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Keywords

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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 "better" corporate governance increased insolvency risk relatively more for larger financial institutions and during the period of the global financial crisis. Our findings suggest that too-big-to fail and deposit insurance policies encourage excessive risk taking by financial institutions.

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

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

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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 advocates 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. In this regard, John, Litov, and Young (2008) show that 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 excessive risk taking by financial institutions during the financial crisis. Thus, stronger corporate governance practices encourage rather than constrain excessive risk-taking in the financial industry (Iqbal et al., 2015) which may lead to the default of financial institution. Therefore, in this paper, we investigate whether corporate governance affects the insolvency risk of financial institutions.

'Stronger'[1] corporate governance not only affects the performance of the firms (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). However, for financial institutions, the optimal degree of risk taking is different than for non-financial firms because financial institutions have deposit insurance subsidy (e.g., Merton, 1978) which benefits them if they become distressed. This financial safety encourages financial institutions to take excessive risks and since larger financial institutions are considered "too-big-to-fail" by regulators, they can benefit relatively more from deposit insurance at a substantial cost to stakeholders (see Acharya, Anginer and Warburton, 2016). This "too-big-to-fail" phenomenon creates moral hazard problems and shareholder-friendly governance mechanisms may further encourage managers to adopt riskier corporate policies (Chava and Purnanadam, 2010) which may, in turn, lead to higher insolvency risk in financial institutions. Although managers are more risk averse than shareholders (Jensen and Meckling, 1976) the presence of deposit insurance in financial institutions, especially in banks, may affect the relationship between corporate governance mechanisms and risk-taking in financial institutions (Anginer, Demirguc-Kunt, Huizinga, and Ma, 2014) and stronger corporate governance mechanisms in financial institutions can lead to greater risk-taking. Therefore, we hypothesize that strong corporate governance mechanisms are positively associated with insolvency risk of financial institutions.

[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 (2015) provide comprehensive discussions about the corporate governance of financial institutions and the elements of "good" governance.

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 advertise that it is preferable because it also accounts for creditors risk (Colonello, 2016; Feldhutter, Hotchkiss, and Karakas, 2016). Despite growing literature on the relationship between CDS spread and corporate finance issues, surprisingly little is known about the relationship between corporate governance mechanisms and CDS spread. We extend this growing literature by empirically examining whether the strength of corporate governance mechanisms affects CDS spread for financial institutions.

In summary, we find that the insolvency risk of financial institutions, proxied by 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 significantly stronger 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). These findings suggest that stronger corporate governance mechanisms may encourage excessive risk-taking in the financial industry and the deposit insurance subsidy could also be a contributing factor to excessive risk-taking. Since financial institutions are entering into more complex activities and have broadened their scope, this effect has 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 share-holder-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 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. It is therefore timely and imperative to empirically examine the association between the shareholder-friendliness of corporate governance mechanisms and insolvency risk for a large sample of U.S. financial institutions around the period of the recent global financial crisis.

We contribute to the literature in the following ways. First, we contribute to the growing body of 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, 2013; 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 (2013) 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 insolvency risk of financial institutions.

Second, we contribute to the literature on the effects of corporate governance on risk taking by financial institutions (see Laeven and Levine, 2009; Pathan, 2009; Fahlenbrach and Stulz, 2011; Beltratti and Stulz, 2012; Peni and Vahamaa, 2012; Berger et al., 2014; Iqbal et al., 2015)[2]. These studies mainly find that shareholder-friendly corporate governance mechanisms encourage excessive risk-taking in the financial industry. For instance, Pathan (2009) finds that board size can affect the risk-taking in banks and show that banks with larger boards take less risk. Further, 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 level 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 that can cause 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[3]. Further, most of the previous studies on board effectiveness do not include financial institutions

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

[3] Adams et al. (2010) survey literature on the role of the board of directors. de Haan and Vlahu (2015) also provide detailed discussion on corporate governance and risk taking in the financial industry.

in their sample (see Adams et al., 2010). 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.

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 our 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[4]. Lastly, data on financial statement and balance sheet variables is collected from BankScope of Bureau Van Dijk.

[4] 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.

Starting from the entire population of U.S. financial institutions (commercial banks, investment banks, non-bank lending institutions, and financial services firms) in Corporate Governance Quotient database, 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 taken from BankScope. This leaves us with a final sample of 556 individual financial institutions and an unbalanced panel of 2126 firm-year observations.

3.1. 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 statement through which these models are derived (Agarwal and Taffler, 2008). On the other hand, 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).[5] Empirical studies such as Hillegeist et al. (2004) recommend researchers to 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 in gauging insolvency risk (see appendix A: general procedure to calculate DD). CDS are credit derivatives that allow the transfer of the firm's default risk between two agents for a predetermined time period. 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.[6] 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 higher is the CDS spread. Tang and Yan (2010) find that the CDS spread captures the major 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 extract 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"[7]. 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

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[5] 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.

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

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

risk-neutral that is why no upfront fee is initially required. Therefore, actuarial spread has the same features as the standard CDS spread.

3.2. 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)[8]. We obtain these data from RiskMetrics Group. *CGQ* is comprehensive corporate governance index which comprises of 67 different firm-related characteristics including internal and external governance. For instance, different mechanisms included in *CGQ* include 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* 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 four sub-indices, called board, compensation and ownership, auditing and takeover that summarize information different attributes related to the various 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 may take values from 1 to 5, with higher values of the index representing stronger, more shareholder-friendly mechanisms.

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[8] 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).

3.3. 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. We control for firm size, profitability, growth, and assets as well as income structure. When comparing financial institutions, size is the most important control variable. The size (*Size*) variable is constructed as the log of a financial institution's total assets. This approach is also consistent with the previous studies. Larger financial institutions may pursue riskier strategies, if they are considered to be "too-big-to-fail". Moreover, Brunnermeier et al. (2012) show that larger financial institutions are also systemically important. Secondly, in previous literature, capital ratio (or leverage ratio) is used when comparing financial institutions. However, in this study we do not include capital ratio as both our measures for insolvency risk (DD and CDS) have equity as a main constituent in their calculation.

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. 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. The definitions of variables are summarized in Table A.

(insert Table A about here)

4. Empirical analysis

4.1. Descriptive statistics and correlations

Table 1 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 50.2. Further, the corporate governance sub-indices, board, compensation, audit, and takeover, also vary from lowest (0) to the highest (5) suggesting that our sample of financial institutions is diverse in terms of very weak and very strong corporate governance mechanisms. In addition to this, our sample is also quite heterogeneous in terms of insolvency risk. It can be noted from Table 1 that *DD* has a minimum value of -2.2 and a maximum value of 20.7. Moreover, *CDS* varies from a minimum of -2.4 to a maximum of 7.9 with a mean value of 3.6.

Table 1 further depicts that our sample is also quite heterogeneous in terms of control variables. The sample contains small and large U.S. financial institutions. There is considerable variation in size ranging from 12.7 million to 2.26 trillion USD. In brief, our sample of U.S. financial institutions is very heterogeneous.

(insert Table 1 about here)

Table 2 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 (positive) correlation with *DD* (*CDS*),[9] suggesting better governed financial institutions have a greater level of insolvency risk. Moreover, as expected, the two insolvency risk variables, *DD* and *CDS*, are inversely correlated by construction (r=0.93). As the correlation results do not control the factors that affect financial distress, they should be viewed with caution.[10] The correlations also indicate that larger financial institutions have less insolvency risk.

(insert Table 2 about here)

4.2. 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 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 weaker corporate governance structures, that is, those with CGQ values in bottom

[9] 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.
[10] 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).

30 percent. After creating two groups based on the strength of corporate governance mechanisms, we check for the difference in means by performing two-tailed *t*-tests.

(insert Table 3 about here)

We report the results of the univariate analysis in Table 2. We find that the two groups are significantly different in many respects. First, the difference of means between the two groups 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.

4.3. 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: distance to default and CDS spread for financial institution *i* at time *t*. First, 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 (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 strength of the institution's corporate governance mechanisms or one of the sub-indices namely; board index, compensation and ownership index, auditing index, and takeover index which summarizes information regarding different corporate governance mechanisms. In order to capture the effect of global financial crisis we also estimate the modified versions of Equation (1) where we include the interaction variable *Governance* × *GFC*. Where GFC denotes the crisis year 2008. Further, we also use the interaction variable *Governance* × *Size* in order to investigate the effect of the size of the financial institution.

As discussed earlier, we use several firm-level control 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). These control variables are defined as follows: *Size* is measured as the logarithm of 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, 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.

Table 4 reports the estimates of 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-effect, and Models 3 and 8 include both year and firm fixed-effects along with full set of control variables. Further, Model 4 and 9 include interaction variables *CGQ* × *GFC* and *BoardQ* × *GFC* respectively 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 the models are almost 50 percent. The *F*-statistics for all the ten alternative regressions are statistically significant at the 1 percent level.

(insert Table 4 about here)

Table 4 illustrates that the overall corporate governance index has a negative and statistically significant coefficient in Models 1, 2, 3, 6 and 7, suggesting that more shareholder-friendly corporate governance increases insolvency risk of financial institutions. Moreover, in Models 4 and 9, the negative effect is stronger during the period of the financial crisis and in Models 5 and 10, the negative effect is also stronger for larger financial institutions. This shows greater insolvency risk during financial crisis period and also suggests that larger financial institutions take on more risk as they benefit from a “too-big-to-fail” status. In summary, Table 4 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 4 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, 2015; Iqbal et al., 2015). Our results are also economically significant. For instance, the change in CGQ from 25th percentile to 75th percentile is associated with up to a 7.28 percent increase in the insolvency risk of financial institutions (see Table 6) and during the global financial crisis, the increase in insolvency risk rises to 7.81 percent. We measure the economic significance 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. We then divide this variation by the average insolvency risk.

(insert Table 5 about here)

Table 5 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 4 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 of 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 4. All the coefficient estimates in Table 5 are positively associated with CDS spread indicating that stronger corporate governance mechanisms are associated with greater insolvency risk. This effect is even stronger during the period of financial crisis and for larger financial institutions. These findings provide further evidence that insolvency risk of financial institutions is positively associated with shareholder-friendly corporate governance mechanisms. Bigger financial institutions may be riskier, because they expect a bailout by regulators in case of insolvency since they benefit from "too-big-to-fail" status. 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 6) and during the global financial crisis the increase in insolvency risk as measured by CDS spread is up to 3.39 percent.

(insert Table 6 about here)

(insert Table 7 about here)

Table 7 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.

Table 7 depicts how 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 8 about here)

Table 8 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 7 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 7 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 4, 5, 7, and 8, 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, 2015) highlights that strong, shareholder-friendly governance practices may encourage excessive risk-taking in the financial industry in order to increase shareholders' wealth. We provide empirical support for this argument.

4.4. Addressing endogeneity

We recognize that the coefficients reported in Tables 4 and 5 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.

4.4.1 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 4 and 5 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.

4.4.2. Propensity score matching

To further eliminate the endogeneity bias, we conducted 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 9 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 9 and the same control variables are included as in Table 4 and Table 5. 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.

We then ensure that financial institutions with stronger corporate governance mechanisms (the treatment group) are (sufficiently) similar to the matched financial institutions with CGQ lower than median (the control group) by adopting the nearest neighbor criteria. 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 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 9. 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 9 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 9, respectively. As is evident in Panel C of Table 9, 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 9 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 lead to greater insolvency risk in the financial industry.

4.5. 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 4 and 5. The regression results (not tabulated) 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 instruction does 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 the 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 4 and 5 with this restricted sample. The regression results (not tabulated) are similar to our previous findings in Tables 4 and 5, 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 financial institutions from the main sample. The re-estimated regression results (not tabulated) for the subsample without the smallest 10 percent of financial institutions are quite similar to our main results reported in the Tables 4 and 5, 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 4 and 5 based on this sample. We observe, based on empirical results (not tabulated), 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.

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 to infer that in financial institutions stronger and more shareholder-friendly governance mechanisms can lead to a higher level of insolvency risk.

5. Conclusions

Given the high-profile failures of financial institutions (e.g., Lehman Brothers) during the global financial crisis, investors and regulators are looking skeptically at global financial markets. The financial crisis is arguably related to the unethical behavior of corporate executives and failures of corporate governance to curtail excessive risk-taking in financial institutions. Our study, therefore, is important to provide insight on the implications of the corporate governance in financial institutions which are encouraged to take on too much risk owing to the presence of financial safety net. 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 showing that the presence of a financial safety net for financial institutions if they become distressed, together with shareholder-friendly corporate governance, encourages corporate executives to take on extra risk which might ultimately lead to insolvency.

Since the global financial crisis is particularly associated with excessive risk taking, 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 excessive risk taking by financial institutions. We also explored the "too-big-to-fail" phenomenon that encourages financial institutions to take excessive 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 together with policies like "too-big-to-fail" and financial safety nets can encourage excessive risk taking, which can cause instability in the overall financial system. Overall, our results require corporate governance reforms to address financial safety net and "too-big-to-fail" issues and reduce moral hazard leading to excess risk taking by financial institutions. Without such reforms, stronger corporate governance mechanisms in the financial industry may result in undesirable outcomes.

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Table A. 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
Bank 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 1. Descriptive statistics.

Variable	Mean	St.dev	Min	Max	P25	P75	Observations
<u>*Dependent variables:*</u>							
DD	1.89	1.79	-2.04	20.71	0.67	2.89	2126
CDS	3.89	1.54	-2.40	7.89	2.96	4.88	2126
<u>*Corporate governance variables:*</u>							
CGQ	51.42	26.63	0.50	100.00	29.90	73.70	2342
BoardQ	2.94	1.32	0.00	5.00	2.00	4.00	2342
Compensation	3.45	1.34	0.00	5.00	2.00	5.00	2342
Audit	3.14	1.54	0.00	5.00	2.00	5.00	2342
Takeover	2.95	1.26	0.00	5.00	2.00	4.00	2342
<u>*Control variables:*</u>							
Size	14.48	1.72	9.45	21.54	13.43	15.10	2342
Return on assets	0.41	2.54	-18.42	44.31	0.13	1.05	2338
Loans to assets	67.14	15.24	0.00	93.54	61.04	76.64	2292
Loan growth	7.30	24.79	-84.15	704.49	-2.67	12.92	2132
Deposits to assets	0.77	0.15	0.00	0.98	0.74	0.86	2322
Non-interest income	23.97	38.57	-938.37	271.50	13.90	31.52	2331

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 2. 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.

Table 3. Univariate tests.

Variable	Strong Governance Mean	Weak Governance Mean	Diff. in Means	
Dependent variables:				
CDS	3.7536	3.3743	0.3782866	***
DD	2.0651	2.5243	-0.459197	***
Explanatory variables:				
CGQ	86.4921	14.4276	72.06444	***
BoardQ	4.3848	1.4919	2.892917	***
Compensation	4.1202	2.5189	1.60126	***
Audit	3.7986	2.4191	1.37949	***
Takeover	3.2746	2.9416	0.3330693	***
Control variables:				
Total assets	14.6783	14.6489	0.0296883	
Return on assets	0.1565	0.5261	-0.3695937	***
Loans to assets	66.5127	67.4004	-0.8876757	
Loan growth	5.0647	7.9700	-2.905315	***
Deposits to assets	0.7743	0.7718	0.0025219	
Non-interest income	23.3517	22.9185	0.4332103	

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 4. 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	0.0138					
	(-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 4. *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 5. 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 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	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 6. Economic significance analysis.

Insolvency risk proxies	Change in CG 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

Table 7. 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 7. *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 R^2	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 8. 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 8. *Continued*.

Variable	Model (1)		Model (2)		Model (3)		Model (4)		Model (5)		Model (6)	
<u>*Control variables:*</u>												
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 R^2	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* g*rowth* 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. 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 9. 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

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:

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

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:

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

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:

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

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

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

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