr_{t-1}) \tag{A.8}$$

where R_i is the daily stock returns, Ln is the natural logarithm, pr_t is the stock price at the end of the day and pr_{t-1} is the stock price at the end of the previous day: i =1, 2, 3…n.

Annualized volatility is then estimated as:

$$\sigma_e = \frac{1}{\sqrt{\frac{1}{n}}}\sqrt{\frac{1}{n-1\sum_{i=1}^{n} R_i^2} - \frac{1}{n(n-1)}\left(\sum_{i=1}^{n} R_i\right)^2} \tag{A.9}$$

where n denotes the number of observations in one year i.e., number of trading days.

Selecting the forecasting horizon (T). Generally, the forecast horizon is one year (T=1).

Measuring the face value of the debt (X). Generally, current liabilities plus half of the non-current liabilities are used to proxy the face value of debt, as also advised by Moody's KMV.

Collecting the risk-free rate (r). 3-month bank accepted bill or T-bills can be used to proxy risk-free rate.

Measuring the market value of equity (V_e). It is calculated as the number of outstanding shares multiplied by market price per share.

Solving Eq. (A.2) and (A.5) simultaneously for the values of (V_A) and(σ_e), and then calculate the DD using Eq. (A.6) and PD using Eq. (A.7).