SIZE, LEVERAGE, AND RISK-TAKING OF FINANCIAL INSTITUTIONS

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Size, Leverage, and Risk-taking of Financial Institutions

Thesis directed by Provost Professor of Finance Sanjai Bhagat

We investigate the link between firm size and risk-taking among financial institutions during the period of 1998—2008 and make four contributions. First, size is positively correlated with risk-taking measures even when controlling for other observable firm characteristics, such as market-to-book asset ratio, corporate governance, and ownership structure. This is consistent with the notion that "too-big-to-fail" policies distort the risk incentives of financial institutions. Second, a simple decomposition of the risk measure, the Z-score, reveals that financial firms engage in excessive risk-taking mainly through leverage. Third, we find that the recently developed governance variable, measured as the median director dollar stockholding, has a substantial impact on reducing firms' risk-taking. Lastly, investment banks are generally riskier than commercial banks. These findings suggest that rather than capping the firm size, it is more effective for policymakers to control a financial firm's risk-taking by strengthening regulations on capital requirement; they also provide justification for the functional separation of investment banking from wholesale financial services. In terms of corporate risk management policy, these findings suggest that the excessive risk-taking problem can potentially be attenuated by focusing on the governance structure.

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CHAPTER 1

Introduction

"Too-big-to-fail policies offer systemically important firms the explicit or implicit promise of a bailout when things go wrong. These policies are destructive, for several reasons. First, because the possibility of a bailout means a firm's stakeholders claim all the profits but only some of the losses, financial firms that might receive government support have an incentive to take extra risk. The firm's shareholders, creditors, employees, and management all share the temptation. The result is an increase in the risks borne by society as a whole."

———— The Squam Lake Report: Fixing the Financial System

Too-big-to-fail (TBTF) is a concept that governments have to bail out a failing financial institution (FI) because its failure may present a threat to the proper functioning of the financial intermediation process and cause severe disruption to the economy. When firms are perceived TBTF, they may have a propensity to assume excessive risks to profit in the short term. Indeed, TBTF policy has been blamed by many, including the Obama administration, as one of the main factors causing distortion in financial firms' risk-taking incentives, which played a pivotal role in the recent financial crisis. The risk distortion resulting from TBTF policies are often referred to as the "moral hazard" problem in the finance literature.[1]

In turn, policy makers propose an array of regulations to reshape financial institutions. Specifically designed to address the TBTF issue, suggestions such as limiting the size of financial institutions have been proposed by the Obama administration along with academics.[2] The reason for dealing with size directly is that the regulators believe that the larger the firm is, the more likely it is systematically important or TBTF.[3] On the one hand, proponents of such a proposal argue that it will deter financial firms from becoming so large that they put the broader

[1] See Boyd, Jagannathan and Kwak (2009) for a detailed description of this problem

[2] See, for example, "Proposal Set to Curb Bank Giants", Wall Street Journal, January 21, 2010, A2. Boyd, Jagannathan and Kwak (2009) and Walter (2009) also propose size limits on firms.

[3] We use the term TBTF and systematically important interchangeably hereafter.

economy at risk and distort normal competitive forces. Indeed, Baker and McArthur (2009) estimate that the gap of funding costs between small and TBTF firms averaged 0.29 percentage points in the period 2000 through 2007, and that this gap widened to an average of 0.78 percentage points from 2008 through 2009. Rime (2005) finds that the TBTF status has a significant, positive impact on bank issuer ratings. Lastly, using an international sample of banks, Kemirguc-Kunt and Huizinga (2011) find that systemically large banks achieve lower profitability and operate with higher risk. Their results suggest that it is not in the bank shareholders' interests but is in managers' interests for a bank to become large relative to its national economy as it hurts the owners but benefits managers through higher manager pay and status. On the other hand, many problems are associated with this reform. First of all, it is practically impossible to determine the correct size threshold; secondly, this simple size metric will still miss many small firms that perform critical payment processing and pose significant systemic risk, even if the first issue can be solved (Stern and Feldman, 2009). In addition, opponents of such a proposal often cite the literature on scale of economy and are concerned such restraint could weaken the global competitiveness of the U.S. financial industry and cause loss of market share. Further, Dermine and Schoenmaker (2010) argue that capping the size is not the best tool, based on the finding that countries with relatively small banks faced large bailout cost; in addition, they caution that capping the size can have unintended effects, such as a lack of credit risk diversification.

Is size the problem? This paper attempts to shed light on the issue by studying the size effect on the risk-taking of financial institutions, including commercial banks, investment banks and life insurance companies. Using data on the size and risk-taking of financial institutions from 1998 to 2008, we investigate whether cross-sectional variation in the scale of firms is related to heterogeneity in risk-taking. Our measures of risk-taking are comprehensive. They include a model-based measure such as the Z-score[4], a market-based measure that captures market's perception about firms' risk-taking such as volatility of stock return, and an accounting-based measure that such as write-downs.[5] We focus primarily on Z-score; the other risk measures serve as a robustness check. Our baseline analysis is to regress the Z-score on firm size along with other firm characteristics.

If size does affect risk-taking as measured by Z-score, then an interesting question is, how does size affect the components of Z-score? This question is interesting because if we can find out what factors might drive the relation between firm size and risk-taking, we can target the risk-taking problem of financial institutions more directly. We argue that if limiting the size focuses on exclusively the normative aspects of the issue of risk-taking, then the factor analysis would address the positive aspects of the problem. We answer this question by regressing each of the components of Z-score on firm size and other firm characteristics.

Motivated by proposals that would treat TBTF firms differently.[6] we also investigate whether TBTF firms behave differently from small firms as a natural extension to our baseline analysis. We first define firms as TBTF when they pass a commonly-agreed size threshold (for example, $10 billion in assets), then interact the TBTF firm dummy with size. We establish the following findings. First, firm size is positively correlated with risk-taking, even when controlling for observable firm characteristics such as market-to-book ratio and ownership

[4] Z-score measures the distance to default and a higher Z-score implies more stability. It is calculated as the sum of return on asset and capital asset ratio divided by volatility of asset return. Theoretic development of this variable from Boyd and Runkle (1993) is attached in Appendix A. Z-score has been used extensively as a measure of bank risk recently; see, for example, Boyd, De Nicolo, and Jalal (2006); Laeven and Levine (2009); Houston, et al (2010); Beltratti and Stulz (2010).

[5] See Chesney, Stromberg and Wagner (2010) for a description of this variable.

[6] For example, the Obama administration proposes using tax policy to punish large banks based on their exposure to risk. See "White House's Tax Proposal Targets Big Banks' Risks", Wall Street Journal, January 14, 2010.

structure, which are believed have an effect on risk-taking. For instance, a one-standard deviation increase in size will decrease Z-score by 4 points, which is sufficient to make a capital-constrained firm fail. To ensure that that our result is not contaminated by the issue of endogeneity, as prominent in the corporate finance research, we apply the identification strategy of instrumental variable, where we instrument our endogenous variable, firm size, with the dummy variable for whether a firm is incorporated in Delaware. To further rule out the possibility that our result is driven by any firm-specific unobservable effect, we employ the firm fixed-effect model. We show that our result holds when these additional concerns are taken into consideration.

The analysis of decomposing Z-score reveals that firm size has a significant, negative impact on capital asset ratio but not on return on asset or earnings volatility. These findings suggest that financial firms engage in excessive risk-taking mainly through increased leverage. On the other hand, they also suggest that economy of scale does not exist, which is consistent with existing literature. Regressions with volatility of stock return as a dependent variable indicate that size-related diversification may not exist in the financial sector since size is positively associated with return volatility.

Second, we find that the newly developed corporate governance measure, calculated as median director dollar stockholding, is negatively associated with risk-taking for all risk measures, and they are significant at a 1% level across all specifications and estimations. Lastly, we find that investment banks, but not insurance companies, engage in more risk-taking compared to commercial banks. However, this result is not driven by leverage since investment banks on average are less leveraged than commercial banks.

While there is a substantial literature that examines the risk-taking behavior of financial institutions (see Saunders, Strock and Travlos, 1990; Demsetz, Saidenberg and Strahan, 1997; Stiroh, 2006; Laeven and Levine, 2009; Houston et al, 2010; and Demirguc-Kunt and Huizinga, 2011), to our knowledge, we are the first to study comprehensively the relation between size and risk-taking of financial institutions (see Table I for a detailed comparison of this study with existing literature on the risk-taking of financial institutions). The gap is surprising because the TBTF phenomenon is not new,[7] and one might think this question would have been settled a long time ago. While Boyd and Runkle (1993) is the closest to this study, there are significant differences. First, the motivation is different. Their study is motivated by two theories related to banking firms – deposit insurance and modern intermediation theory – while ours is motivated by the political debate about capping the financial firm's size. Secondly, the scope of their study is limited by focusing on only large bank holding companies (BHCs), while our sample includes commercial banks, investment banks and insurance companies, and they have a large variation in size. We argue that, since the recent financial crisis was not caused by bank holding companies alone, excluding these important components will not provide a complete picture about risk-taking in the financial industry. Lastly, the inference of Boyd and Runkle (1993) is also limited because in their empirical test, the only explanatory variable is size, which is more like a univariate analysis. Ours, on the other hand, includes covariates which in theory might affect firm's risk-taking. Another paper which is close to ours is Demsetz and Strahan (1997), who provide evidence that diversification and size are highly correlated in BHCs. Since BHC size is not correlated with stock return variance in many years of their sample period, they conclude that

[7] The existence of TBTF policy was first admitted by federal government in 1984 when the Comptroller of the Currency contributed roughly $1 billion to save Continental Illinois Bank from default. See Morgan and Stiroh (2005).

size-related diversification does not translate into reductions in risk. In their regression analysis, however, they find that firm size has a significant effect in reducing firm-specific risk.

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Table I

Comparison of this research with existing literature

Study	Sample period &size	Data source & screens	Dependent Variable (risk)	Firm Size	Sign	Variable of interest	Other independent variables
Sauders, Strock and Travlos (1990)	1978-1985 38	Call Report Bank holding company only	Standard deviation of dairly stock return	Total asset	+	Insider ownership	Insider ownership Capital asset ratio Operating leverage
Boyd and Runkle (1993)	1971-1990 122	Annual COMPUSTAT data Bank holding company only Total asset >$1 billion Require 5 consecutive years	Z-score Standard deviation of ROA Equity/asset	Log of total asset	-	Size	
Demsetz and Strahan (1997)	1980-1993 134	Bank holding companies only Y-9C Report & CRSP Trading weekds >30	Firm-specific risk (σ(ε))	Log of total asset	-***	Size	Capital asset ratio squared Loan characteristics
De Nicolo (2000)	1988-1998 419	Worldscope Bank holding company only Require at least 3 year data	Z-score Volatility of ROA Equity asset ratio ROA	Log of total asset	-**	Size	Asset growth rate
Boyd, De Nicolo and Al Jalal (2006)	June, 2003 2500	Small banks Operate only in rural non-Metropolitan Statistical Areas	Z-score Equity asset ratio	Log of total asset	-***	Bank competition	Bank Competition Country controls
Stiroh (2006)	1997-2004 400	Y-9C Bank holding companies only	Standard deviation of weekly stock return	Log of asset	-***		Log of equity asset ratio Loan & income controls
Laeven and Levine (2009)	1996-2001 270	Bankscope&Bankers Almanac 10 largest public banks in each country	Z-score	Log of total asset	-*	Cash flow right	Cash flow right Country controls
Houston et al (2010)	2000-2007 2400	BankScope Banks only Cross-country study	Z-score ROA Capital asset ratio Volatility of ROA	Log of total asset	+***	Creditor right	Log of total asset square Credit rights Country controls
This Paper	1998-2008 302	Compustat & Proxy statement Commercial bank, investmnet bank and insurance	Z-score Write-down Volatility of stock return	Log of total asset Log of total avenue	-**	Size Governance	Market to book Corporate governance CEO ownership Industry controls

Our paper builds on the literature related to economy of scale. Berger and Mester (1997) estimate banking returns to scale using a U.S. bank sample for the 1990s to find an optimal banking size of around $25 billion in assets. Hughes and Mester (1997) find that banks of all sizes enjoy significant scale economy when financial capital is considered as a mechanism for signaling risk to less informed investors, and that bank managers are assumed risk-averse. They argue that scale economy exists because as banks grow larger, they are able to economize on the use of financial capital, and the cost of signaling risk decreases. In line with this, Hughes, Mester, and Moon (2001) offer evidence that scale economies so often cited by merging banks do, indeed exist, but are elusive. They argue this is because these scale economies are influenced by banks' risk-taking and can, in fact, be obscured by risk-taking.

Our study also contributes to the broader literature on governance (see Gompers, Ishii and Metrick, 2003; Bebchuk, Cohen and Ferrell, 2009; and Brown and Caylor, 2006) by incorporating a new measure of corporate governance, namely, the median director dollar stockholding (see Bhagat and Bolton, 2008) and by offering empirical evidence that the new measure has a significant impact in reducing the risk-taking of financial institutions.

Our analysis is crucial from a public policy perspective because the risk-taking behavior of financial institutions affects financial and economic fragility, business cycle fluctuations, and economic growth (see Bernanke, 1983, Calomiris and Mason, 1997, 2003a, b, and Keely, 1990). Our findings have important policy implications that are particularly relevant today, as the calls for strict restrictions and reinforcement of corporate governance on financial sector accelerate.[8] First, they suggest that instead of capping the firm size, it is more effective for regulators to strengthen and enhance regulations on capital requirements for all FIs. Secondly, our finding on

[8] See The Art and Science of Risk Management, 2009 Federal Reserve Bank of Chicago Annual Report.

corporate governance indicates that median director dollar stockholding can be used as an effective internal corporate risk control mechanism. Our last finding provides justification for the functional separation of investment banking from wholesale financial services, as pointed out by Walter (2009).

The paper is organized as follows. In Chapter 2, we review the existing literature and develop the hypotheses. Chapter 3 summarizes the data. Chapter 4 presents core results. Chapter 5 compares the marginal effect of size on risk-taking between TBTF firms and non-TBTF firms. Chapter 6 concludes with policy implications.

CHAPTER 2

Literature review and hypotheses development

The recent financial crisis has generated tremendous interest in the study of risk-taking of financial institutions (FIs). A variety of issues have been considered by researchers. For instance, in a cross county study, Laeven and Levine (2009) analyze the relation between bank risk-taking, bank governance (measured by cash flow rights), and national bank regulations. Specifically, they investigate how governance and national regulations jointly shape the risk-taking behavior of individual banks. Based on a sample of the largest 279 banks in 48 countries, they find that cash flow right plays a critical role in shaping banks' risk-taking to the extent that the actual sign of the effect of regulation on risk varies with ownership concentration. Beltratti and Stulz (2010) exploit variation in the cross-section of performance of large banks across the world during the period of the financial turmoil. They document that banks with dispersed ownership have lower idiosyncratic risk, and that banks with more non-interest income are associated with higher idiosyncratic risk. Based on a U.S. sample of FIs, Cheng, Hong and Scheinkman (2010) investigate whether compensation structure contributes to excessive risk-taking. They find that risk-taking, measured as firm beta, return volatility, etc., are correlated with short-term pay such as options and options. Their main result suggests that, besides the greediness of management, investors' short-termism may also have contributed to the crisis by encouraging management to engage in excessive risk-taking. In a similar context, Balachandran, Kogut, and Harnal (2010) find that equity-based pay such as restricted stock and options increases the probability of default of financial institutions, while non-equity pay such as cash bonuses decreases it. Lastly, Bolton, Mehran, and Shapiro (2010) propose addressing the excessive risk-taking by tying executive compensation to both stock and debt prices.

We focus on size-related risk distortion in this study; we construct a few hypotheses drawn from the moral hazard and risk-taking literature. This first is the view of moral hazard in financial firms due to the TBTF policies. Moral hazard is a concept that refers to the distortion of incentives caused by insurance; it occurs when a party insulated from risk may behave differently than it would if it were fully exposed to the risk. In banking, this distortion of behavior may happen for a variety of reasons, such as protection of bank creditors provided by the Discount Window, Deposit Insurance, and especially the TBTF policy. With the government safety net in place, the downside risks of FIs are limited: TBTF firms know they will be bailed out by passing their losses to the government and taxpayers when their bets go sour while keeping all the profits when gambles succeed. Since firm size is positively correlated with the likelihood of being TBTF, it follows that, as firms become larger, they are more likely to engage in excessive risk-taking. This strand of literature includes Boyd and Runkle (1993), Boyd, Jagannathan and Kwak (2009), and Walter (2009), to name just a few.

The role of corporate governance in coping with risk is not obvious. Standard theory on corporate governance predicts that firms with better governance increase firm value by adopting projects with positive net present value (NPV).[9] However, it does not preclude the possibility of projects with risky cash flows. Therefore, it might be in the interest of shareholders to take risky projects as long as they are value-enhancing. In addition, option theory (Black and Scholes, 1973) tells us that, all else being equal, the value of option increases with volatility of the underlying asset. Since a company's shareholders are essentially holding a European call option with the total value of the company as the underlying asset, and the value of debt as the striking price (assuming the firm has risky debt), it follows that the more volatile the company's cash flow is, the more valuable the call option is. Thus, the value of common stock increases. Based on these arguments, we would expect a positive association between corporate governance and risk-taking.

This relation, however, can go in the opposite direction. As Rajan (2006) and Diamond and Rajan (2009) pointed out, the compensation structure is different in the finance industry in that the performance of CEOs is evaluated based in part on the earnings they generate relative to their peers. With this pressure, executives have incentives to take excessive risk to profit in the short run even if they are not truly value-maximizing — a term coined "short-termism" in banking literature (see Cheng, Hong, and Scheinkman, 2010). As noted in Diamond and Rajan (2009), "even if managers recognize that this type of strategy is not truly value-creating, a desire to pump up their stock prices and their personal reputations may nevertheless make it the most attractive option for them"(p.607). If these researchers are right, we would expect FIs with better governance to have set incentives and controls to avoid taking risks that did not benefit shareholders. Thus, we should see a negative relation between corporate governance and risk-

[9] Gompers, Ishii and Metrick (2003) provide evidence that firms with better governance have higher firm value; Bhagat and Bolton (2008) have similar findings.

taking.[10] We argue that Diamond and Rajan (2009) is more relevant to our study since it is specifically tailored to financial institutions; we expect a negative association between corporate governance and risk-taking.

The third hypothesis is based on the fact that commercial banks and insurance companies have relatively stricter regulations compared to investment banks, so we expect the risk-taking of commercial banks and insurance companies to be more constrained. The last one is motivated by the proposed differential treatment of big vs. small firms, and it extends the first hypothesis and argues that firms in different size cohorts behave differently. These hypotheses are summarized as the following:

H1. *On average, bigger FIs are riskier than small FIs. The exact size beyond which government will bail out the troubled firm is unknown, but generally we expect the likelihood of government rescue is bigger for large FIs than for small FIs.*

H2. *The effect of corporate governance on firm risk-taking is negative.*

H3. *Investment banks are riskier than commercial banks are.*

H4. *Conditional on whether a FI is TBTF firm, the marginal effect of size on risk is higher for systemic important firms than non-systemic firms.*

CHAPTER 3

Sample collection and variable construction

Our main sources of data are Compustat, the Center for Research in Security Prices (CRSP), RiskMetrics, and Bloomberg supplemented by hand-collected data from companies' SEC filings

[10] Indeed, as argued by John, Litov, and Yeung (2008), the relationship between corporate governance and risk-taking could be either positive or negative.

on EDGAR. We define financial industry as all financial institutions consisting of commercial banks, investment banks, and life insurance companies,[11] as classified by their 4-digit standard industrial classification (SIC). Specifically, firms with the 4-digit SIC codes of 6020, 6211 and 6311 are identified as commercial banks, investment banks and life insurance companies, respectively.[12] We use this narrower classification on the grounds that it greatly reduces unobservable heterogeneity among firms within each category, thus it alleviates omitted variable bias and enhances comparability.

The starting point for the sample selection is the Compustat, where we collect annual accounting data on all U.S. commercial banks, investment banks and life insurance. Our sample spans the period 1998—2008. Following Boyd and Runkle (1993) and John, Litov and Yeung (2008), we require that firms have at least five years of data on key accounting variables over the period to be included in the sample. This process yields an initial sample of 687 unique financial institutions or an unbalanced panel of 6180 firm-year observations, comprising 587 commercial banks, 59 investment banks, and 41 life insurance companies.

Our study requires governance and CEO ownership data. This data is available through RiskMetrics. However, RiskMetrics only provides data for S&P 1500 companies, which includes around 10% of financial firms. After matching our initial sample with this database, we lost the majority of our observations. For this reason, we hand-collected data on governance and ownership from each company's proxy statement. However, extracting data on all 687 firms is labor intensive, so we limit our investigation to a random sample of 250 commercial banks, while keeping all the investment banks and life insurance companies from the original sample.

[11] We would like to include mortgage companies such as Fannie Mae and Freddie Mac in our sample, but the observations for these firms are too small to make a reliable inference.

[12] This classification is similar to Cheng, Hong and Scheinkman (2010)

The advantage of the sampling process is that it avoids the estimation problem of selection on observables (size) since firms in the S&P 1500 are relatively large. We then match this random sample to CRSP to retrieve the stock return data in order to calculate stock return volatility.

We use accounting write-down as one of our risk-taking measures. The description of write-down is provided in the following section. We obtain most of this data from companies' 10-K and 10-Q during the years 2007 and 2008 while the rest comes from Bloomberg[13] using the WDCI function. To be consistent with Bloomberg, we search each company's filings using key words such as write-down/off, provision for credit losses, charge-off, impairments, and so on.

Our final sample has a total of 302 observations with available data, consisting of 238 commercial banks, 38 investment banks and 26 life insurance companies. In our sample, insurance companies include firms such as AIG, Prudential Financial Inc, and Lincoln National Corp, while investment banks include Bear Stearns, Lehman Brothers, and Goldman Sachs.

A. Definition of variables

A1. Risk-taking

Our primary measure for firm risk-taking is the Z-score, which equals the average return on assets (ROA) plus the capital asset ratio (CAR) divided by the standard deviation of asset returns (σ(ROA)) (see Appendix A for the theoretical development of variable).

In banking, the definition of capital is different from non-banking firms and it varies depending on the level of reliability as a cushion against losses and financial distress. According to Basel I Accord, for example, Tier 1 capital consists primarily of common stock and retained

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[13] Bloomberg started to collect write-down data for financial institutions from the 3rd quarter of 2007. While companies did take write-downs in the 1st and 2nd quarters of 2007, the magnitude is relatively small.

earnings, while Tier 2 capital is composed of supplementary capital, which is categorized as undisclosed reserves, revaluation reserves, general provisions, hybrid instruments and subordinated term debt[14]. In this research, we calculate CAR as total asset minus total liability divided by total asset, following Laeven and Levine (2009), Houston et al (2010), Balachandran, Kogut and Harnal (2010), and Vyas (2011).

Z-score has been widely used in the recent literature as a measure of bank risk. The Z-score measures the distance from insolvency. A higher value of Z-score indicates more stability. Since the Z-score is highly skewed, we follow Laeven and Levine (2009) and Houston et al (2010), and use the natural logarithm of the Z-score as the risk measure. However, the problem with this transformation is that it is not defined when you have non-positive Z-scores, which renders some loss of observations. Due to this reason, we rely on raw Z-score as our primary measure for risk-taking while taking into account the skewness of the distribution as we perform the regression analysis, and use the logarithm of Z-score as a robustness check. We use the sample to estimate the population average ROA and σ(ROA). Specifically, ROA and CAR are calculated as the average over 1998—2008 using annual data, and σ(ROA) is the standard deviation of annual ROA over 1998—2008.

As a robustness check, we incorporate additional risk-taking measures including market betas, a measure that captures a firm's non-diversifiable risk, accounting based write-downs[15] that reflect a CEO's risk-taking incentives, and the standard deviation of annual stock return which indicates the market's perception about firms' risk-taking. For each firm, we calculate market beta as the average CAPM betas for 60-month rolling regressions over the sample period.

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[14] See http://www.bis.org/publ/bcbsc111.pdf?noframes=1 for source and Appendix B for illustration.

[15] See Chesney, Stromberg and Wagner (2010) for a detailed description about the advantages and disadvantages of this variable.

As for write-down, we follow Vyas (2011) and define it as net credit losses recognized by financial institutions through accounting treatments, which include fair value adjustments, impairment charges, loan loss provisions, and charge-offs. We focus on total write-downs that occurred during the commonly-agreed crisis period of 2007 and 2008 because it is this period that exposes the investments undertaken by banks in prior years to the bad state of the world. For equity volatility, we use both annual and monthly stock return data.

To gain insights about which component of the Z-score is principally driving the relationship between the independent variables (e.g., size, ownership, and corporate governance) and Z-score, we use the three components of Z-score (i.e., ROA, CAR, and σ(ROA)) as separate dependent variables.

A2. Firm size

The potential candidates for measuring firm size include accounting-based measures such as total asset and total revenue, and market based measures such as market capitalization. We prefer total asset and total revenue to market capitalization because previous literature argues these two accounting measures are less noisy as a proxy for the "scale" of the firm than market measure (see Baker and Hall, 2004).[16] Following the existing literature, we focus primarily on total asset and use total revenue as a robustness check. We apply logarithm transformation on both the average total asset and average total revenue over the sample period 1998—2008. We expect the effect of this variable on risk taking to be positive.

A3. Corporate governance

[16]Nevertheless, we also tried total market capitalization as measure for firm size in an unreported regression. The results are qualitatively the same as our primary size measures, and are available from the authors upon request.

The commonly used governance measures are G-index (Gompers, Ishii, and Metrick, 2003), E-index (Bebchuk, Cohen, and Ferrell, 2004), and Gov-Score (Brown and Caylor, 2006). Though these governance indices are widely used in empirical research, such use has both strengths and weaknesses. In particular, recent studies (e.g., Bhagat, Bolton, and Romano, 2008; Bhagat, and Bolton, 2008) have questioned whether governance indices measure the right governance attributes. As such, we employ a new measure of corporate governance – the median director dollar stockholding – developed by Bhagat and Bolton (2008). The advantage of this measure is that it is simple, intuitive, less prone to measurement errors and can enhance the comparability of research findings.[17] As mentioned earlier, RiskMetrics provide limited data on financial firms (123 out of 302 observations), so we supplement it by hand-collecting director ownership information, as of the last year in our sample period, from companies' proxy statements. We then calculate the natural logarithm of median director dollar stockholding by matching this data to stock price information obtained from CRSP.

A4. CEO stock ownership

Following Bhagat and Bolton (2008), we use CEO ownership as our measure for bank ownership structure. Like the governance variable, we hand-collect CEO ownership data in addition to the data provided by RiskMetrics, as of the last year in our sample period, from companies' proxy statement. Since ownership patterns tend to be relatively stable over time, we do not view this as a serious shortcoming.

Risk-averse managers, whose employment income is tied to changes in firm value, have incentives to take on less than optimal firm risk to protect their firm-specific human capital. This

[17] See Bhagat and Bolton (2008) for a detailed description and Bhagat and Bolton (2010) for the strength about this variable.

is an agency problem in essence as described in Jensen and Meckling (1976), Amihud and Lev (1981), and Smith and Stulz (1985). However, ownership by managers may be used to induce them to act in a manner that is consistent with the interest of shareholders. Thus, we would expect to see a positive relation between CEO ownership and risk-taking.

Researchers have documented the impact of ownership structure on firm risk-taking. For instance, analyzing nonfinancial firms, Agrawal and Mandelker (1987) find a positive relation between security holdings of managers and the changes in firm variance, while John, Litov, and Yeung (2008) find that managers enjoying large private benefits of control select suboptimally conservative investment strategies. Saunders, Strock, and Travlos (1990) find the stockholder controlled banks exhibit higher risk taking behavior than managerially controlled banks. A recent study by Laeven and Levine (2009) considers the potential conflicts between managers and owners and analyzes the relations between the risk-taking of banks, their ownership structures, and bank regulations. They find that bank risk is generally higher in banks that have controlling shareholders.

A5. Market-to-book ratio

Market-to-book asset ratio, has been identified an important risk factor in the asset pricing literature. For instance, Fama and French (1992) point out that firms with high ratios of book-to-market value (or low market-to-book) are more likely to be in financial distress. We compute this variable by averaging each firm's year-end market-to-book asset ratio over the sample period.

In the banking literature, this variable has often been used as a proxy for bank charter value (see Demsetz, Saindenberg and Strahan 1997; Goyal 2005). A charter has value because of barriers to entry into the industry and usually it is defined as the discounted stream of future profits that a bank is expected to earn from its access to protected markets.[18] Since loss of charter imposes substantial costs, it is argued that charter value can incentivize banks to adopt prudent decision-making——the so-called charter-value hypothesis (see Keeley, 1990; Carletti and Hartmann, 2003). Empirical models of bank risk have focused on this disciplinary role of charter value. Based on a sample of 367 bank holding companies from 1991—1995, for instance, Demsetz, Saidenberg and Strahan (1997) found that charter value is negatively associated with bank risk-taking. Galloway, Lee and Roden (1997) also found that banks with low charter value assumed significantly more risk.

A6. Other controls

We use average annual return on asset as a control for firms' profitability and debt/asset ratio as a control for firms' leverage. We expect a negative association between profitability and risk-taking, and positive association between risk-taking and leverage. In addition, we use firm age to control for firm experience, and we expect that experienced firms are better at handling risk than less-experienced firms, ceteris paribus.

B. Summary statistics

Table II presents the summary statistics for all key variables. The variable definitions and the data sources are described in Appendix C. In this table, I also separate the sample into three subsamples according to their classification for easy comparison. Summary statistics in Table II shows that the Z-score has a mean of 34 and a standard deviation of 31. This fairly high standard deviation and the wide range in Z-scores suggest a considerable cross-sectional variation in the level of firm risk. Further, since the average Z-score is greater than its median, we know it has a

[18] See Hellmann, Murdock, and Stiglitz (2000) for a description of this variable.

right-skewed distribution. Also noticeable is that investment banks have the lowest average Z-score followed by commercial banks, and insurance companies have the highest Z-score. Since higher Z-score means more stability, it seems that investment banks are riskier than their peers, which holds up to our initial conjecture (this is later confirmed in our regression analysis).

Table II

Summary statistics.

This table reports summary statistics of the main regression variables for all financial institutions (Panel A), commercial banks (Panel B), investment banks (Panel C) and life insurance (Panel D). SIC codes 6020, 6211 and 6311 are used to define commercial banks, investment banks and life insurance, respectively. Sample consists of 258 commercial banks, 38 investment banks and 26 life insurance companies. Statistics based on average annual data over 1998-2008, unless otherwise indicated. Z-score is firm's return on assets plus the capital asset ratio divided by the standard deviation of asset return over period 1998-2008. σ(ROA) is the volatility of the firm's return on assets over the period 1998-2008. Equity volatility is standard deviation of annual stock return over 1998-2008. Size is the book total asset (millions). Market-to-book is calculated as market value of equity plus book value of debt divided by book total asset. ROA is the return on asset. Leverage is the debt asset ratio. Director ownership ($) is median director dollar stockholding as of the last year in our sample period (thousands). Director ownership (%) is median director percentage stockholding as of the last year in our sample period. CEO ownership (%) is percentage of CEO stock ownership as of the last year in our sample period. Firm age is proxied by the difference between 2008 and the year that the firm first appears in Compustat monthly stock return database.

Panel A: all financial institutions

variable	mean	median	Standard Deviation	min	max	N
Z-score	34.08	25.29	30.82	-0.29	203.14	302
ln(Z-score)	3.10	3.24	1.08	-4.09	5.28	300
σ(ROA)	0.02	0.00	0.07	0.00	0.61	302
equity volatility	0.36	0.30	0.25	0.08	2.30	302
size	32,777	2,240	116,119	12	1,027,891	302
ln(size)	7.98	7.71	2.11	2.50	13.84	302
CAR	0.13	0.09	0.14	0.03	0.86	302
market-to-book	1.16	1.07	0.43	0.76	4.76	302
ROA	0.01	0.01	0.05	-0.41	0.56	302
leverage	0.87	0.91	0.14	0.14	0.97	302
director ownership ($)	1,626	891	2,205	11	14,364	300
ln(director ownership)	13.63	13.70	1.24	9.28	16.48	300
director ownership (%)	0.01	0.00	0.01	0.00	0.05	302
CEO ownership (%)	0.04	0.01	0.10	0.00	0.89	302
firm age	19.01	15.00	11.59	2.00	46.00	302

Panel B: commercial banks

variable	mean	median	Standard Deviation	min	max	N
Z-score	38.30	30.70	32.12	2.00	203.14	238
ln(Z-score)	3.28	3.42	0.94	0.69	5.28	238
σ(ROA)	0.01	0.00	0.01	0.00	0.07	238
equity volatility	0.31	0.29	0.14	0.08	0.92	238
size	24,352	2,112	104,774	79	1,027,891	238
ln(size)	7.92	7.66	1.83	4.37	13.84	238
CAR	0.09	0.09	0.02	0.05	0.23	238
market-to-book	1.08	1.07	0.06	0.98	1.48	238
ROA	0.01	0.01	0.01	-0.03	0.04	238
leverage	0.91	0.91	0.02	0.77	0.95	238
director ownership ($)	1,721	929	2,254	11	14,364	238
ln(director ownership)	13.74	13.74	1.16	9.28	16.48	238
director ownership (%)	0.01	0.00	0.01	0.00	0.05	238
CEO ownership (%)	0.03	0.01	0.06	0.00	0.53	238
firm age	19.63	15.50	11.38	2.00	46.00	238

Table II. (*continued*)

Penal C: investment banks

variable	mean	median	Standard Deviation	min	max	N
Z-score	10.21	8.35	9.04	-0.29	39.66	38
ln(Z-score)	1.90	2.15	1.36	-4.09	3.68	36
σ(ROA)	0.12	0.06	0.16	0.00	0.61	38
equity volatility	0.67	0.46	0.50	0.23	2.30	38
size	52,361	689	146,691	12	656,829	38
ln(size)	7.21	6.53	2.95	2.50	13.40	38
CAR	0.37	0.34	0.28	0.03	0.86	38
market-to-book	1.73	1.26	1.03	0.76	4.76	38
ROA	-0.01	0.01	0.15	-0.41	0.56	38
leverage	0.63	0.66	0.28	0.14	0.97	38
director ownership ($)	1,174	626	1,626	29	9,069	38
ln(director ownership)	13.23	13.35	1.34	10.29	16.02	38
director ownership (%)	0.00	0.00	0.00	0.00	0.02	38
CEO ownership (%)	0.14	0.03	0.23	0.00	0.89	38
firm age	14.68	11.50	10.00	2.00	44.00	38

Panel D: life insurance

variable	mean	median	Standard Deviation	min	max	N
Z-score	30.28	24.71	22.08	2.94	96.98	26
ln(Z-score)	3.18	3.21	0.73	1.08	4.57	26
σ(ROA)	0.01	0.00	0.01	0.00	0.04	26
equity volatility	0.32	0.31	0.11	0.11	0.64	26
size	81,275	15,824	150,747	78	641,511	26
ln(size)	9.65	9.66	2.22	4.36	13.37	26
CAR	0.12	0.10	0.07	0.03	0.26	26
market-to-book	1.03	1.01	0.09	0.88	1.32	26
ROA	0.01	0.01	0.01	0.00	0.03	26
leverage	0.88	0.90	0.07	0.74	0.97	26
director ownership ($)	1,396	615	2,474	14	12,096	24
ln(director ownership)	13.12	13.33	1.63	9.56	16.31	24
director ownership (%)	0.00	0.00	0.00	0.00	0.00	26
CEO ownership (%)	0.03	0.00	0.06	0.00	0.26	26
firm age	19.73	15.00	14.42	4.00	46.00	26

Table II (continued)

small = total assets < 1 billion($); middle = total asset ≥ 1 billion & ≤ 10 billion; large = total assets > 10 billions

All financial institutions

	small				middle				Large			
variable	mean	median	sd	N	mean	median	sd	N	mean	median	sd	N
Z-score	34.75	27.03	35.63	107	35.75	29.14	31.03	117	30.64	24.49	22.33	78
ln(Z-score)	2.94	3.35	1.38	105	3.21	3.37	0.92	117	3.17	3.20	0.75	78
σ(ROA)	0.05	0.00	0.11	107	0.01	0.00	0.02	117	0.01	0.00	0.01	78
equity volatility	0.42	0.32	0.35	107	0.33	0.30	0.16	117	0.31	0.27	0.15	78
size	468	453	249	107	3,682	2,890	2,357	117	120,741	37,856	205,245	78
ln(size)	5.90	6.12	0.90	107	8.01	7.97	0.64	117	10.79	10.54	1.27	78
CAR	0.19	0.10	0.21	107	0.11	0.09	0.07	117	0.09	0.09	0.03	78
market-to-book	1.26	1.05	0.69	107	1.09	1.08	0.11	117	1.11	1.09	0.11	78
ROA	0.00	0.01	0.09	107	0.01	0.01	0.01	117	0.01	0.01	0.01	78
leverage	0.81	0.90	0.21	107	0.89	0.91	0.07	117	0.91	0.91	0.03	78
director ownership ($)	948	574	1,116	106	1,728	922	2,189	117	2,403	1,340	2,970	77
ln(director ownership)	13.10	13.26	1.29	106	13.78	13.73	1.07	117	14.12	14.11	1.14	77
director ownership (%)	0.01	0.01	0.01	107	0.00	0.00	0.01	117	0.00	0.00	0.00	78
CEO ownership (%)	0.07	0.02	0.15	107	0.04	0.01	0.07	117	0.01	0.01	0.03	78
firm age	12.34	11.00	6.39	107	17.96	18.00	7.67	117	29.76	27.50	14.12	78

Commercial banks

	small				middle				large			
variable	mean	median	sd	N	mean	median	sd	N	mean	median	sd	N
Z-score	41.77	33.65	36.75	81	37.98	30.80	31.82	105	33.53	24.68	23.86	52
ln(Z-score)	3.27	3.52	1.09	81	3.29	3.43	0.91	105	3.27	3.21	0.73	52
σ(ROA)	0.01	0.00	0.01	81	0.01	0.00	0.01	105	0.00	0.00	0.00	52
equity volatility	0.32	0.30	0.13	81	0.33	0.30	0.15	105	0.26	0.25	0.10	52
size	497	465	226	81	3,583	2,843	2,282	105	103,450	35,901	206,958	52
ln(size)	6.09	6.14	0.53	81	7.99	7.95	0.63	105	10.65	10.49	1.18	52
CAR	0.10	0.09	0.03	81	0.09	0.09	0.02	105	0.09	0.09	0.02	52
market-to-book	1.05	1.04	0.04	81	1.08	1.08	0.05	105	1.13	1.11	0.09	52
ROA	0.01	0.01	0.01	81	0.01	0.01	0.01	105	0.01	0.01	0.00	52
leverage	0.90	0.91	0.03	81	0.91	0.91	0.02	105	0.91	0.91	0.02	52
director ownership ($)	1,009	669	1,156	81	1,824	924	2,280	105	2,622	1,435	3,043	52
ln(director ownership)	13.24	13.41	1.20	81	13.84	13.74	1.07	105	14.33	14.18	0.93	52
director ownership (%)	0.01	0.01	0.01	81	0.00	0.00	0.01	105	0.00	0.00	0.00	52
CEO ownership (%)	0.04	0.02	0.07	81	0.03	0.01	0.07	105	0.01	0.01	0.02	52
firm age	11.98	12.00	4.80	81	17.80	17.00	7.46	105	35.23	38.00	10.19	52

Investment banks

	small				middle				large			
variable	mean	median	sd	N	mean	median	sd	N	mean	median	sd	N
Z-score	6.37	5.16	5.51	21	13.63	9.79	12.10	8	16.14	14.27	9.14	9
ln(Z-score)	1.38	1.90	1.59	19	2.31	2.24	0.82	8	2.61	2.66	0.64	9
σ(ROA)	0.20	0.12	0.18	21	0.05	0.04	0.05	8	0.01	0.00	0.01	9
equity volatility	0.83	0.61	0.60	21	0.47	0.37	0.28	8	0.51	0.42	0.27	9
size	322	329	264	21	3,528	2,371	2,491	8	217,194	96,783	243,837	9
ln(size)	5.11	5.80	1.47	21	7.99	7.77	0.60	8	11.41	11.48	1.60	9
CAR	0.53	0.50	0.26	21	0.30	0.34	0.15	8	0.07	0.08	0.03	9
market-to-book	2.14	1.90	1.23	21	1.27	1.16	0.35	8	1.17	1.07	0.19	9
ROA	-0.02	-0.02	0.21	21	0.02	0.01	0.03	8	0.01	0.01	0.01	9
leverage	0.47	0.50	0.26	21	0.70	0.66	0.15	8	0.93	0.92	0.03	9
director ownership ($)	856	413	1,027	21	716	547	545	8	2,322	1,528	2,714	9
ln(director ownership)	12.89	12.93	1.39	21	13.17	13.20	0.90	8	14.07	14.24	1.29	9
director ownership (%)	0.00	0.00	0.01	21	0.00	0.00	0.00	8	0.00	0.00	0.00	9
CEO ownership (%)	0.22	0.06	0.28	21	0.06	0.01	0.08	8	0.04	0.02	0.06	9
firm age	12.29	10.00	9.90	21	20.00	18.50	11.58	8	15.56	14.00	7.52	9

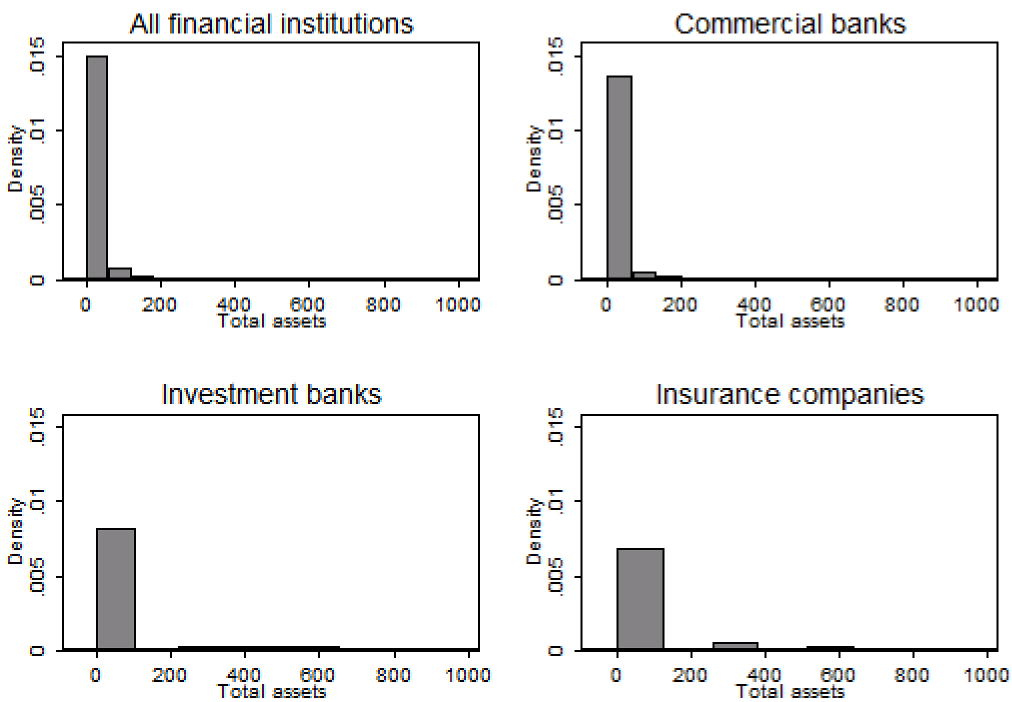
Insurance companies

	small				middle				large			
variable	mean	median	sd	N	mean	median	sd	N	mean	median	sd	N
Z-score	40.18	27.03	34.97	5	21.31	21.41	6.39	4	29.49	25.48	19.92	17
ln(Z-score)	3.38	3.30	0.89	5	3.02	3.06	0.32	4	3.16	3.24	0.77	17
σ(ROA)	0.01	0.00	0.01	5	0.01	0.01	0.00	4	0.01	0.00	0.01	17
equity volatility	0.29	0.27	0.07	5	0.24	0.28	0.09	4	0.34	0.33	0.12	17
size	616	749	341	5	6,601	6,371	2,842	4	122,568	30,199	173,973	17
ln(size)	6.15	6.62	1.03	5	8.72	8.71	0.45	4	10.90	10.32	1.31	17
CAR	0.20	0.21	0.06	5	0.12	0.12	0.04	4	0.10	0.07	0.06	17
market-to-book	1.04	1.02	0.18	5	1.02	1.00	0.04	4	1.03	1.02	0.07	17
ROA	0.01	0.01	0.00	5	0.01	0.01	0.00	4	0.01	0.01	0.01	17
leverage	0.80	0.79	0.06	5	0.88	0.88	0.04	4	0.90	0.93	0.06	17
director ownership ($)	203	116	254	4	1,228	1,315	1,042	4	1,736	763	2,940	16
ln(director ownership)	11.39	11.38	1.64	4	13.52	13.89	1.36	4	13.45	13.54	1.49	16
director ownership (%)	0.00	0.00	0.00	5	0.00	0.00	0.00	4	0.00	0.00	0.00	17
CEO ownership (%)	0.02	0.01	0.04	5	0.11	0.09	0.13	4	0.01	0.00	0.01	17
firm age	18.40	21.00	9.24	5	18.00	19.50	4.24	4	20.53	11.00	17.27	17

The other measures of risk, such as volatility of equity return, also indicate the same pattern. In terms of leverage, commercial banks are the highest, followed by insurance and investment banks. This result is a little surprising considering the fact that the biggest investment banks are also the most leveraged firms among financial institutions. In our sample, investment banks take four places in the top six most highly leveraged firms (see Appendix D). We see this result because most middle and small sized investment banks do not have this high leverage, which significantly drives down the average leverage. Lastly, the summary statistics for Z-score are similar to those reported by Houston et al (2010), as they report a mean log Z-score of 3.240 and a standard deviation of 1.086, while we have 3.103 and 1.075, respectively.

The average financial institution has $33 billion in assets with a standard deviation of $116 billion, and it ranges from a minimum of $12 million to a maximum of $1 trillion. The huge standard deviation and range indicate a significant variation in firm size. Examination of the size distributions by different categories indicates a common pattern: in each category, there are a few very large companies with the rest being small and middle sized. For example, out of 238 commercial banks, only 11 have assets over $100 billion. This pattern is also demonstrated by Figure 1, which shows the histograms for all firms, along with firms in their separate categories. In addition, insurance companies have the highest average size, followed by investment banks and commercial banks. Due to the highly skewed distribution of size, the natural logarithm transformation is applied to this variable.

Figure 1
Histogram of firm size (in billion dollars)



The governance variable, measured as the natural logarithm of median director dollar stockholding, has a mean of 13.63 and standard deviation of 1.24 and it ranges from a minimum of 9.28 to a maximum of 16.48. The distribution of this variable is similar across categories. Lastly, the sample shows an average firm age of 19 years, with investment banks significantly younger than commercial banks and insurance companies.

Table III presents the correlation among the key variables. First of all, as expected, all three risk measures are highly correlated. Secondly, the log of firm size is significantly correlated with risk as measured by the log(Z-score), volatility of return on asset and equity return, but not raw Z-score. Firm age is negatively correlated with risk, consistent with our initial conjecture that all else being equal, older firms have more experience in risk management. Interestingly, we found that more stable FIs are associated with a lower market-to-book ratio, which is inconsistent with the finding in Demsetz, Saindenberg and Strahan (1996). In addition, the governance variable is highly correlated with risk as measured by Z-score and volatility of return on assets, but not the equity volatility. Lastly, CEO ownership is positively correlated with all three risk measures, indicating that stock ownership by CEO induces risk-taking.

Table III

Correlation matrix of main regression variables.

This table reports the correlations between the main regression variables. Sample consists of 302 financial institutions. Statistics based on averages of annual data over the period 1998-2008, unless otherwise indicated. Z-score =(ROA+CAR)/σ(ROA). σ(ROA) is the volatility of the firm's return on assets over the period 1998-2008. Equity volatility is standard deviation of annual stock return over 1998-2008. Size is the total asset (in $ millions). ln(rev) is log of total revenue (in $ millions). Market-to-book is calculated as market value of equity plus book value of debt divided by book total asset. ROA is the return on asset. Leverage is the debt asset ratio. Director ownership ($) is natural logarithm of median director dollar stockholding as of the last year in our sample period. CEO ownership (%) is percentage of CEO stock ownership as of the last year in our sample period. age is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database. p-values denoting the significance level of each correlation coefficients are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	z_score	ln(Z-score)	σ(ROA)	equity volatility	size	ln(size)	ln(rev)	Market-to-book	ROA	leverage	director ownership	CEO ownership
ln(Z-score)	0.807***											
	(0.000)											
σ(ROA)	-0.271***	-0.597***										
	(0.000)	(0.000)										
equity volatility	-0.329***	-0.531***	0.554***									
	(0.000)	(0.000)	(0.000)									
size	-0.098*	-0.034	-0.059	-0.038								
	(0.090)	(0.555)	(0.309)	(0.517)								
ln(size)	-0.053	0.106*	-0.309***	-0.256***	0.588***							
	(0.358)	(0.067)	(0.000)	(0.000)	(0.000)							
ln(rev)	-0.141**	-0.018	-0.111*	-0.093	0.590***	0.950***						
	(0.014)	(0.760)	(0.055)	(0.107)	(0.000)	(0.000)						
market-to-book	-0.168***	-0.250***	0.564***	0.349***	-0.048	-0.159***	0.024					
	(0.003)	(0.000)	(0.000)	(0.000)	(0.411)	(0.006)	(0.681)					
ROA	0.083	0.236***	-0.278***	-0.370***	0.010	0.148**	0.100*	0.275***				
	(0.149)	(0.000)	(0.000)	(0.000)	(0.857)	(0.010)	(0.084)	(0.000)				
leverage	0.207***	0.370***	-0.545***	-0.305***	0.108*	0.369***	0.141**	-0.573***	0.036			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.060)	(0.000)	(0.015)	(0.000)	(0.534)			
director ownership	0.181***	0.215***	-0.116**	-0.085	0.132**	0.320***	0.280***	0.031	0.150***	0.214***		
	(0.002)	(0.000)	(0.044)	(0.142)	(0.022)	(0.000)	(0.000)	(0.590)	(0.009)	(0.000)		
CEO ownership	-0.144**	-0.221***	0.200***	0.295***	-0.095*	-0.302***	-0.170***	0.334***	-0.073	-0.525***	-0.159***	
	(0.012)	(0.000)	(0.001)	(0.000)	(0.099)	(0.000)	(0.003)	(0.000)	(0.208)	(0.000)	(0.006)	
Age	0.021	0.116**	-0.183***	-0.238***	0.301***	0.559***	0.563***	-0.081	0.063	0.113**	0.158***	-0.066
	(0.722)	(0.044)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.160)	(0.274)	(0.049)	(0.006)	(0.251)

CHAPTER 4

Size and firm risk

A. Baseline regression

The premise of the paper is that size has a positive effect on a firm's risk taking due to the moral hazard associated with the TBTF policy. The primary measure of risk-taking is the Z-score with a higher Z-score indicating more stability. We began by examining whether larger size is associated with greater risk as suggested by Boyd, Jagannathan and Kwak (2009). For brevity, we use label 'size' in referring to the natural logarithm of size in the remainder of the paper. In Chapter 5, we extend the analysis by testing whether systematically important firms behave differently from smaller ones.

More formally, our baseline model is as follows:

$$z_i = \alpha_0 + \alpha_1 size_i + \alpha_2 mb_i + \alpha_3 dir_i + \alpha_4 own_i + \alpha_5 age_i + \alpha_6 ibk_i + \alpha_7 ins_i + \varepsilon_i \quad (1)$$ [19]

where z_i is the Z-score of firm *i*, $size_i$ is log of average total asset of firm *i*, mb_i is market-to-book asset ratio of firm *i* computed as the market value of equity plus book value of debt divided by book value of total asset, which is then averaged over 1998—2008. dir_i is the governance variable, computed as the logarithm of median director dollar stockholding of firm *i* as of the last year in our sample period, own_i is the percentage of CEO ownership of firm *i* as of the last year in our sample period, age_i is the firm age as proxied by the difference between 2008 and the year that the firm first appears in the Compustat monthly stock return database. ibk_i is a dummy

[19] Implicit in this specification is that we assume that relation between size and risk is linear and the effect of size on risk-taking is constant. Quadratic form on variable size has been used in some studies (i.e. Houston et al, 2010), however, we prefer the linear specification because a simple t-test in an unreported regression fails to reject the null hypothesis that the coefficient on variable size-squared equals zero when quadratic form is used.

variable, which equals one if firm i is an investment bank and 0 otherwise, ins_i is a dummy variable for an insurance company, and is defined analogously. ε_i is the error term and β_s (s=1…6) are vectors of coefficient estimates. Note that we only include leverage and profitability as controls in specifications when other risk-taking measures are used as the dependent variable because the Z-score is a deterministic function of these two variables.

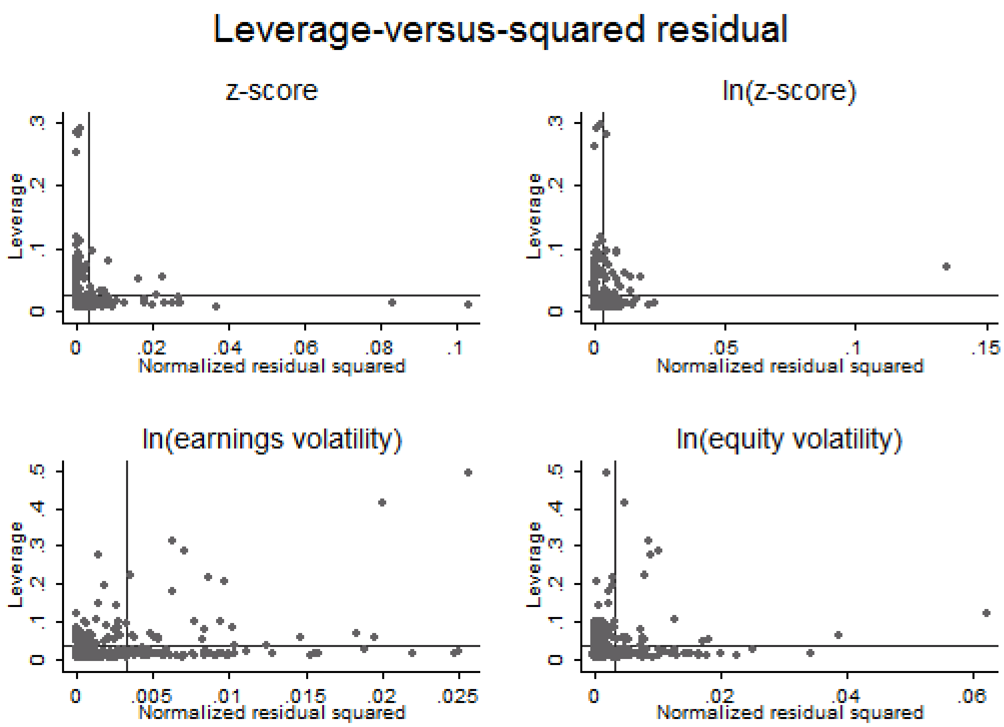
The discrepancies in the level of significance and signs on the variable Z-score and its log transformation ln(Z-score) from correlation Table III raises concerns about the existence of outliers. In regression analysis, the presence of outliers can strongly distort the classical least squares estimator and lead to unreliable results. To investigate whether this is the case, we perform a series of standard diagnostics such as Cook's D influence statistic and studentized residuals. Results from these analyses indicate unusual points in our data. Figure 2 also presents the leverage-versus-squared residuals plot by running four separate OLS regressions in Eq (1), with Z-score, ln(Z-score), earnings volatility, and equity volatility as the respective dependent variables. The points far away from the mass of points indicate unusual observations.[20] Figure 2 suggests that outliers exist in our sample regardless of which risk measures are used.

[20] Appendix E shows some outliers in my sample. They have been manually verified to be accurate.

Figure 2

Plot of leverage versus squared-residuals.

This figure is generated by running four separate OLS regressions, with Z-score, log of Z-score, log of earnings volatility, and log of equity volatility as respective dependent variables (Eq.1). Leverage on the y-axis measures how far an independent variable deviates from its mean. Normalized residual square on x-axis indicates outliers. Variable definitions are in Appendix A.



The simple diagnostic analysis precludes us from relying on the standard ordinary least squares (OLS) regression for inference. The common ways to deal with outliers are truncation or winsorization; we opt out of these approaches for two reasons: first, we verify that those outliers are not data entry errors; second, the total observations in our sample are rather limited. Instead, we rely on two other approaches to address this issue: median and robust regression.[21]

[21] Median regression, focusing on the 0.5 quantile, is a special case of quantile regression. The difference between median and OLS regression is that OLS minimizes the squared error loss, while as median regression minimizes the absolute error loss. Median regression is more robust to outliers than least-squares regression. See Cameron and Trivedi (2005) for details. This method is used by Aggarwal and Samwick (1999). It is the QREG command in Stata, version 10.0. Robust regression is used by Baker and Hall (2004). RREG uses Huber weight iterations followed by biweight iterations. It is the RREG command in Stata, version 10.0. See Hamilton (1991) for details.

Table IV presents the results of the regression analysis with both raw Z-score and log Z-score as the dependent variables. They are estimated using three distinct methods: median, robust, and OLS regressions. Since the lines between banks, investment banks, and insurance companies are increasingly blurring,[22] I also present the results without industry controls. For reasons mentioned previously, we focus on raw Z-score. The overarching message from the regressions presented in Table IV is that bigger size is generally associated with greater risk. Size enters negatively and is significant at conventional levels. In regressions with the log-transformation of Z-score, the signs on size are still expected but are less significant. Comparing the results across estimation methods, we find that both median and robust regressions generate similar estimates, while the OLS estimate has a much larger magnitude. This is not surprising considering outliers in our sample.

[22] For example, Goldman Sachs and MetLife are now bank holding companies.

Table IV

Firm size (total asset) and risk taking

The dependent variable is raw Z-score for the first 6 regressions and logarithm of Z-score for the second 6, which are further separated by whether or not they have industry controls. Results from three estimation methods are presented: Median means median quantile regression (QREG in STATA), Robust means robust regression or iteratively reweighted least squares (RREG in STATA), OLS regressions are based on heteroskedasticity-consistent standard errors (White 1980). Sample consists of 300 financial firms. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. *Ln(Z-score)* is natural logarithm of Z-score. *ln(at)* is the logarithm of total asset. *mb* is the average market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database. *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A

	Z-score						ln(Z-score)					
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-2.214**	-2.448***	-3.607***	-1.166	-2.080**	-3.291***	-0.100***	-0.0801**	-0.0461	-0.0661	-0.0633*	-0.0217
	(1.115)	(0.886)	(0.909)	(0.903)	(0.935)	(1.007)	(0.0367)	(0.0348)	(0.0414)	(0.0432)	(0.0369)	(0.0497)
mb	-9.284**	-10.15***	-12.04***	-3.115	-3.750	-4.521**	-0.668***	-0.599***	-0.555***	-0.350**	-0.305**	-0.196
	(3.811)	(3.523)	(2.498)	(3.646)	(3.822)	(2.074)	(0.142)	(0.139)	(0.150)	(0.173)	(0.149)	(0.168)
dir	5.069***	4.879***	5.698***	3.169***	4.246***	5.075***	0.187***	0.209***	0.185***	0.143**	0.190***	0.152***
	(1.509)	(1.208)	(1.712)	(1.190)	(1.216)	(1.750)	(0.050)	(0.047)	(0.054)	(0.057)	(0.047)	(0.056)
own	-16.58	-26.22*	-35.48**	2.567	-13.60	-20.82**	-0.555	-0.735	-1.351	0.122	-0.121	-0.519
	(17.99)	(14.95)	(13.79)	(12.74)	(14.94)	(10.40)	(0.604)	(0.585)	(0.876)	(0.610)	(0.587)	(0.688)
age	0.111	0.258*	0.279*	-0.0599	0.176	0.200	0.009	0.012**	0.010*	0.001	0.008	0.006
	(0.187)	(0.149)	(0.156)	(0.147)	(0.150)	(0.163)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)
ibk				-19.26***	-18.17***	-21.58***				-0.939***	-0.909***	-1.107***
				(4.824)	(5.011)	(3.492)				(0.228)	(0.197)	(0.271)
ins				-2.521	0.777	0.964				-0.0678	0.0981	0.006
				(5.254)	(5.521)	(5.291)				(0.247)	(0.214)	(0.193)
Constant	-16.03	-8.446	-4.542	0.125	-7.100	-3.786	2.106***	1.445**	1.445**	2.311***	1.371**	1.468**
	(20.06)	(16.10)	(21.65)	(15.43)	(15.73)	(21.41)	(0.661)	(0.626)	(0.694)	(0.732)	(0.611)	(0.654)
Obs	300	300	300	300	300	300	298	298	298	298	298	298
R-squared		0.101	0.101		0.141	0.138		0.140	0.132		0.205	0.210

Table IV (continued)

Panel B: interacting firm size with industry dummies

	Z-score			ln(Z-score)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-2.920**	-2.977**	-5.184***	-0.174***	-0.132***	-0.113***
	(1.240)	(1.158)	(1.493)	(0.061)	(0.047)	(0.043)
mb	-1.424	-1.807	-1.588	-0.091	-0.190	-0.037
	(3.776)	(3.755)	(1.824)	(0.192)	(0.154)	(0.193)
dir	2.668**	3.978***	5.121***	0.171***	0.193***	0.155***
	(1.231)	(1.152)	(1.745)	(0.060)	(0.047)	(0.054)
own	2.608	-4.967	-12.439	0.146	0.315	0.131
	(13.903)	(14.440)	(9.377)	(0.667)	(0.608)	(0.625)
age	0.162	0.289*	0.380*	0.016*	0.014**	0.015**
	(0.172)	(0.160)	(0.198)	(0.008)	(0.007)	(0.007)
ibk	-46.761***	-42.793***	-61.604***	-3.294***	-2.633***	-3.514***
	(14.845)	(14.479)	(12.437)	(0.782)	(0.629)	(1.143)
ins	-27.796	-13.837	-8.797	-1.469	-0.375	0.264
	(24.879)	(24.864)	(33.792)	(1.186)	(1.018)	(1.107)
ibk*size	3.687**	3.365*	5.097***	0.284***	0.207***	0.300**
	(1.821)	(1.743)	(1.527)	(0.093)	(0.075)	(0.120)
ins*size	3.069	1.731	1.398	0.190	0.061	-0.006
	(2.616)	(2.562)	(3.357)	(0.124)	(0.105)	(0.119)
Constant	14.558	-2.962	3.632	2.162***	1.656***	1.791***
	(16.308)	(15.287)	(22.573)	(0.794)	(0.627)	(0.677)
Observations	300	300	300	298	298	298
R-squared		0.142	0.153		0.232	0.252

Our governance variable (*dir*) enters positively and is significant at the 1% level in all regressions, meaning better governance as measured by median director dollar stockholding is associated with less risk-taking. This result provides strong evidence that our initial conjecture based on Diamond and Rajan (2009) is correct. However, it is in sharp contrast to Cheng, Hong and Scheinkman (2009), who use standard governance measures such as G-index and E-index and find that governance has no effect on financial firms' risk-taking. We find similar results, as shown in Appendix F, when standard governance indices such as G-index and E-index are used as explanatory variables. The reason is that these indices are mostly measures of anti-takeover provisions.[23] Theoretically, it is hard to make a connection between these provisions and firm risk-taking. The economic size of coefficient on *dir* is consequential. A one standard deviation change in *dir* (1.24) is associated with a change in *Z-score* of 5.27 (1.24*4.246), an approximate 21 percent increase from its median (25.29).

Comparing the results from regressions with and without industry control reveals that the magnitude of the coefficient is smaller in regressions with industry controls, indicating that the industry fixed effect might play an important role in shaping financial firms' risk-taking behavior. This point is confirmed by the finding that investment banks are significantly riskier than commercial banks: all the coefficients on the investment bank dummy (*ibk*) are negative and significant at the 1% level. This result, however, is not driven by leverage as we have documented in the summary statistics that the average investment bank is less leveraged than commercial banks. At this point, we are not certain what the underlying factor driving this relation is: it may be the nature of investment banking business. In fact, Kwast (1989) documents that securities activities have a higher standard deviation of returns than non-securities activities,

[23] The coefficient on size lost its significant because financial firms that are included in the S&P1500 are relatively large companies, and may be subject to sample selection bias.

and Allen and Jagtiani (1997) find that securities firms on average have the highest market risk exposure among all financial institutions. CEO ownership has a negative effect on Z-score, but enters insignificantly. As expected, the sign of firm age on Z-score is positive, but its effect is only marginally significant.

As a robustness check, we use total revenue and total market capitalization as our measures for the size of the firm. The results, with the log of total revenue and log of market capitalization replacing the log of total asset, are shown in Appendix G and H, respectively. The coefficients on total revenue are very similar to those in Table IV, except they are slightly larger in magnitude. Coefficients on other variables are qualitatively the same. The results from total capitalization are qualitatively similar as well. As an additional robustness check, we restrict our sample to those firms with total assets less than $10 billion because we are concerned that the extremely large FIs may be fundamentally different from middle and small sized firms, and we report the results in Appendix I. As we can see, the results are similar to the previous results.[24]

The results from our additional risk measures broadly support our hypothesis. Panel A of Table V shows regression results with market beta, and monthly and annual stock return volatility as dependent variables, while Panel B presents the results using write-down as the dependent variable. Firstly, the coefficients on firm size are positive and significant, especially in market beta and write-down. Secondly, the coefficients on the governance variable are negative and significant in the regressions from Panel A but not from Panel B. Lastly, the coefficients on the investment bank dummy demonstrate a similar pattern. The result that investment banks have a higher beta is consistent with Allen and Jagtiani (1997).

[24] We also ran a separate regression on commercial banks only. The results, shown in Appendix J, support our hypothesis.

Table V

Alternative risk measures

In Panel A, the dependent variable is market beta (CAPM) for the first 3 regressions and stock return volatilities for the second 6, which are further separated by whether it is calculated using monthly or annual return data over the 1998-2008 periods. In Panel B, the dependent variable is log of write-downs and write-down/asset. Write-down is the sum of accounting write-downs for 2007 and 2008, which is obtained from company's SEC filings and Bloomberg using the WDCI function. Results from three estimation methods are presented: Median means median quantile regression (QREG in STATA), Robust means robust regression or iteratively reweighted least squares (RREG in STATA), OLS regressions are based on heteroskedasticity-consistent standard errors (White 1980). Sample consists of 300 financial firms. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. For each firm, market beta is calculated as the average CAPM betas for 60 month rolling regressions over 1998-2008. *ln(at)* is the logarithm of asset. *mb* is the average market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A

	Market Beta			σ(RET)(annual)			σ(RET)(monthly)		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS
ln(at)	0.084***	0.072***	0.090***	0.008	0.006	0.003	0.023*	0.020*	0.021*
	(0.014)	(0.011)	(0.016)	(0.021)	(0.017)	(0.016)	(0.014)	(0.011)	(0.012)
mb	0.342***	0.356***	0.451***	0.242***	0.332***	0.309***	0.226***	0.199***	0.187***
	(0.056)	(0.047)	(0.110)	(0.089)	(0.072)	(0.098)	(0.059)	(0.049)	(0.065)
dir	-0.037**	-0.028**	-0.037**	-0.057**	-0.028	-0.021	-0.039**	-0.027**	-0.027*
	(0.016)	(0.012)	(0.016)	(0.026)	(0.020)	(0.021)	(0.017)	(0.014)	(0.015)
own	0.491**	0.481***	0.040	0.723**	0.933***	0.504	0.245	0.410**	0.411**
	(0.228)	(0.183)	(0.270)	(0.321)	(0.257)	(0.494)	(0.213)	(0.173)	(0.172)
age	-0.004*	-0.002	-0.006***	-0.009***	-0.010***	-0.010***	-0.006***	-0.004**	-0.005***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
ibk	0.806***	0.809***	0.926***	0.344***	0.471***	0.533***	0.328***	0.396***	0.410***
	(0.082)	(0.064)	(0.116)	(0.128)	(0.101)	(0.119)	(0.081)	(0.068)	(0.081)
ins	0.095	0.139**	0.053	0.047	0.066	0.066	0.107	0.097	0.094
	(0.074)	(0.057)	(0.069)	(0.116)	(0.093)	(0.081)	(0.077)	(0.062)	(0.059)
roa	-3.672***	-4.112***	-3.884***	-2.296***	-2.306***	-2.248***	-1.553***	-1.856***	-1.806***
	(0.483)	(0.403)	(1.248)	(0.559)	(0.458)	(0.559)	(0.365)	(0.308)	(0.446)
leverage	0.746***	0.751***	0.743*	0.457	0.950***	0.792**	0.091	0.185	0.196
	(0.262)	(0.209)	(0.392)	(0.343)	(0.279)	(0.315)	(0.216)	(0.187)	(0.198)
Constant	-0.721**	-0.789***	-0.787*	-1.046**	-1.943***	-1.840***	-2.319***	-2.542***	-2.537***
	(0.309)	(0.247)	(0.424)	(0.431)	(0.348)	(0.377)	(0.283)	(0.234)	(0.247)
Observations	267	267	267	300	300	300	300	300	300
R-squared		0.726	0.637		0.361	0.337		0.425	0.425

Table V (continued)

Panel B

	log of write-down			write-down/asset		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	1.111***	1.159***	1.121***	0.002	0.005*	-0.019
	(0.134)	(0.089)	(0.080)	(0.006)	(0.003)	(0.019)
mb	0.132	0.132	0.013	0.003	0.005	-0.039
	(0.344)	(0.275)	(0.180)	(0.014)	(0.008)	(0.043)
dir	-0.051	-0.061	-0.130	-0.003	-0.003	-0.039
	(0.196)	(0.122)	(0.123)	(0.008)	(0.004)	(0.027)
own	4.452	4.242*	4.864*	0.371***	0.283***	1.224
	(2.810)	(2.276)	(2.507)	(0.116)	(0.073)	(1.331)
age	-0.027	-0.029**	-0.030***	-0.001	-0.001*	-0.001
	(0.018)	(0.012)	(0.010)	(0.001)	(0.000)	(0.002)
ibk	-1.500**	-1.503***	-0.976	-0.037	-0.043***	0.136
	(0.625)	(0.424)	(0.607)	(0.026)	(0.013)	(0.200)
ins	-0.631	-0.450	-0.226	-0.013	-0.015	0.159
	(0.695)	(0.441)	(0.432)	(0.029)	(0.014)	(0.169)
Constant	-3.161	-3.400*	-1.919	0.067	0.042	0.827*
	(2.950)	(1.846)	(1.927)	(0.119)	(0.056)	(0.493)
Observations	95	95	95	96	95	96
R-squared		0.738	0.711		0.219	0.133

To summarize: consistent with H1, we have identified that size has a positive effect on risk-taking, although this effect becomes weaker when the log transformation of Z-score was used. Better governance can significantly reduce risk-taking, which is consistent with H2; and lastly, investment banks are riskier than commercial banks, which supports H3.

A1. Endogeneity of firm size

The empirical corporate finance research has long been plagued by the problem of endogeneity, and this research is no exception. Specifically, we are particularly concerned about the joint determination of risk-taking and firm size. Previous research has identified that banks are willing to pay large premium to make acquisitions that will make them sufficiently large and TBTF (Brewer III and Jagtiani, 2009). Therefore, although firms are more likely to pursue risk-taking activities when they become larger, it is also likely that high-risk firms have the incentives to increase their sizes to achieve TBTF status. To address this issue, we use the identification strategy of instrumental variable (IV). In particular, we make use of variation in whether or not a firm incorporates in Delaware as an instrument for firm size. The idea for this instrument is that when a company decides to go public, the decision where to incorporate, while not random, should be exogenous to the unobservable factors that affect firms' risk-taking as induced by moral hazard of TBTF. The validity of an instrument critically hinges on this exclusion restriction.

Empirical legal and financial studies have investigated extensively why a firm would choose Delaware as its domicile. For example, Daines (2001) and Bhagat and Romano (2002) find there is a wealth effect associated with Delaware incorporation, due to the fact that Delaware corporate law encourages takeover bids and facilitates the sale of public firms by reducing the cost of acquiring a Delaware firm. Apparently, this wealth effect should have nothing to do with a firm's risk-taking. Bebchuck and Cohen (2003) identify that favorable anti-takeover protections are important for a state to attract out-of-state incorporation.[25] From a different angle, Romano (1985) argues that Delaware's large store of precedent reduces transaction costs and uncertainty about legal liability. Lastly, Fisch (2000) notes the peculiar role of the Delaware judiciary in corporate lawmaking, arguing that Delaware lawmaking offers Delaware corporations a variety of benefits, including flexibility, responsiveness, insulation from undue political influence, and transparency. While these factors affect a firm's domicile decision, all of them appear centered around the legal environment of Delaware. In addition, other researchers have argued that a firm's choice of domicile is unimportant and trivial (Black, 1990) This literature suggests that our instrumental variable, dummy for Delaware incorporation, does not belong to the structural equation, we thus conclude that it is a valid instrument.

Table V, Panel A compares Delaware firms with non-Delaware firms in terms of firm characteristics, revealing that Delaware firms tend to have a larger market-to-book asset ratio, are more likely to be investment banks, and are less leveraged. Panel B of the Table compares size and risk-taking for Delaware and non-Delaware firms. It shows that Delaware firms are significantly larger and riskier. Figure 3 shows the distributions of firm size, revealing a systematic shift in firm size from non-Delaware firms to Delaware firms.

[25] We are concerned that anti-takeover protections might affect risk-taking, thus rendering the instrument invalid. However, the regression of Z-score on the G/E-indices, which are primarily measures of anti-takeover provisions, failed to yield significant results (see Table VIII).

Table VI

Comparison of Delaware and non-Delaware firms

This table shows the mean difference in firm characteristics, risk-taking and firm size between Non-Delaware and Delaware firms. Statistics based on average annual data over 1998-2008, unless otherwise indicated. Z-score is firm's return on assets plus the capital asset ratio divided by the standard deviation of asset return over period 1998-2008. σ(ROA) is the volatility of the firm's return on assets over the period 1998-2008. σ(RET) is standard deviation of annual stock return over 1998-2008. Market-to-book is calculated as market value of equity plus book value of debt divided by book total asset. ROA is the return on asset. Leverage is the debt asset ratio. Director ownership ($) is natural logarithm of median director dollar stockholding as of the last year in our sample period. CEO ownership (%) is percentage of CEO stock ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appears in Compustat monthly stock return database. *Investment bank* is a dummy which equals one if investment bank, zero otherwise. *Insurance company* is defined analogously.

Panel A

	Firm characteristics							
Variables	market to book ratio	Director Ownership	CEO ownership	age	Investment bank	Insurance company	ROA	Leverage
non-Delaware	1.110	13.611	0.041	18.791	0.058	0.068	0.004	0.882
Delaware	1.262	13.657	0.048	19.490	0.271	0.125	0.014	0.843
Difference	0.152	0.047	0.007	0.698	0.213	0.057	0.010	-0.039
t statistics	2.21	0.30	0.55	0.45	4.40	1.49	1.20	-1.990

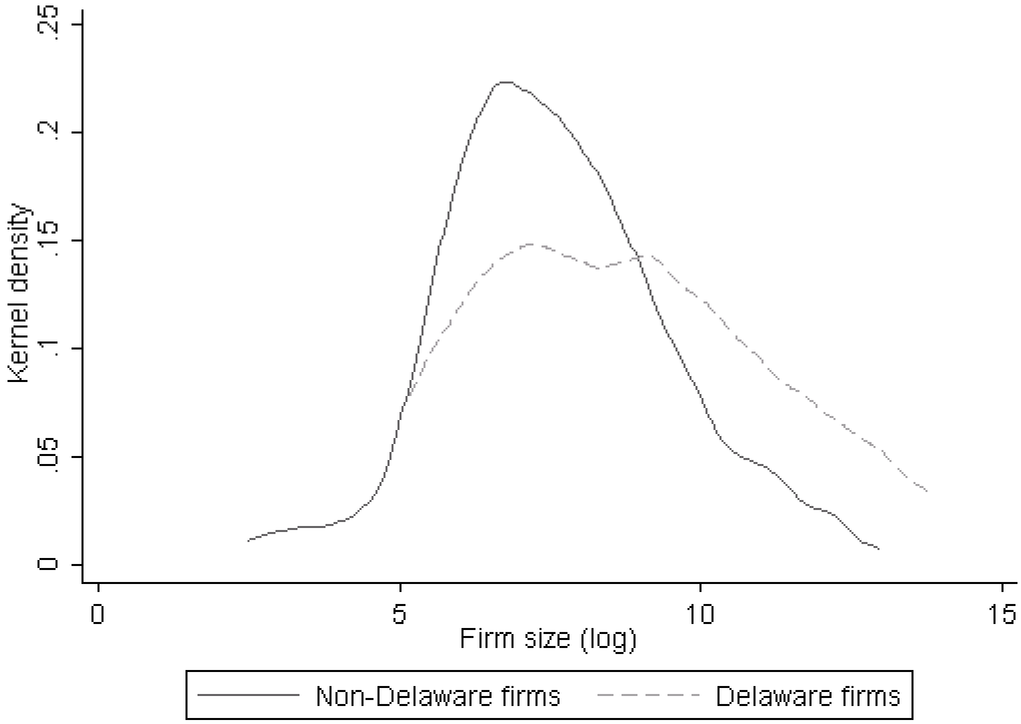
Panel B

	Size measures			Risk measures			
Variables	Log(total asset)	Log(total revenue)	Log(mkt value)	Z-score	log(Z-score)	σ(ROA)	σ(RET)
non-Delaware	7.589	5.086	5.812	38.397	3.260	0.017	0.337
Delaware	8.827	6.556	7.153	24.802	2.770	0.030	0.398
Difference	1.238	1.470	1.341	-13.594	-0.489	0.013	0.061
t statistics	4.59	5.74	5.15	-3.85	-3.89	1.45	2.05

Figure 3

Empirical distribution of firm size by non-Delaware firms and Delaware firms.

Firm size is the logarithm transformation of the average size from 1998-2008 for each firm. The sample includes commercial banks, investment banks and insurance companies. Epanechnikov kernel.



The IV approach involves estimating a two-stage model of the following form:

$$z_i = \alpha_0 + \alpha_1 size_i + \alpha_2 mb_i + \alpha_3 dir_i + \alpha_4 own_i + \alpha_5 age_i + \alpha_6 ibk_i + \alpha_7 ins_i + \varepsilon_i \quad (2)$$

$$size_i = \beta_0 + \beta_1 de_i + \beta_2 mb_i + \beta_3 dir_i + \beta_4 own_i + \beta_5 age_i + \beta_6 ibk_i + \beta_7 ins_i + \upsilon_i \quad (3)$$

where de_i is a dummy variable which equals one if firm i is Delaware incorporated, and the rest of the variables are defined as per Eq. (1)

Identification of the IV model requires a strong correlation between the Delaware dummy variable and firm size because a weak instrument can lead to large inconsistencies. Results from the first-stage regression with and without the full set of controls are presented in Table VII, Part A. For the specification with a full set of controls (col. 2), the entire set of independent variables explains about 60% of the variation in firm size while the included instrument variable alone explains about 10%. The standard error is 0.21 and the partial F-statistic on the excluded instrument is 25.89, which satisfies the weak instrument test (the rule of thumb value is 10) as discussed in Bound et al (1995) and Staiger and Stock (1997). To further verify this is the case, we perform a formal weak instrument test as proposed by Stock and Yogo (2005): if the F-statistic from the first-stage regression exceeds the critical value (using 5% bias), the instrument is deemed to be valid. As we can see from the bottom of the table, the critical value is 16.38, which is less than the F-statistic; we thus claim that we do not have a weak instrument problem. Overall, the results from the first stage regression indicate that Delaware firms on average are significantly larger than non-Delaware firms. This result is consistent with Bebchuk and Cohen

(2004) who identify a similar pattern based on a universe of all publicly traded firms in the Compustat database at the end of 1999.[26]

Results from IV estimates for risk-taking, as measured by Z-score, logarithm of Z-score, standard deviation of return on assets and annual stock return, are reported in Table VII, Part B. The results on Z-score are not only consistent with but also strengthen our previous findings in Table IV: the coefficient on size is negative and the magnitude is around four times larger for IV estimates. This fact suggests that the OLS estimate underestimates the true effect of firm size on risk-taking. In addition, we find that CEO ownership does have an impact on inducing risk-taking, consistent with existing theory. The results in Column 3 reveal that size does not have a significant impact on volatility of stock return. This result is consistent with Demsetz and Strahan (1997), who do not find evidence that the size of bank holding companies is negatively correlated with stock return variance. The findings on governance variable and investment banks are consistent with previous findings.

[26] See Table 8, page 403 of their paper.

Table VII

Two-Stage Least Square (2SLS) IV regression of firm size on risk-taking

Part A presents the first-stage regressions of firm size on the instrumental variable (Delaware), and other pre-determined controls included in the second stage regressions of risk-taking on firm size. These controls include market-to-book asset ratio, median director dollar stockholding, CEO stock ownership, firm age, dummy for investment bank, dummy for insurance company, return on asset, and leverage. Part B reports the results from the second-stage regressions of risk-taking on firm size and control variables, in which firm size, instrumented by Delaware, is treated as an endogenous variable. Sample consists of 300 financial firms. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. *Delaware* is dummy, which equals 1 if a firm is incorporated in Delaware. Z-score = (ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. *Ln(Z-score)* is natural logarithm of *Z-score*. *σ(RETY)* is the standard deviation of annual stock return over 1998-2008. *σ(RETM)* is the standard deviation of monthly stock return over 1998-2008. *ln(at)* is the logarithm of total asset. *mb* is the market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. *Leverage* is debt/asset ratio. *F*-statistic is the partial *F*-statistic on the instrument. Stock and Yogo (2005) weak instrument tests report the critical value using 5% relative bias tolerance. DWH test is Durbin-Wu-Hausman test of endogeneity. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Part A: First-Stage Regression: Firm Size (log)

	(1)	(2)	(3)
Delaware	1.238***	1.046***	0.923***
	(0.270)	(0.206)	(0.197)
mb		-0.494*	-0.166
		(0.260)	(0.357)
dir		0.411***	0.327***
		(0.074)	(0.068)
own		-4.273***	-2.271**
		(1.241)	(1.146)
age		0.092***	0.092***
		(0.008)	(0.008)
ibk		0.290	1.430***
		(0.491)	(0.527)
ins		2.003***	2.103***
		(0.463)	(0.432)
roa			2.941
			(2.862)
leverage			5.410***
			(1.158)
Constant	7.589***	0.879	-3.285**
	(0.132)	(0.988)	(1.355)
Partial R^2		0.098	0.088
F-statistic	21.04	25.89	21.99
Observations	302	300	300
R-squared	0.075	0.568	0.623
Stock and Yogo (2005) Weak Instrument Tests	-	16.38	16.38

Table VII (*continued*)

Part B: Second-Stage Regression: Firm Size on Risk-taking

VARIABLES	(1) Z-score	(2) ln(Z-score)	(3) σ(RETY)	(4) σ(RETM)
ln(at)	-8.348**	-0.249*	0.007	0.008
	(3.744)	(0.149)	(0.029)	(0.005)
mb	-6.818**	-0.279	0.219***	0.035***
	(3.422)	(0.210)	(0.082)	(0.012)
dir	7.258***	0.248***	-0.001	-0.005**
	(2.201)	(0.087)	(0.014)	(0.003)
own	-44.387**	-1.663*	0.337	0.064*
	(22.548)	(0.917)	(0.265)	(0.034)
age	0.681*	0.027*	-0.004	-0.001**
	(0.401)	(0.015)	(0.003)	(0.001)
ibk	-17.565***	-0.890**	0.261**	0.039**
	(6.267)	(0.376)	(0.103)	(0.018)
ins	12.535	0.526	0.011	-0.005
	(10.108)	(0.376)	(0.074)	(0.014)
roa			-1.996***	-0.363***
			(0.698)	(0.122)
leverage			0.426	0.004
			(0.288)	(0.054)
Constant	0.029	1.659**	-0.270	0.072
	(23.403)	(0.735)	(0.274)	(0.049)
Observations	300	298	300	300
R-squared	0.082	0.118	0.455	0.459

A2. Time and firm fixed effect

The previous analyses use cross-sectional regressions with average annual data over a 10-year period. Such a long period raises concerns that any changes in macroeconomic conditions or market-wide fluctuations could have influenced risk-taking in the financial industry. Even worse, any unobservable firm fixed effect could also bias our results. To address these concerns, we apply the identification strategy of the fixed effect model. To make sure there is enough variation in firm size from one period to the next, we obtain quarterly data during 2001—2008 and divide it into a two 4-year sub-periods, 2001—2004 and 2005—2008. We choose 2001 instead of 1998 as the starting point as this will avoid the impact of a series of bank-related regulations enacted in the late 1990s and beginning of the 2000s, such as the Gramm-Leach-Bliley Act of 1999 and the Commodities and Futures Modernization Act of 2000. We specify our model as follows:

$$z_{it} = \alpha_i + \rho_1 size_{it} + \rho_2 mb_{it} + \lambda_t + \varepsilon_{it} \text{ [27]} \qquad (t = 1, 2) \qquad (4)$$

where *i* indexes firm. *t* indexes period. z_{it} is Z-score for firm *i* in period *t*, calculated using quarterly data in period *t*; $size_{it}$ is the average size of firm *i* over 16 quarters (4 years) in period *t*; mb_{it} is the average market-to-book asset ratio of firm *i* over 16 quarters in period *t*; α_i and λ_t are firm and time fixed effects, respectively. I cluster standard errors at the firm level to account for correlations in standard errors specific to a firm (Petersen, 2009).

Results from the fixed effects models, as shown in Table VIII, strengthen our previous finding: firm size enters negatively and is significant at the 1% level in regressions with Z-score as the dependent variable. In addition, the coefficient on the *period2* dummy is negative and highly significant, implying a significant increase in risk-taking in the second period (2004—2008) comparing with the first one, consistent with the recent financial turmoil.

[27] Fixed effect estimator is also called the within estimator. The effect of any time-invariant variables, such as industry dummies and director ownership, or variables that are perfectly correlated with time, such as age, will not be identified and thus are excluded from this model.

Table VIII

Fixed effect model

This table shows the effect of firm size on risk taking based on quarterly data from 2001-2008, except for stock return volatility which uses monthly stock return data. This period is further divided into two sub-periods, 2001-2004 and 2005-2008. Using quarterly data or monthly data, regression variables are computed as the averages over each of the two 4-year periods, unless otherwise noted. The dependent variable is raw Z-score, log of Z-score, and monthly stock return volatility, respectively. Sample consists of 670 financial firms or 1,190 firm-periods. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio. σ(ROA) is the standard deviation of ROA. Higher Z-score implies more stability. *Ln(Z-score)* is natural logarithm of Z-score. *ln(at)* is the logarithm of total asset. *mb* is the average market-to-book asset ratio. *Period2* is a dummy variable which equals 1 if it is second period, zero otherwise. *Leverage* is debt/asset ratio. Standard errors, clustered at firm level, are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)
VARIABLES	Z-score	ln(Z-score)	σ(RET)
ln(at)	-50.12***	-0.691***	-0.498
	(18.57)	(0.223)	(1.152)
mb	-31.21	-0.937	8.639*
	(43.13)	(0.777)	(4.672)
period2	-44.13***	-0.375***	1.234**
	(9.824)	(0.0988)	(0.494)
roa			-148.2*
			(84.45)
leverage			15.71*
			(9.017)
Constant	564.7***	10.69***	-11.18
	(146.9)	(1.836)	(13.77)
# of firm-period	1,193	1,186	1,193
R-squared	0.153	0.242	0.116
Number of firms	670	668	670

B. Decomposition of Z-score

In this section, we argue that what contributed to the demise of many financial institutions during the financial crisis was their extremely low and deteriorating capital asset ratio. We show that, over time, large FIs have been reducing their capital asset ratio, and that cross-sectionally, larger FIs are substantially less capitalized compared to smaller ones. At the 2011 American Finance Association (AFA) annual meeting, MIT Professor Simon Johnson called it dangerous debt and questioned the rationale of maintaining such a high leverage for large FIs.

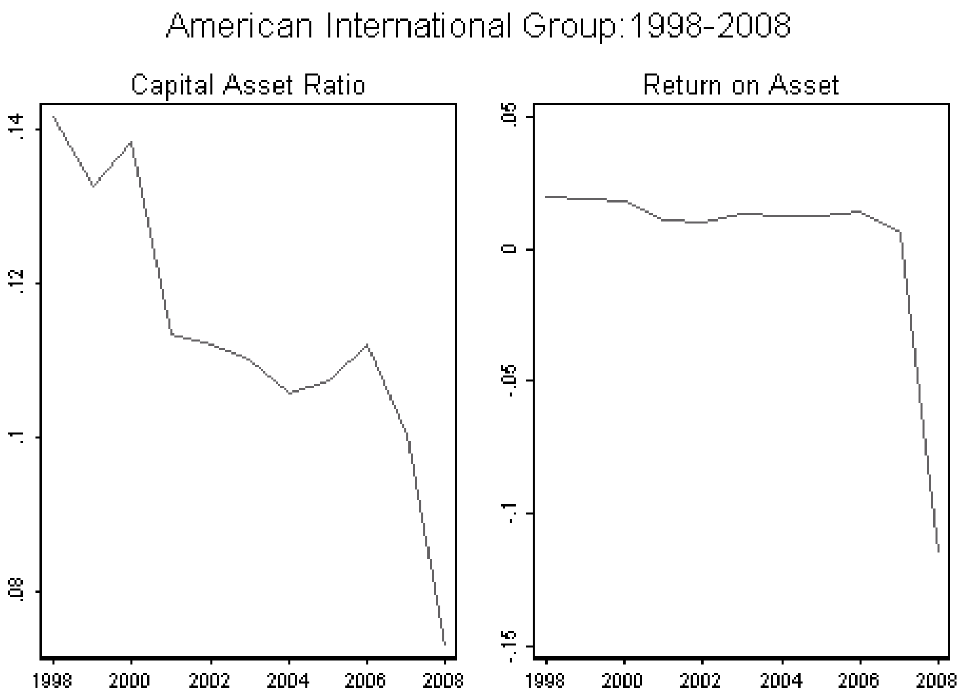
Figure 4 shows the time series of several large financial firms' capital ratio and return on asset, such as the AIG, Wells Fargo & Co, and Prudential Financial Group Inc. Figure 4 shows clearly that those firms' capital asset ratio has been decreasing steadily, regardless of whether the whole sample period (Panel A) or just the crisis period (Panel B) is considered. As for the magnitude of the change, it decreased from above 14% in 1998 to just over 7% in 2008 – an approximate of 50% decrease, in the case of AIG.

Figure 4

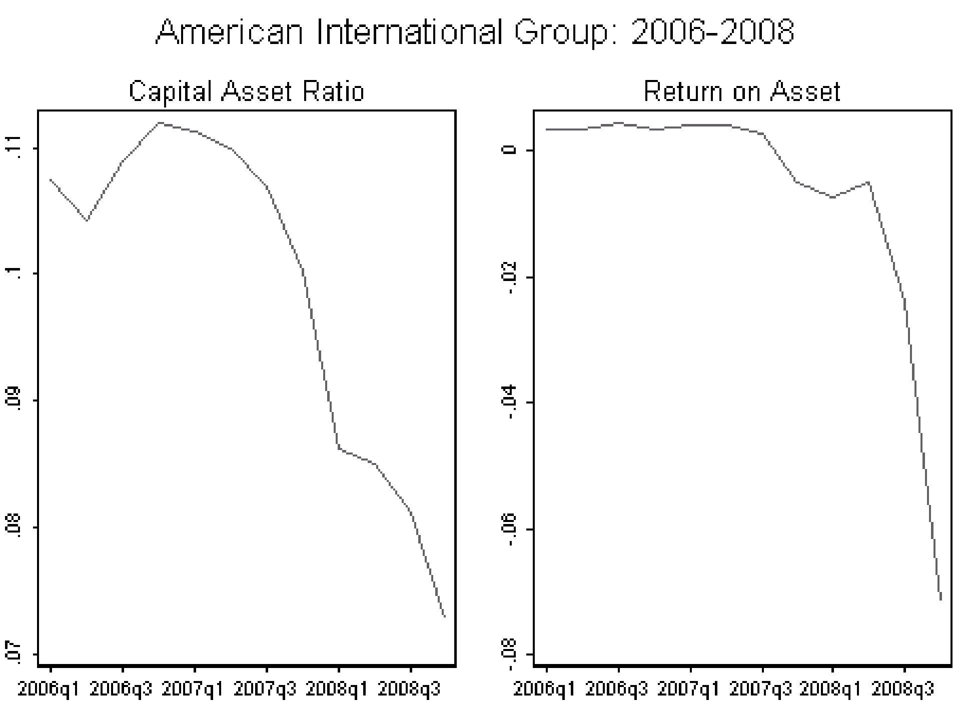
Time series of Capital Asset Ratio and Return on Asset for periods: 1998-2008 and 2006-2008

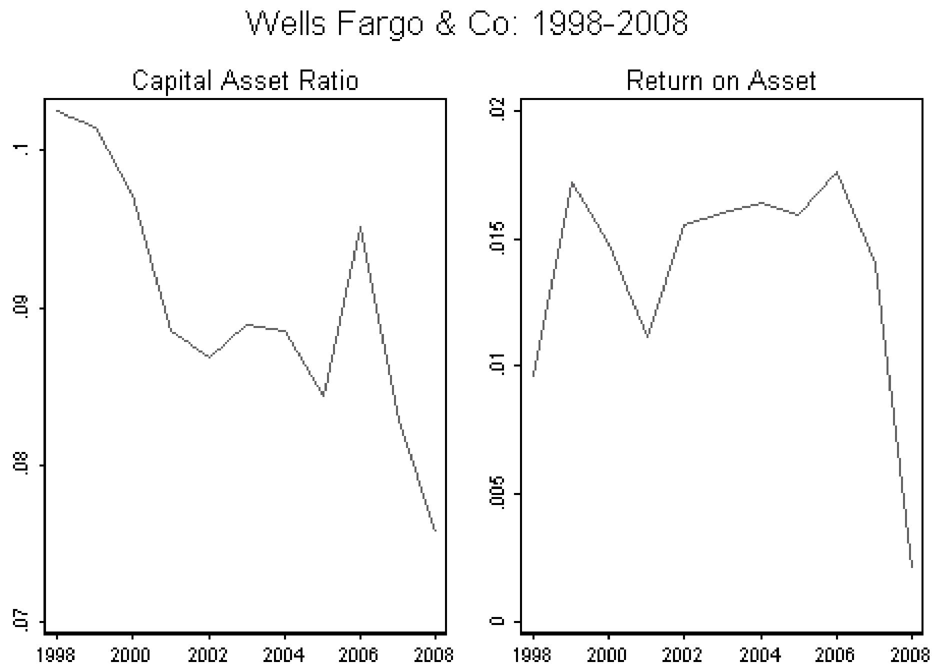
This figure shows the time-series capital asset ratio and return on asset over the whole sample period (1998-2008, Panel A) and the crisis period (2006-2008, Panel B) for the 10 largest firms in my sample.

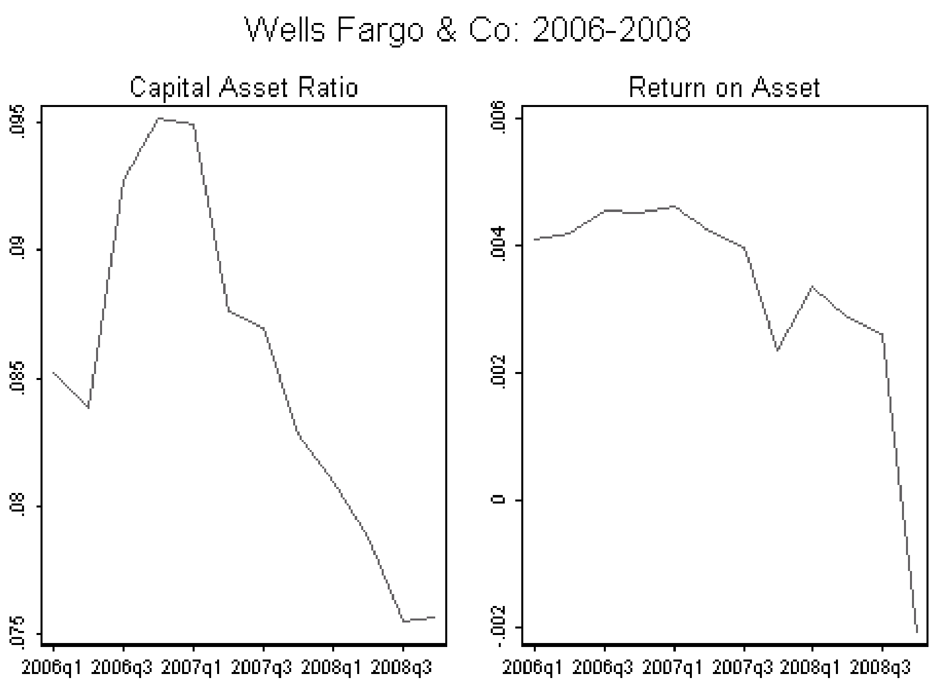
Panel A

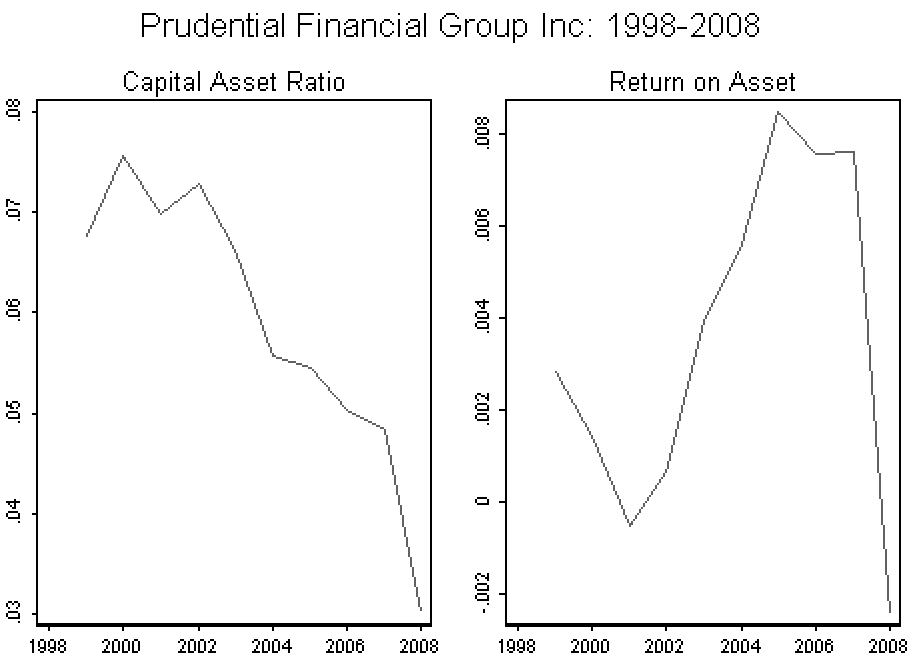


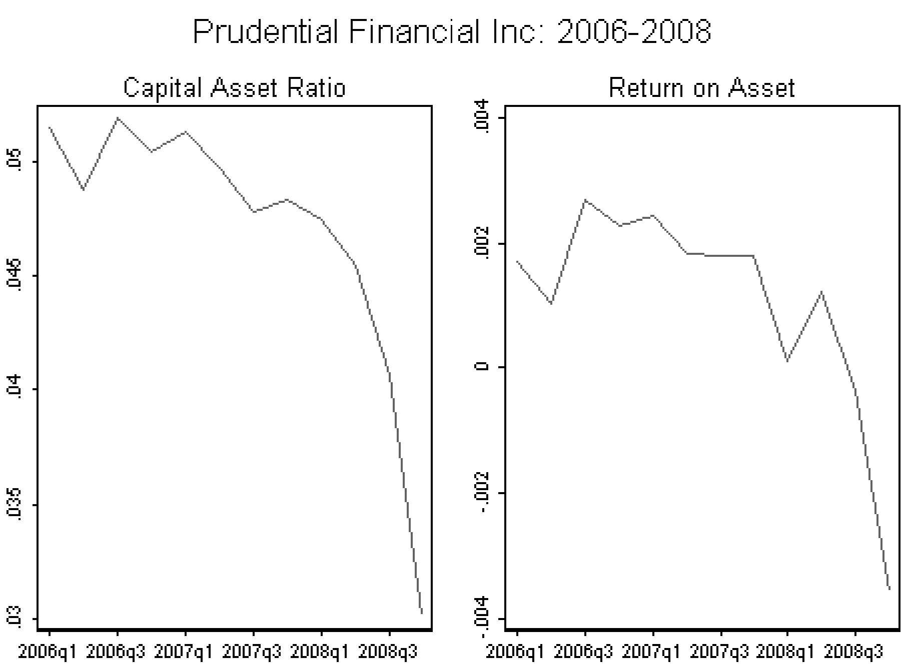
Panel B

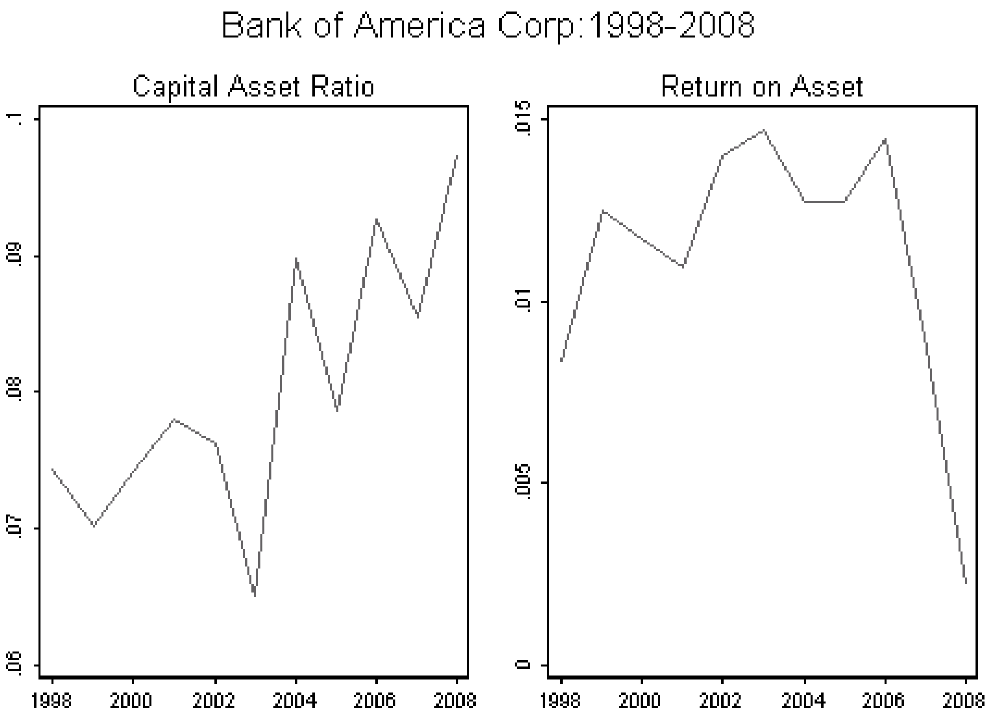


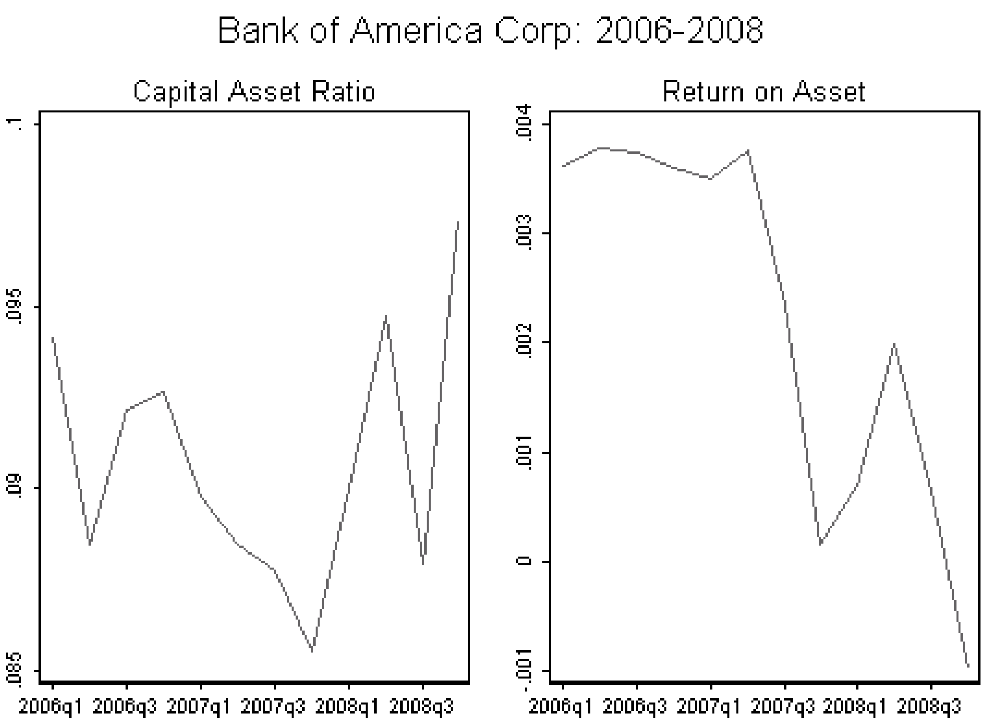

Wells Fargo & Co: 1998-2008
Capital Asset Ratio
Return on Asset
.07
.08
.09
.1
0
.005
.01
.015
.02
1998
2000
2002
2004
2006
2008


Wells Fargo & Co: 2006-2008
Capital Asset Ratio
Return on Asset
.075
.08
.085
.09
.095
-.002
0
.002
.004
.006
2006q1
2006q3
2007q1
2007q3
2008q1
2008q3


Prudential Financial Group Inc: 1998-2008
Capital Asset Ratio
.03
.04
.05
.06
.07
.08
1998
2000
2002
2004
2006
2008
Return on Asset
-.002
0
.002
.004
.006
.008
1998
2000
2002
2004
2006
2008


Prudential Financial Inc: 2006-2008
Capital Asset Ratio
.03
.035
.04
.045
.05
2006q1
2006q3
2007q1
2007q3
2008q1
2008q3
Return on Asset
-.004
-.002
0
.002
.004
2006q1
2006q3
2007q1
2007q3
2008q1
2008q3


Bank of America Corp:1998-2008
Capital Asset Ratio
Return on Asset
.06
.07
.08
.09
.1
0
.005
.01
.015
1998
2000
2002
2004
2006
2008


Bank of America Corp: 2006-2008
Capital Asset Ratio
Return on Asset
.085
.09
.095
.1
-.001
0
.001
.002
.003
.004
2006q1
2006q3
2007q1
2007q3
2008q1
2008q3

Also noteworthy from the figure is the change in profitability over time. As a consequence of the financial crisis, which exposed them to the downside of the risk, not only has the return on asset become more volatile, it also has decreased dramatically from 2.5% in 1998, to negative 7% in 2008, a magnitude of about 200% drop in profitability. The significant drop in capital asset ratio and profitability, and a rise in the volatility of profitability contributed to the very low level of the Z-score. While the capital asset ratio of these large FIs indicates a decreasing pattern, variation does exist. For example, the Bank of America Corp's capital ratio has increased slightly over time.

To further investigate the relationship between capital asset ratio and firm size, we decompose the Z-score. Z-score has three components –ROA, CAR, and σ(ROA) – and a higher level of ROA and higher capital asset ratios (CAR) translate into higher Z-scores, while a larger standard deviation of ROA translates into lower Z-scores[28]. Thus, when we find a positive relation between size and risk-taking, it may attribute to a lower ROA, lower capital ratio, and/or a higher standard deviation. Therefore, it is possible that size may not necessarily increase the risk of firm assets, but rather the drop in Z-score may instead be attributed to a decline in the average bank capital ratio or return on asset. To further explore how the various components of the Z-score move in response to an increase in firm size, we run regressions treating each of these Z-score components as a separate dependent variable.[29] The empirical results are reported in Table IX

[28] Since the year 2004 when Basel II Accord was implemented is included in our sample period, we are concerned that this event might affect firms' capital asset ratio. However, simple tests rule out this is the case (see Appendix K).

[29] We follow Houston et al, 2010.

Table IX

Decomposition of Z-score

The dependent variables are CAR, log of CAR (panel A), ROA, and σ(ROA) (panel B), respectively. Results from three estimation methods are presented: Median is median quantile regression, Robust is robust regression or iteratively reweighted least squares, OLS is ordinary least squares with White heteroskedasticity-robust standard error. Sample consists of 300 financial firms. Regression variables are computed as the averages over 1998-2008, unless otherwise noted Following Houston et al (2010), ROA is return on assets and CAR is capital-asset ratio, both are averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher of ROA and CAR imply more stability. The ROA multiplied by 100 is used in regressions. *ln(at)* is the logarithm of total asset. *mb* is the market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. *Leverage* is debt/asset ratio. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A: capital asset ratio

	CAR			ln(CAR)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.006***	-0.007***	-0.021***	-0.071***	-0.092***	-0.117***
	(0.001)	(0.001)	(0.005)	(0.011)	(0.012)	(0.019)
mb	0.137***	0.193***	0.083**	0.423***	0.521***	0.327***
	(0.004)	(0.004)	(0.040)	(0.043)	(0.051)	(0.114)
dir	-0.002**	-0.002**	-0.005	-0.001	-0.010	-0.023
	(0.001)	(0.001)	(0.004)	(0.014)	(0.015)	(0.017)
own	0.138***	-0.023	0.250**	0.094	-0.081	0.301
	(0.013)	(0.014)	(0.105)	(0.156)	(0.183)	(0.319)
age	0.001***	0.001***	0.002***	0.009***	0.009***	0.011***
	(0.000)	(0.000)	(0.001)	(0.002)	(0.002)	(0.003)
ibk	0.116***	0.001	0.192***	0.772***	0.699***	0.753***
	(0.005)	(0.005)	(0.041)	(0.057)	(0.063)	(0.145)
ins	0.022***	0.026***	0.061***	0.193***	0.309***	0.300***
	(0.005)	(0.005)	(0.014)	(0.061)	(0.067)	(0.098)
roa	-0.262***	-0.489***	-0.024	-0.856***	-1.291***	0.078
	(0.025)	(0.031)	(0.322)	(0.279)	(0.339)	(0.850)
Constant	0.005	-0.038**	0.189***	-2.473***	-2.285***	-1.742***
	(0.014)	(0.015)	(0.064)	(0.181)	(0.196)	(0.258)
Observations	300	299	300	300	300	300
R-squared		0.925	0.661		0.702	0.608

Panel B: ROA and volatility of ROA

	ROA			σ(ROA)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.039**	-0.029*	0.492	0.029	0.043	-0.004
	(0.018)	(0.015)	(0.446)	(0.056)	(0.038)	(0.042)
mb	4.335***	3.587***	5.956*	0.662***	0.648***	0.743***
	(0.069)	(0.071)	(3.424)	(0.219)	(0.177)	(0.232)
dir	0.071***	0.050***	0.140	-0.126*	-0.159***	-0.147***
	(0.021)	(0.019)	(0.222)	(0.069)	(0.046)	(0.050)
own	-1.687***	-1.054***	-3.228	-1.637*	-1.162*	-0.909
	(0.262)	(0.246)	(8.123)	(0.855)	(0.598)	(0.812)
age	0.009***	0.009***	-0.027	0.001	-0.003	-0.002
	(0.003)	(0.002)	(0.043)	(0.008)	(0.006)	(0.006)
ibk	-0.177*	-0.193**	-4.404	1.375***	0.714***	0.970***
	(0.101)	(0.092)	(3.045)	(0.338)	(0.232)	(0.268)
ins	0.209**	0.069	-0.747	0.020	-0.084	0.044
	(0.099)	(0.085)	(1.238)	(0.307)	(0.213)	(0.189)
roa				-7.630***	-10.833***	-4.720**
				(1.458)	(1.245)	(2.183)
leverage	1.127***	1.385***	0.876	-2.920***	-4.321***	-3.341***
	(0.282)	(0.270)	(12.023)	(0.933)	(0.639)	(0.827)
Constant	-5.542***	-4.777***	-11.553	-2.117*	-0.369	-1.205
	(0.350)	(0.328)	(11.650)	(1.171)	(0.799)	(0.912)
Observations	300	298	300	300	299	300
R-squared		0.918	0.187		0.609	0.540

Panel C: Interacting investment banks with firm size

	CAR			ln(CAR)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.004***	-0.004***	-0.004	-0.040***	-0.044***	-0.052***
	(0.001)	(0.001)	(0.003)	(0.014)	(0.012)	(0.016)
mb	0.039***	0.046***	0.036	0.144***	0.093*	0.141
	(0.004)	(0.004)	(0.045)	(0.053)	(0.053)	(0.121)
dir	-0.001	-0.002	-0.006	-0.014	-0.020	-0.026*
	(0.001)	(0.001)	(0.004)	(0.015)	(0.013)	(0.016)
own	0.036***	-0.030**	0.167	-0.472***	-0.523***	-0.027
	(0.012)	(0.013)	(0.106)	(0.164)	(0.168)	(0.335)
age	0.001***	0.000**	0.000	0.005***	0.004**	0.005*
	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.002)
ibk	0.632***	0.676***	0.622***	2.926***	3.109***	2.458***
	(0.013)	(0.014)	(0.119)	(0.192)	(0.175)	(0.324)
ins	0.020***	0.011**	0.025*	0.171**	0.167***	0.157
	(0.005)	(0.005)	(0.014)	(0.069)	(0.062)	(0.110)
roa	0.047**	0.616***	0.242	0.934**	0.691*	1.133
	(0.021)	(0.030)	(0.398)	(0.360)	(0.379)	(1.106)
ibk*size	-0.054***	-0.055***	-0.053***	-0.258***	-0.273***	-0.211***
	(0.001)	(0.002)	(0.012)	(0.022)	(0.020)	(0.034)
Constant	0.084***	0.083***	0.153***	-2.162***	-1.961***	-1.887***
	(0.013)	(0.014)	(0.052)	(0.194)	(0.175)	(0.230)
Observations	300	299	300	300	299	300
R-squared		0.974	0.739		0.797	0.685

Panel D: Full interaction

	CAR			ln(CAR)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.002*	-0.003***	-0.001	-0.022*	-0.016	-0.026
	(0.001)	(0.001)	(0.003)	(0.013)	(0.013)	(0.017)
mb	0.036***	0.049***	0.034	0.159***	0.071	0.131
	(0.004)	(0.004)	(0.046)	(0.047)	(0.050)	(0.120)
dir	-0.002	-0.002*	-0.006*	-0.018	-0.021	-0.026*
	(0.001)	(0.001)	(0.004)	(0.013)	(0.013)	(0.015)
own	0.026*	-0.033**	0.167	-0.283*	-0.562***	-0.030
	(0.015)	(0.014)	(0.107)	(0.153)	(0.159)	(0.334)
age	0.000*	0.000	-0.000	0.004**	0.001	0.002
	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.003)
ibk	0.650***	0.679***	0.647***	2.902***	3.372***	2.661***
	(0.016)	(0.015)	(0.120)	(0.176)	(0.172)	(0.323)
ins	0.173***	0.203***	0.182***	1.798***	1.953***	1.437***
	(0.027)	(0.023)	(0.057)	(0.275)	(0.271)	(0.443)
roa	0.051*	0.604***	0.244	-0.027	0.726**	1.150
	(0.026)	(0.031)	(0.399)	(0.320)	(0.360)	(1.110)
ibk*size	-0.056***	-0.055***	-0.056***	-0.263***	-0.305***	-0.237***
	(0.002)	(0.002)	(0.012)	(0.020)	(0.020)	(0.035)
ins*size	-0.016***	-0.018***	-0.017***	-0.174***	-0.186***	-0.135***
	(0.003)	(0.002)	(0.006)	(0.029)	(0.028)	(0.046)
Constant	0.082***	0.076***	0.135***	-2.230***	-2.088***	-2.029***
	(0.017)	(0.014)	(0.051)	(0.178)	(0.169)	(0.218)
Observations	300	299	300	300	299	300
R-squared		0.973	0.743		0.821	0.700

Panel E: Interacting investment bank with firm size.

	ROA			σ(ROA)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.046***	-0.026*	-0.128	0.068	0.064	0.066*
	(0.013)	(0.015)	(0.149)	(0.059)	(0.043)	(0.038)
mb	5.222***	3.419***	6.535*	0.346*	0.554***	0.579***
	(0.049)	(0.062)	(3.372)	(0.203)	(0.174)	(0.182)
dir	0.041***	0.048***	0.220	-0.103	-0.165***	-0.160***
	(0.015)	(0.016)	(0.201)	(0.065)	(0.047)	(0.050)
own	-1.422***	-0.842***	-1.644	-1.312*	-1.068*	-1.057
	(0.186)	(0.215)	(8.426)	(0.755)	(0.601)	(0.690)
age	0.010***	0.010***	0.031	-0.005	-0.007	-0.008
	(0.002)	(0.002)	(0.022)	(0.009)	(0.006)	(0.006)
ibk	-5.870***	-5.929***	-26.398**	4.244***	3.940***	3.779***
	(0.219)	(0.246)	(11.431)	(0.991)	(0.769)	(0.760)
ins	0.194***	0.082	0.390	-0.031	-0.079	-0.087
	(0.067)	(0.076)	(0.695)	(0.296)	(0.220)	(0.192)
roa				-3.971***	-3.322***	-3.177*
				(1.466)	(1.143)	(1.642)
leverage	-3.261***	-3.404***	-10.240	-2.103**	-1.817**	-1.968***
	(0.220)	(0.267)	(14.795)	(0.994)	(0.743)	(0.756)
ibk*size	0.490***	0.487***	2.524**	-0.332***	-0.325***	-0.315***
	(0.024)	(0.027)	(1.061)	(0.106)	(0.082)	(0.078)
Constant	-2.036***	-0.253	0.534	-3.107***	-2.620***	-2.534***
	(0.270)	(0.316)	(14.639)	(1.194)	(0.884)	(0.912)
Observations	300	298	300	300	300	300
R-squared		0.930	0.287		0.557	0.563

Panel F: full interaction

	ROA			σ(ROA)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.049***	-0.024	-0.180	0.105*	0.091*	0.085**
	(0.013)	(0.016)	(0.125)	(0.057)	(0.047)	(0.043)
mb	5.215***	3.420***	6.543*	0.546***	0.544***	0.574***
	(0.045)	(0.063)	(3.377)	(0.201)	(0.174)	(0.180)
dir	0.040***	0.048***	0.221	-0.106*	-0.166***	-0.160***
	(0.013)	(0.016)	(0.201)	(0.057)	(0.047)	(0.050)
own	-1.404***	-0.840***	-1.676	-1.140*	-1.043*	-1.045
	(0.169)	(0.216)	(8.459)	(0.675)	(0.598)	(0.679)
age	0.009***	0.010***	0.037*	-0.007	-0.010	-0.010
	(0.002)	(0.002)	(0.021)	(0.008)	(0.006)	(0.006)
ibk	-5.886***	-5.889***	-26.935**	4.918***	4.245***	3.984***
	(0.207)	(0.257)	(11.813)	(0.855)	(0.793)	(0.796)
ins	0.161	0.181	-2.245	2.306*	1.316	0.873
	(0.262)	(0.354)	(3.334)	(1.203)	(1.016)	(1.208)
roa				-3.904***	-3.222***	-3.144*
				(1.256)	(1.137)	(1.622)
leverage	-3.259***	-3.373***	-10.463	-0.897	-1.684**	-1.884**
	(0.200)	(0.270)	(14.988)	(0.842)	(0.744)	(0.757)
ibk*size	0.492***	0.483***	2.588**	-0.400***	-0.361***	-0.339***
	(0.023)	(0.028)	(1.106)	(0.093)	(0.085)	(0.083)
ins*size	0.005	-0.011	0.277	-0.240**	-0.148	-0.101
	(0.028)	(0.036)	(0.303)	(0.122)	(0.105)	(0.131)
Constant	-2.005***	-0.290	1.021	-4.654***	-2.871***	-2.711***
	(0.251)	(0.324)	(15.036)	(1.055)	(0.898)	(0.919)
Observations	300	298	300	300	300	300
R-squared		0.930	0.288		0.563	0.564

We see that an increase in size is associated with a decrease in capital asset ratio at the 1% significance level across all three estimation methods, consistent with Schmid and Walter (2009). As for the economic effect, on average, a 10% percent increase in size translates into almost a one percentage point reduction in capital asset ratio, holding other variables constant. Size negatively affects return on asset, but only marginally, and size does not decrease earnings volatility. These results indicate that the lower Z-score is driven primarily by a reduction in capital, and the size-related economy of scale, if any, does not exist in the financial industry. Indeed, a large body of empirical literature on the economies of scale of financial firms has produced inconclusive results.

Our finding is also consistent with Geanakoplos (2010) who argues that extremely high leverage in boom times has a huge impact on the price of assets, contributing to economic bubbles and busts. He suggests that the Federal Reserve should manage system-wide leverage, curtailing leverage in ebullient times, and propping up leverage in anxious times. This finding has direct policy implications: instead of setting a size threshold, strengthening capital requirements might be a more direct way to solve the excessive risk-taking problem as pronounced in the FIs.

Beyond the revealing finding regarding how exactly size affects the Z-score, note that the results from the specification on CAR in Table IX are consistent with several stylized facts known from capital structure literature.[30] For instance, market-to-book asset ratio is positively correlated with CAR, ROA is negatively correlated with CAR, and the constant term, which can

[30] See Frank and Goyal (2008) for a survey of literature on capital structure.

be thought of as a tangible asset,[31] is negatively correlated with CAR. These results are consistent with the trade-off theory of capital structure.

The control variables also yield interesting and consistent findings. Corporate governance (*dir*) is positively associated with ROA and negatively associated with earning volatility, but has no effect on capital asset ratio. These results suggest better governance enhances firm performance, consistent with Bhagat and Bolton (2008) who note a significant and positive relationship between this variable and contemporaneous and next year's operating performance. These findings aid us in understanding more about the effect of variable *dir* on risk-taking as shown in Table IV: the risk-reducing mechanism of corporate governance is mainly through an increase in ROA and a reduction in earnings volatility. The market-to-book asset ratio enters positively in all regressions in Table IX, and is significant at the 1% level. The coefficients on age indicate that, all else being equal, experienced firms are more profitable, better capitalized, and better at reducing stock return volatility, as they should be.

CHAPTER 5

Do financial firms of different size behave differently?

A. Specification

After having established that on average, larger firms are riskier than small firms, a natural question to ask is: do firms of different size cohorts behave differently? Researchers have shown that the status of TBTF itself has values. For instance, using an event study methodology, O'hara and Shaw (1990) find a positive wealth effect accruing to TBTF banks. Brewer III and Jagtiani (2009) document that financial firms were willing to pay at least $14 billion in added premiums

[31] Financial firms usually have a relatively small portion of tangible assets, which can be thought of as constant in the specification.

to mergers which will make them obtain the status of TBTF. To address the above question, we test whether the marginal effect of firm size on risk-taking is different between firms who may be considered TBTF and firms who are not.

Specifically, we interact the firm size with the dummy variable for the TBTF group. This method suits our needs well because it gives us the difference in estimates of size on risk-taking with a standard error for two separate regressions: for the TBTF group and for the non-TBTF group.

To be more concrete, I estimate the following equation:

$$z_i = \lambda_0 + \lambda_1 big_i + \lambda_2 size_i + \lambda_3 big_i * size_i + \lambda_4 mb_i + \lambda_5 dir_i + \lambda_6 own_i + \lambda_7 age_i + \lambda_8 ibk_i + \lambda_9 ins_i + \xi_i \quad (5)$$

where big_i is a dummy variable indicating whether firm *i* is TBTF, and the rest of the variables are defined as per Eq. (1). We are particularly interested in estimating λ_3, which captures the effect of size on firm's risk-taking for large firms as compared to small firms. To identify TBTF correctly is not a trivial task. The reason is that, although we observe government rescues *ex post*, but no firm has ever been identified officially as TBTF *ex ante*. We address this issue by relying on theory based on Goodhart and Huang (2005) who show that the central bank would only rescue banks which are above a threshold size.[32] We define firms with total asset over $10 billion as TBTF.[33]

B. Results on risk shift

[32] As shown in Goodhart and Huang (2005), in addition to size, the central bank's ultimate rescue decision also depends on the tradeoff between contagion and moral hazard effects.

[33] We tried $50 billion and $100 billion cutoffs, the results are qualitatively unchanged for variable Z-score. For variable equity volatility, the coefficient on the interaction term lost its significance.

The empirical literature on bank risk-shifting begins with Marcus and Shaked (1984), and it occurs when the government is exposed to loss from increased asset volatility or leverage without receiving corresponding adequate compensation for the risk entailed. Systemic FIs have stronger incentives to engage in riskier activities due to the fact that the risk-shifting is subsidized: the cost of becoming TBTF is far less than the value of the explicit and implicit government guarantees.

Results for risk-shifting are shown in Table X with the raw Z-score, the log of Z-score and equity volatility as respective dependent variables. Again, the results with three estimation methods are presented. The variable of interest is the interaction term (*big_size*). The sign on *big_size* is negative, meaning an increase in size is associated with greater decrease in *Z-score* (and *ln(Z-score)*) for big firms than for small firms, but it is not significant at conventional level. The coefficient on *big* seems contradictory to our previous finding that larger firms are associated with higher risk-taking. Our explanation is that, for this particular specification, the coefficient on *big* tests whether there is difference in risk-taking between big and small firms when firm size equals zero, which does not bear any meaningful interpretation. Consistent with the findings in Table IV, governance variable (*dir*) has a significant effect in reducing firm risk-taking; investment banks are riskier than commercial banks.

Table X

Changes in risk for TBTF firms.

The dependent variables are *Z-score,* log of *Z-score*, and *σ(RET),* respectively. Results from three estimation methods are presented: Median is median quantile regression, Robust is robust regression or iteratively reweighted least squares, OLS is ordinary least squares with White heteroskedasticity-robust standard error. Sample consists of 300 financial firms. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. *Ln(Z-score)* is natural logarithm of *Z-score*. σ(RET) is the standard deviation of annual stock return over 1998-2008. *big* is dummy, which equals 1 for firms with total assets over $10 billion. *ln(at)* is the logarithm of total asset. *big_size* is interaction term of *big* and *ln(at)*. *mb* is the market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibd* is dummy for investment banks, and *ins* is dummy for insurance companies. *Leverage* is debt/asset ratio. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	Z-score			ln(Z-score)			σ(RET)		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS
big	0.795	20.67	13.34	-0.347	0.167	0.867	-1.098***	-0.989**	-0.878**
	(24.22)	(25.51)	(23.36)	(1.220)	(0.996)	(0.964)	(0.381)	(0.416)	(0.401)
logat	-0.806	-1.611	-3.017	-0.082	-0.058	0.029	-0.062***	-0.038	-0.031
	(1.372)	(1.407)	(1.856)	(0.070)	(0.056)	(0.092)	(0.022)	(0.024)	(0.026)
big_size	-0.281	-1.985	-1.288	0.0359	-0.0171	-0.103	0.126***	0.107**	0.0932**
	(2.417)	(2.541)	(2.451)	(0.122)	(0.0995)	(0.106)	(0.038)	(0.042)	(0.040)
mb	-2.741	-3.783	-4.580**	-0.352*	-0.305**	-0.202	0.214***	0.325***	0.308***
	(3.635)	(3.827)	(2.052)	(0.181)	(0.150)	(0.164)	(0.062)	(0.071)	(0.098)
dir	3.126***	4.104***	5.008***	0.162***	0.189***	0.148**	-0.056***	-0.024	-0.018
	(1.184)	(1.224)	(1.768)	(0.060)	(0.048)	(0.058)	(0.018)	(0.020)	(0.021)
own	1.790	-12.51	-20.27*	0.134	-0.110	-0.439	0.772***	0.909***	0.470
	(12.72)	(15.00)	(10.76)	(0.642)	(0.594)	(0.692)	(0.226)	(0.253)	(0.489)
age	-0.0562	0.166	0.191	0.001	0.008	0.006	-0.007***	-0.010***	-0.010***
	(0.150)	(0.154)	(0.162)	(0.007)	(0.006)	(0.006)	(0.002)	(0.003)	(0.002)
ibk	-19.70***	-17.61***	-21.25***	-0.937***	-0.905***	-1.060***	0.337***	0.442***	0.509***
	(4.931)	(5.140)	(3.762)	(0.246)	(0.202)	(0.249)	(0.090)	(0.010)	(0.120)
ins	-2.271	0.430	0.826	-0.0121	0.0958	0.0286	0.025	0.060	0.063
	(5.395)	(5.614)	(5.422)	(0.263)	(0.219)	(0.189)	(0.085)	(0.093)	(0.080)
roa							-1.527***	-2.140***	-2.122***
							(0.406)	(0.456)	(0.523)
leverage							0.546**	1.004***	0.828***
							(0.242)	(0.275)	(0.316)
Constant	-1.715	-8.651	-4.724	2.146**	1.350**	1.165	-0.653**	-1.732***	-1.687***
	(16.74)	(17.21)	(24.68)	(0.844)	(0.674)	(0.749)	(0.330)	(0.359)	(0.405)
Obs	300	300	300	298	298	298	300	300	300
R-squared		0.141	0.139		0.205	0.213		0.380	0.348

Regression results with equity volatility as a dependent variable from the last panel in Table X are interesting. The coefficient on *logat* measures the effect of size on risk-taking for small firms only; they are negative and significant in the median regression, indicating size-related diversification only exists for firms below a certain threshold size; once firms pass this threshold, the diversification effect either disappears or attenuates significantly. Finding on *roa* and *leverage* are consistent with Table V as well.

Based on findings from Table X, we conclude that there is no significant evidence that big firms behave differently than small firms, which is inconsistent with H4.

CHAPTER 6

Policy Implications

The recent financial crisis of 2008 has eroded the economic net worth of many financial institutions. The consensus has been that TBTF financial firms took too much risk prior to the crisis. Regarding remedies, many opinions have been expressed such as capping the size of firms. However, given the difficulty of correctly identifying TBTF financial institutions, serious concerns have been raised with this simple size constraint. In this paper, we went one step further to find out that, although we do observe a positive association between firm size and risk-taking, what is really going on behind the scene is that these firms have taken too much leverage. This finding has important implications for policy makers: regulations designed to rein in the risk-taking of financial firms should focus more on capital requirements,[34] this suggestion is also reinforced by the fact that leverage is positively associated with equity volatility. As Judah S. Kraushaar, managing director of Roaring Brook Capital, L.P., pointed out, "attacking excessive

[34] To be clear, what is the optimal capital requirement policy is a question deserving future research and beyond the scope of this paper. Kashyap, Rajan and Stein (2008) have a discussion about this question.

leverage in the banking system may go a long way toward dampening the boom-bust cycle that has become alarmingly intense in recent decades"[35].

As a suggestion, for example, regulators can set capital requirements in such a way that they are proportionate in size[36]. The common concern for raising capital is that equity is "expensive" and capital adversely affects bank value. However, recent study on bank capital challenges this view and provides theoretical and empirical evidence that total bank value and the bank's equity capital are positively correlated in the cross-section (Mehran and Thakor, 2010). We agree that such solution may not be optimal,[37] but it has the advantage of tackling the problem from the root: correcting the distortion in risk-taking incentives. This becomes even more relevant when policy makers are faced with the thorny problem of correctly categorizing TBTF banks along with other obstacles mentioned earlier.

Our second finding that corporate governance, measured as median director dollar stock ownership, can significantly influence firm's risk-taking also bears its own merits. This measure is rather simple and intuitive compared with standard governance indices, thus it is relatively easier for corporate boards to implement when making risk management policies. Our last finding that investment banks are consistently riskier than commercial banks reminds us of the watershed events of the 1930s when the so-called Glass-Steagall Act was passed to prohibit

[35] "Banks Need Clear Capital Rules", the Wall Street Journal, January 22, 2010.

[36] This point is similar to the recommendation in The Squam Lake Report, where it argues that, if everything else is the same, large banks should face higher capital requirements than small banks. This idea has also been proposed by Congressional Oversight Panel as one way to limit excessive risk-taking (see, Congressional Oversight Panel, 2009, p. 26). "Of Banks and Bonus", New York Times, July 27, 2009, has similar arguments as well.

[37] Hellmann, Murdock, and Stiglitz (2000) argue that it is impossible to implement any Pareto-efficient outcome using just capital requirements as the tool of prudential regulation. They propose a combination of deposit rate controls and capital requirements. However, their arguments only apply to deposit-taking financial firms. Marshall and Prescott (2001) have similar arguments.

firms with a commercial banking charter from conducting security business. It provides justification for the functional separation of investment banking from universal banking.

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Appendix A

Theoretical development of Z-score (Boyd and Runkle (1993))

Notation: let

$$\tilde{\pi} = profits, A = assets, E = equity, k = -E/A, \tilde{r} = \tilde{\pi}/A$$

In their paper, Z-score is a measure of probability of failure, which is a state when losses exceed equity:

$$p(\tilde{\pi} < -E) = p(\tilde{r} < k) = \int_{-\infty}^{k} \phi(\tilde{r})dr$$

If we assume that:

$$\tilde{r} \sim N(\rho, \sigma)$$

here ρ and σ is the population mean and standard deviation of return on asset, respectively.

Then:

$$p(\tilde{r} < k) = p(\tau < (k-\rho)/\sigma)$$

$$= \int_{-\infty}^{(k-\rho)/\sigma} N(0,1)d\tau$$

$$= \int_{-\infty}^{-(E/A+\pi/A)/\sigma} N(0,1)d\tau$$

$$= \int_{-\infty}^{-z} N(0,1)d\tau$$

here τ is standard normal random variable, N(0,1) is standard normal PDF.

We thus have:

$$z = \frac{E/A + \pi/A}{\sigma} = \frac{CAR + ROA}{\sigma(ROA)}$$

Appendix B

Capital Asset Ratio

Definitions:

Tier 1 capital ratio = Tier 1 capital / Risk-adjusted assets

Total capital (Tier 1 and Tier 2) ratio = Total capital (Tier 1 and Tier 2) / Risk-adjusted assets

Leverage ratio = Tier 1 capital / Average total consolidated assets

Common stockholders' equity ratio = Common stockholders' equity / Balance sheet assets

Illustration:

In millions of dollars at year-end	2003	2007	2008
Tier 1 capital	-		
Common stockholders' equity	$96,889	$113,447	$70,966
Qualifying perpetual preferred stock	1,125		70,664
Qualifying mandatorily redeemable securities of subsidiary trusts	6,257	23,594	23,899
Minority interest	1,158	4,077	1,268
Total Tier 1 capital	$66,871	$89,226	$118,758
Tier 2 capital	-		
Allowance for credit losses	9,545	15,778	12,806
Qualifying debt	13,573	26,690	24,791
Total Tier 2 capital	$23,472	$44,895	$37,640
Total capital (Tier 1 and Tier 2)	$90,343	$134,121	$156,398
Risk-adjusted assets	$750,293	$1,253,321	$996,247

Ratios:

At year-end	2003	2007	2008
Tier 1 capital	8.91%	7.12%	11.92%
Total capital (Tier 1 and Tier 2)	12.04%	10.70%	15.70%
Leverage	5.56%	4.03%	6.08%
Common stockholders' equity	7.67%	5.19%	3.66%

Source: Citigroup 10-K

Note: some items are omitted due to space limit, so numbers may not add up.

Appendix C

Variable definitions and data sources.

Variable	Definition	Original sources
Risk measures		
Z-score	equals (ROA+CAR/σ(ROA), where ROA=π/A is return on assets and CAR =E/A is capital-asset ratio where E equals total liability – total asset, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z implies more stability	Compustat
ln(Z-score)	equals natural logarithm of Z-score	
ROA	Return on assets, averaged over 1998-2008. Higher value implies more stability	Compustat
CAR	Capital asset ratio, averaged over 1998-2008. Higher value implies more stability	Compustat
σ(ROA)	Equals standard deviation of ROA, computed over 1998-2008	Compustat
σ(RET)	equals standard deviation of RET, computed over 1998-2008. RET is annual stock return from 1998 to 2008	CRSP
write-down	Sum of accounting write-down for 2007 and 2008	Bloomberg and 10-K, 10-Q
Controls		
size	equals the natural logarithm of the average total asset over 1998-2008	Compustat
ln(rev)	equals the natural logarithm of the average total revenue over 1998-2008	Compustat
mb	equals the market-to-book value, averaged over 1998-2008	Compustat
dir	equals the median director dollar stockholding as of the last year of the sample period	RiskMetrics and Proxy statement
own	equals the percentage of CEO stock ownership, as of the last year of the sample period	RiskMetrics and Proxy statement
age	Firm age, calculated as the difference between 2008 and the year that firms first appear in the Compustat monthly stock return database	Compustat
leverage	equal total liability divided by total asset, averaged over 1998-2008	Compustat
ibk	a dummy variable that equals one if investment bank, zero otherwise	Compustat
ins	a dummy variable that equals one if insurance company, zero otherwise	Compustat
big	equals 1 if total asset is over $10billions, 0 otherwise	

Appendix D

List of financial institutions

This table lists a sample of financial institutions by assets in descending order. Variable definition can be found in Appendix C. For the purpose of comparison, I list write-down data collected by Chesney, Stromberg and Wagner (2010) (write-down) and data collected by myself (write-down1).

Company Name	Classification	Total Asset	Z-score	Leverage	CAR	Director ownership	write-down	write-down1
BANK OF AMERICA CORP	Commercial banks	1,027,890.64	25.11	0.92	0.08	14.89	42,600	19,872
JPMORGAN CHASE & CO	Commercial banks	1,014,138.55	20.21	0.93	0.07	13.32	33,100	33,100
MORGAN STANLEY	Investment banks	656,829.09	14.27	0.96	0.04	14.24	21,500	21,500
AMERICAN INTERNATIONAL GROUP	Life insurance	641,511.09	2.94	0.89	0.11	14.13	87,400	62,979
GOLDMAN SACHS GROUP INC	Investment banks	537,268.09	22.07	0.95	0.05	16.02	7,200	6,065
WELLS FARGO & CO	Commercial banks	455,839.45	22.72	0.91	0.09	15.15	23,400	23,400
WACHOVIA CORP	Commercial banks	432,197.60	24.38	0.91	0.09	14.50	101,800	101,800
PRUDENTIAL FINANCIAL INC	Life insurance	366,882.20	16.70	0.94	0.06	13.97	5,612	8,700
METLIFE INC	Life insurance	362,102.55	23.88	0.94	0.06	13.10	12,700	12,700
LEHMAN BROTHERS HOLDINGS INC	Investment banks	335,290.60	29.30	0.96	0.04	14.49	16,200	16,200
BEAR STEARNS COMPANIES INC	Investment banks	235,648.92	25.02	0.97	0.03	14.95	3,200	0
U S BANCORP	Commercial banks	168,807.23	24.16	0.91	0.09	15.49	4,866	3,700
SUNTRUST BANKS INC	Commercial banks	139,000.79	39.15	0.91	0.09	13.93	4,164	6,100
LINCOLN NATIONAL CORP	Life insurance	124,429.77	25.90	0.95	0.05	14.92	1,598	9,289
NATIONAL CITY CORP	Commercial banks	117,415.27	19.65	0.92	0.08	13.46	25,400	25,400
PRINCIPAL FINANCIAL GRP INC	Life insurance	112,151.85	29.90	0.94	0.06	13.65	1,385	4,400
BANK OF NEW YORK MELLON CORP	Commercial banks	109,227.27	17.74	0.90	0.10	14.11	2,826	480
GENWORTH FINANCIAL INC	Life insurance	107,529.33	19.11	0.88	0.12	10.81	2,537	2,421
NATIONWIDE FINL SVCS -CL A	Life insurance	103,118.15	37.03	0.96	0.04	12.72	1,504	1,650
PNC FINANCIAL SVCS GROUP INC	Commercial banks	102,734.09	18.20	0.90	0.10	13.85	2,883	2,406
AMERIPRISE FINANCIAL INC	Investment banks	96,782.67	24.60	0.92	0.08	11.43	958	1,987
STATE STREET CORP	Commercial banks	94,185.00	62.92	0.94	0.06	14.19	1,200	6,039
BB&T CORP	Commercial banks	90,405.84	53.11	0.91	0.09	15.32	2,829	6,882
KEYCORP	Commercial banks	89,275.27	11.12	0.92	0.08	13.93	2,000	2,000
FIFTH THIRD BANCORP	Commercial banks	80,955.16	10.67	0.90	0.10	14.01	4,900	4,328

REGIONS FINANCIAL CORP	Commercial banks	78,609.52	7.43	0.90	0.10	14.08	10,382	10,597
COMERICA INC	Commercial banks	51,502.12	25.51	0.91	0.09	14.00	1,523	1,026
NORTHERN TRUST CORP	Commercial banks	47,478.26	58.09	0.93	0.07	13.18	283	182
M & T BANK CORP	Commercial banks	43,839.52	51.35	0.90	0.10	14.27	309	786
UNIONBANCAL CORP	Commercial banks	42,569.22	60.15	0.91	0.09	11.70	615	795
SCHWAB (CHARLES) CORP	Investment banks	41,199.04	7.38	0.91	0.09	14.80	75	276
MARSHALL & ILSLEY CORP	Commercial banks	39,234.56	7.52	0.90	0.10	14.35	5,511	2,300
POPULAR INC	Commercial banks	36,476.47	6.14	0.93	0.07	16.48	1,333	807
HUNTINGTON BANCSHARES	Commercial banks	34,732.61	18.09	0.91	0.09	14.20	1,701	2,200
ZIONS BANCORPORATION	Commercial banks	33,448.05	20.97	0.91	0.09	15.19	565	1,000
E TRADE FINANCIAL CORP	Investment banks	29,426.68	8.95	0.89	0.11	13.53	5,382	3,655
FIRST HORIZON NATIONAL CORP	Commercial banks	26,992.31	10.34	0.93	0.07	13.48	1,461	1,143
PROTECTIVE LIFE CORP	Life insurance	25,791.57	21.87	0.93	0.07	12.81	587	1,650
SYNOVUS FINANCIAL CORP	Commercial banks	22,600.93	11.95	0.89	0.11	14.93	1,456	1,269
COLONIAL BANCGROUP	Commercial banks	17,565.28	6.00	0.93	0.07	13.06	1,910	2,108
ASSOCIATED BANC-CORP	Commercial banks	17,278.21	47.38	0.91	0.09	14.25	467	113
WEBSTER FINANCIAL CORP	Commercial banks	14,259.03	11.07	0.91	0.09	14.04	551	842
COMMERCE BANCSHARES INC	Commercial banks	13,774.55	71.57	0.90	0.10	13.61	187	164
TORCHMARK CORP	Life insurance	13,396.81	52.26	0.79	0.21	14.40	115	194
TCF FINANCIAL CORP	Commercial banks	12,726.97	27.19	0.92	0.08	15.06	384	384
FIRST BANCORP P R	Commercial banks	12,253.73	23.83	0.93	0.07	13.60	351	740
JEFFERIES GROUP INC	Investment banks	11,550.13	8.51	0.90	0.10	13.97	267	24
BANK OF HAWAII CORP	Commercial banks	11,348.91	23.17	0.92	0.08	14.16	120	81
TD AMERITRADE HOLDING CORP	Investment banks	10,752.83	5.20	0.90	0.10	13.21	36	28,324
FULTON FINANCIAL CORP	Commercial banks	10,453.88	24.67	0.90	0.10	14.90	200	331
FIRSTMERIT CORP	Commercial banks	10,077.32	54.64	0.91	0.09	13.79	89	166
SOUTH FINANCIAL GROUP INC	Commercial banks	9,636.92	7.42	0.90	0.10	12.56	1,116	1,264
WILMINGTON TRUST CORP	Commercial banks	9,090.36	19.10	0.91	0.09	13.74	341	291
RAYMOND JAMES FINANCIAL CORP	Investment banks	8,999.96	39.66	0.87	0.13	13.06	18	105
UMB FINANCIAL CORP	Commercial banks	8,495.63	111.09	0.91	0.09	12.73	27	57

OLD NATIONAL BANCORP	Commercial banks	8,293.04	45.59	0.92	0.08	14.07	60	77
SUSQUEHANNA BANCSHARES INC	Commercial banks	7,240.39	55.00	0.89	0.11	13.47	157	275
FIRST MIDWEST BANCORP INC	Commercial banks	6,754.64	34.47	0.92	0.08	13.67	190	194
UCBH HOLDINGS INC	Commercial banks	6,385.02	15.44	0.93	0.07	13.81	311	449
UNITED BANKSHARES INC/WV	Commercial banks	6,211.21	55.05	0.91	0.09	13.98	109	65
EAST WEST BANCORP INC	Commercial banks	6,027.71	18.48	0.91	0.09	14.63	281	460
WINTRUST FINANCIAL CORP	Commercial banks	5,499.98	40.09	0.93	0.07	13.32	43	128
SVB FINANCIAL GROUP	Commercial banks	5,461.04	19.05	0.88	0.12	12.80	119	321
CATHAY GENERAL BANCORP	Commercial banks	5,385.44	30.14	0.89	0.11	15.75	194	956
UNITED COMMUNITY BANKS INC	Commercial banks	5,260.12	15.83	0.92	0.08	15.31	222	428
FIRST COMMONWLTH FINL CP/PA	Commercial banks	5,244.15	51.42	0.91	0.09	13.39	18	78
CORUS BANKSHARES INC	Commercial banks	5,210.06	5.90	0.88	0.12	11.48	726	724
HANCOCK HOLDING CO	Commercial banks	4,584.19	49.16	0.90	0.10	13.69	44	74
DELPHI FINANCIAL GRP -CL A	Life insurance	4,482.30	18.89	0.82	0.18	14.54	79	148
IRWIN FINANCIAL CORP	Commercial banks	4,414.82	3.09	0.92	0.08	12.52	731	792
SWS GROUP INC	Investment banks	4,382.49	12.61	0.94	0.06	13.90	2,962	12
WESTAMERICA BANCORPORATION	Commercial banks	4,340.53	58.53	0.92	0.08	13.37	3	81
NATIONAL PENN BANCSHARES INC	Commercial banks	4,129.49	37.44	0.91	0.09	14.48	140	180
PRESIDENTIAL LIFE CORP	Life insurance	3,925.70	13.81	0.86	0.14	11.70	28	9,240
UMPQUA HOLDINGS CORP	Commercial banks	3,905.03	50.95	0.87	0.13	13.67	154	397
FIRST FINL BANCORP INC/OH	Commercial banks	3,660.24	35.52	0.91	0.09	13.47	23	31
COMMUNITY BANK SYSTEM INC	Commercial banks	3,541.90	59.74	0.91	0.09	14.96	10	19
CENTRAL PACIFIC FINANCIAL CP	Commercial banks	3,413.58	9.33	0.90	0.10	12.64	548	410
BOSTON PRIVATE FINL HOLDINGS	Commercial banks	3,247.73	5.11	0.91	0.09	13.30	569	852
PROSPERITY BANCSHARES INC	Commercial banks	3,049.64	82.31	0.89	0.11	15.96	24	63
S & T BANCORP INC	Commercial banks	2,912.55	71.32	0.89	0.11	14.37	23	48
PRIVATEBANCORP INC	Commercial banks	2,890.18	14.20	0.93	0.07	15.27	126	469
GLACIER BANCORP INC	Commercial banks	2,842.76	74.22	0.90	0.10	14.17	51	47
PACWEST BANCORP	Commercial banks	2,735.07	2.30	0.87	0.13	13.72	826	854
LABRANCHE & CO INC	Investment banks	2,585.85	6.32	0.68	0.32	12.13	171	681

INDEPENDENT BANK CORP/MI	Commercial banks	2,455.54	5.84	0.93	0.07	13.16	101	131
FIRST FINL BANKSHARES INC	Commercial banks	2,305.56	127.76	0.89	0.11	15.32	10	17
HANMI FINANCIAL CORP	Commercial banks	2,266.34	7.19	0.90	0.10	16.00	282	401
PIPER JAFFRAY COS INC	Investment banks	2,156.83	5.05	0.64	0.36	13.35	131	11
TOMPKINS FINANCIAL CORP	Commercial banks	1,785.19	63.88	0.91	0.09	13.94	7	16
STERLING BANCORP/NY	Commercial banks	1,670.66	30.74	0.92	0.08	13.43	14	35
NARA BANCORP INC	Commercial banks	1,325.58	20.72	0.92	0.08	14.11	59	91
WILSHIRE BANCORP INC	Commercial banks	1,247.77	33.73	0.93	0.07	16.27	2	43
CASCADE BANCORP	Commercial banks	1,097.31	4.28	0.91	0.09	12.53	199	214
WADDELL&REED FINL INC -CL A	Investment banks	566.17	6.66	0.62	0.38	14.14	14	7
OPTIONSXPRESS HOLDINGS INC	Investment banks	428.16	1.95	0.44	0.56	14.85	7	7

Appendix E

Data verification

This table shows the outliers in my sample. The data has been verified to be accurate.

Outliers Check

tic	gvkey	Z-score	ln(at)	mb	leverage	roa	median_d	ceo_own
SIEB	7315	10.730	3.691	3.355	0.137	0.065	11.738	0.889
THFF	18276	133.272	7.657	1.063	0.887	0.011	13.069	0.002
ALAB	31062	187.861	8.258	1.079	0.917	0.011	15.320	0.007
BMRC	31764	94.612	6.522	1.081	0.907	0.012	9.284	0.000
SHBK	65426	203.143	5.298	1.027	0.897	0.010	13.438	0.039
WDR	66599	6.663	6.339	4.568	0.624	0.175	14.137	0.018
BGCP	127377	5.157	5.796	3.735	0.173	-0.031	12.930	0.874
OCNB	150478	120.189	5.258	1.060	0.884	0.005	12.613	0.062
OXPS	162175	1.952	6.060	4.756	0.442	0.562	14.851	0.004

Appendix F

Governance indices as explanatory variables.

G-index is obtained from Andrew Metrick's website, and E-index is obtained from Lucian Bebchuck's website. I require non-missing data on G-index, E-index and director ownership for the purpose of direct comparison of these three governance measures. Results from three estimation methods are presented: Median means median quantile regression (QREG in STATA), Robust means robust regression or iteratively reweighted least squares (RREG in STATA), OLS regressions are based on heteroskedasticity-consistent standard errors (White 1980).Regression variables are computed as the averages over 1998-2008, unless otherwise noted. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. Ln(Z-score) is natural logarithm of Z-score. *ln(rev)* is the logarithm of total revenue. *mb* is the average market-to-book asset ratio. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A:Z-score

	G-index		
	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS
ln(at)	-1.269	-2.172	-3.653**
	(2.179)	(1.612)	(1.600)
mb	-3.525	-4.257	-5.927*
	(5.178)	(6.092)	(3.141)
G-index	0.247	-0.0489	-0.256
	(0.978)	(0.736)	(0.890)
own	-63.33	-59.88	-51.99
	(61.43)	(50.64)	(50.78)
age	-0.0839	0.207	0.202
	(0.258)	(0.190)	(0.253)
ibk	-15.46	-13.99*	-19.36***
	(10.13)	(7.661)	(7.049)
ins	-1.085	0.436	-2.321
	(8.129)	(6.516)	(7.086)
Constant	45.84*	53.64***	76.75***
	(23.24)	(18.08)	(20.41)
Observations	117	117	117
R-squared		0.090	0.092

	E-index		
	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS
ln(at)	-1.459	-2.320	-3.781**
	(2.304)	(1.626)	(1.662)
mb	-3.725	-4.353	-6.048*
	(5.461)	(6.146)	(3.241)
E-index	0.530	0.496	-2.003
	(2.198)	(1.585)	(2.862)
own	-63.05	-56.64	-61.97
	(65.95)	(51.32)	(54.48)
age	-0.0679	0.239	0.180
	(0.274)	(0.191)	(0.273)
ibk	-15.34	-13.62*	-21.01**
	(10.90)	(7.846)	(8.300)
ins	-1.011	0.725	-2.541
	(8.623)	(6.577)	(7.332)
Constant	48.36*	52.64***	82.70***
	(24.55)	(18.43)	(25.34)
Observations	117	117	117
R-squared		0.095	0.100

	Director Ownership		
	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS
ln(at)	-0.932	-2.612	-4.276**
	(2.209)	(1.614)	(1.633)
mb	-2.833	-5.739	-8.676**
	(5.495)	(6.126)	(3.639)
dir	3.444	3.471*	6.263**
	(2.656)	(1.878)	(2.881)
own	-32.57	-44.55	-26.42
	(59.04)	(50.11)	(48.82)
age	-0.0873	0.214	0.226
	(0.262)	(0.189)	(0.243)
ibk	-15.29	-12.31	-15.07**
	(10.57)	(7.710)	(6.487)
ins	0.732	2.159	0.749
	(8.893)	(6.563)	(6.183)
Constant	-6.438	9.974	-6.048
	(40.57)	(29.68)	(33.74)
Observations	117	117	117
R-squared		0.118	0.146

Appendix F (continued)

Panel B: ln(Z-score)

	G-index		
	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS
ln(at)	-0.049	-0.058	-0.055
	(0.063)	(0.058)	(0.050)
mb	-0.221	-0.227	-0.222*
	(0.147)	(0.218)	(0.121)
G-index	0.011	-0.013	-0.015
	(0.029)	(0.026)	(0.024)
own	-2.894	-2.598	-2.491
	(1.918)	(1.810)	(1.708)
age	-0.003	0.005	0.004
	(0.008)	(0.007)	(0.007)
ibk	-0.914***	-0.761***	-0.764***
	(0.291)	(0.274)	(0.286)
ins	-0.050	0.003	-0.006
	(0.234)	(0.233)	(0.192)
Constant	4.111***	4.188***	4.179***
	(0.655)	(0.646)	(0.570)
Observations	117	117	117
R-squared		0.148	0.154

	E-index		
	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS
ln(at)	-0.058	-0.060	-0.059
	(0.075)	(0.058)	(0.050)
mb	-0.225	-0.229	-0.226*
	(0.174)	(0.218)	(0.120)
E-index	0.024	-0.035	-0.043
	(0.071)	(0.056)	(0.061)
own	-3.055	-2.645	-2.589
	(2.133)	(1.818)	(1.723)
age	-0.003	0.004	0.004
	(0.009)	(0.007)	(0.007)
ibk	-0.929***	-0.789***	-0.791***
	(0.352)	(0.278)	(0.295)
ins	-0.050	-0.004	-0.012
	(0.282)	(0.233)	(0.193)
Constant	4.226***	4.227***	4.236***
	(0.785)	(0.653)	(0.583)
Observations	117	117	117
R-squared		0.149	0.156

	Director ownership		
	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS
ln(at)	-0.034	-0.076	-0.073
	(0.097)	(0.056)	(0.049)
mb	-0.208	-0.296	-0.297**
	(0.238)	(0.213)	(0.122)
dir	0.167	0.167**	0.169**
	(0.118)	(0.065)	(0.068)
own	-2.870	-1.848	-1.707
	(3.031)	(1.744)	(1.568)
age	-0.003	0.005	0.005
	(0.012)	(0.007)	(0.007)
ibk	-0.792*	-0.654**	-0.642**
	(0.463)	(0.268)	(0.285)
ins	0.086	0.082	0.076
	(0.387)	(0.228)	(0.164)
Constant	1.578	1.942*	1.890*
	(1.819)	(1.033)	(0.971)
Observations	117	117	117
R-squared		0.196	0.204

Appendix F (continued)

Panel C: interacting firm size with industry dummies (Dep: ln(Z-score))

	G-index				E-index				Director ownership		
	(1)	(2)	(3)		(1)	(2)	(3)		(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	VARIABLES	Median	Robust	OLS	VARIABLES	Median	Robust	OLS
ln(at)	-0.200	-0.154**	-0.145**	ln(at)	-0.174	-0.167**	-0.157**	ln(at)	-0.150	-0.153**	-0.146**
	(0.132)	(0.073)	(0.068)		(0.129)	(0.074)	(0.075)		(0.132)	(0.072)	(0.064)
mb	0.062	0.112	0.104	mb	0.055	0.110	0.100	mb	-0.083	-0.029	-0.042
	(0.282)	(0.257)	(0.145)		(0.296)	(0.255)	(0.138)		(0.309)	(0.256)	(0.157)
G-index	-0.045	-0.026	-0.026	E-index	-0.053	-0.069	-0.069	dir	0.124	0.147**	0.153**
	(0.049)	(0.026)	(0.026)		(0.104)	(0.057)	(0.069)		(0.120)	(0.066)	(0.070)
own	-4.118	-3.217*	-3.103*	own	-4.303	-3.204*	-3.155*	own	-4.275	-2.194	-2.033
	(3.228)	(1.860)	(1.837)		(3.127)	(1.855)	(1.896)		(3.178)	(1.839)	(1.827)
age	0.014	0.013*	0.012	age	0.010	0.013	0.012	age	0.006	0.012	0.011
	(0.015)	(0.008)	(0.008)		(0.014)	(0.008)	(0.008)		(0.014)	(0.008)	(0.008)
ibk	-4.642**	-4.576***	-4.447***	ibk	-4.398*	-4.712***	-4.559***	ibk	-3.069	-3.619**	-3.497***
	(2.245)	(1.639)	(1.185)		(2.235)	(1.644)	(1.245)		(2.309)	(1.607)	(1.248)
ins	-1.292	-0.946	-0.882	ins	-0.602	-1.281	-1.185	ins	-0.698	-0.937	-0.900
	(2.951)	(1.777)	(1.266)		(2.931)	(1.813)	(1.493)		(2.803)	(1.747)	(1.167)
ibk*size	0.401*	0.405**	0.392***	ibk*size	0.368	0.414**	0.400***	ibk*size	0.241	0.314*	0.304**
	(0.226)	(0.172)	(0.119)		(0.222)	(0.172)	(0.122)		(0.232)	(0.169)	(0.128)
ins*size	0.153	0.108	0.100	ins*size	0.089	0.140	0.129	ins*size	0.092	0.110	0.106
	(0.288)	(0.174)	(0.123)		(0.288)	(0.177)	(0.145)		(0.277)	(0.171)	(0.116)
Constant	5.345***	4.636***	4.581***	Constant	4.958***	4.754***	4.686***	Constant	3.030	2.490**	2.358**
	(1.204)	(0.683)	(0.647)		(1.185)	(0.698)	(0.727)		(1.874)	(1.062)	(1.015)
Observations	117	117	117	Observations	117	117	117	Observations	117	117	117
R-squared		0.195	0.196	R-squared		0.199	0.199	R-squared		0.221	0.229

Appendix G

Firm size (total revenue) and risk taking

The dependent variable is raw Z-score for the first 6 regressions and logarithm of Z-score for the second 6, which are further separated by whether or not they have industry controls. Results from three estimation methods are presented: Median means median quantile regression (QREG in STATA), Robust means robust regression or iteratively reweighted least squares (RREG in STATA), OLS regressions are based on heteroskedasticity-consistent standard errors (White 1980). Sample consists of 300 financial firms. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. Ln(Z-score) is natural logarithm of Z-score. *ln(rev)* is the logarithm of total revenue. *mb* is the average market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	Z-score						ln(Z-score)					
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS
ln(rev)	-2.871***	-3.244***	-4.501***	-1.549	-2.631***	-3.905***	-0.110***	-0.109***	-0.0992***	-0.0830	-0.0785**	-0.0517
	(0.926)	(0.865)	(0.910)	(0.945)	(1.000)	(1.084)	(0.0343)	(0.0338)	(0.0320)	(0.0514)	(0.0389)	(0.0426)
mb	-7.871**	-7.847**	-8.753***	-2.604	-2.976	-3.250	-0.558***	-0.524***	-0.493***	-0.233	-0.278*	-0.189
	(3.302)	(3.493)	(2.230)	(3.588)	(3.800)	(2.078)	(0.136)	(0.139)	(0.153)	(0.198)	(0.148)	(0.165)
dir	5.174***	4.949***	5.683***	3.202***	4.414***	5.206***	0.191***	0.213***	0.197***	0.152**	0.195***	0.164***
	(1.285)	(1.176)	(1.671)	(1.167)	(1.214)	(1.740)	(0.048)	(0.046)	(0.052)	(0.063)	(0.047)	(0.054)
own	0.954	-24.37*	-32.21***	2.352	-13.70	-20.03**	0.0756	-0.702	-1.425	0.118	-0.125	-0.614
	(15.21)	(14.43)	(12.31)	(12.43)	(14.77)	(10.03)	(0.528)	(0.565)	(0.930)	(0.733)	(0.577)	(0.728)
age	0.206	0.335**	0.368**	0.0129	0.238	0.273	0.008	0.015**	0.015***	0.004	0.010	0.009
	(0.158)	(0.147)	(0.156)	(0.148)	(0.156)	(0.169)	(0.006)	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)
ibk				-17.09***	-14.79***	-16.54***				-0.895***	-0.814***	-1.022***
				(5.002)	(5.330)	(3.593)				(0.275)	(0.209)	(0.283)
ins				-2.130	2.769	3.618				-0.0293	0.156	0.0911
				(5.180)	(5.720)	(5.521)				(0.291)	(0.221)	(0.186)
Constant	-23.90	-15.20	-13.78	-3.144	-13.92	-13.91	1.713***	1.205*	1.305*	1.905**	1.157*	1.351**
	(17.09)	(15.78)	(21.49)	(15.30)	(15.84)	(21.82)	(0.636)	(0.617)	(0.697)	(0.822)	(0.613)	(0.681)
Obs	300	300	300	300	300	300	298	298	298	298	298	298
R-squared		0.121	0.121		0.147	0.144		0.155	0.149		0.209	0.213

Appendix H

Firm size (market capitalization) and risk taking

The dependent variable is raw Z-score for the first 6 regressions and logarithm of Z-score for the second 6, which are further separated by whether or not they have industry controls. Results from three estimation methods are presented: Median means median quantile regression (QREG in STATA), Robust means robust regression or iteratively reweighted least squares (RREG in STATA), OLS regressions are based on heteroskedasticity-consistent standard errors (White 1980). Sample consists of 300 financial firms. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. Ln(Z-score) is natural logarithm of Z-score. *ln(mkv)* is the logarithm of total market capitalization. *mb* is the average market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	Z-score						ln(Z-score)					
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS
ln(mkv)	-1.699*	-1.393*	-2.358***	-1.504**	-1.062	-2.002**	-0.0613*	-0.0373	-0.0144	-0.0581	-0.0229	0.00479
	(0.987)	(0.736)	(0.847)	(0.644)	(0.749)	(0.875)	(0.0336)	(0.0292)	(0.0317)	(0.0373)	(0.0295)	(0.0341)
mb	-7.988**	-8.553**	-9.427***	-2.114	-2.316	-2.007	-0.584***	-0.565***	-0.548***	-0.128	-0.270*	-0.193
	(4.045)	(3.501)	(2.131)	(3.237)	(3.794)	(1.794)	(0.156)	(0.141)	(0.149)	(0.168)	(0.149)	(0.157)
dir	5.021***	4.749***	5.546***	3.031***	3.859***	4.664***	0.166***	0.204***	0.186***	0.158***	0.177***	0.146***
	(1.617)	(1.200)	(1.709)	(1.045)	(1.211)	(1.737)	(0.0540)	(0.0473)	(0.0533)	(0.0603)	(0.0473)	(0.0534)
own	-6.492	-20.07	-28.02**	2.821	-8.047	-13.36	-0.215	-0.552	-1.203	0.164	0.0897	-0.388
	(18.82)	(14.53)	(12.83)	(11.05)	(14.51)	(9.857)	(0.644)	(0.575)	(0.931)	(0.688)	(0.572)	(0.743)
ibk				-18.55***	-18.84***	-22.31***				-1.004***	-0.962***	-1.145***
				(4.233)	(4.939)	(3.027)				(0.247)	(0.196)	(0.254)
ins				-3.148	-2.118	-2.512				-0.0458	-0.00728	-0.0542
				(4.490)	(5.284)	(5.020)				(0.261)	(0.206)	(0.163)
Constant	-22.50	-15.19	-14.63	-0.0823	-10.19	-11.06	2.032***	1.270**	1.343*	1.691**	1.307**	1.468**
	(21.26)	(15.87)	(21.59)	(13.58)	(15.73)	(21.63)	(0.713)	(0.626)	(0.691)	(0.781)	(0.615)	(0.660)
Observations	300	300	300	300	300	300	298	298	298	298	298	298
R-squared		0.090	0.087		0.132	0.126		0.127	0.124		0.199	0.207

Appendix I

Firm size (for firms with total assets less than 10 billion dollars only) and risk taking

The dependent variable is raw Z-score for the first 6 regressions and logarithm of Z-score for the second 6, which are further separated by whether or not they have industry controls. Results from three estimation methods are presented: Median means median quantile regression (QREG in STATA), Robust means robust regression or iteratively reweighted least squares (RREG in STATA), OLS regressions are based on heteroskedasticity-consistent standard errors (White 1980). Sample consists of 300 financial firms. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. Ln(Z-score) is natural logarithm of Z-score. *ln(rev)* is the logarithm of total revenue. *mb* is the average market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	Z-score						ln(Z-score)					
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-2.305	-1.868	-2.964	-0.293	-2.898*	-4.174**	-0.119	-0.0914	0.0132	-0.149	-0.124*	-0.0375
	(2.103)	(1.664)	(2.007)	(1.214)	(1.654)	(1.956)	(0.0965)	(0.0666)	(0.108)	(0.0978)	(0.0649)	(0.0959)
mb	-8.269**	-9.709**	-11.55***	-1.562	-1.773	-2.006	-0.660***	-0.570***	-0.517***	-0.0947	-0.183	-0.0535
	(4.108)	(3.834)	(2.556)	(3.051)	(4.339)	(2.138)	(0.214)	(0.151)	(0.150)	(0.217)	(0.167)	(0.179)
dir	6.721***	5.767***	6.577***	2.827**	4.848***	5.781***	0.252***	0.263***	0.213***	0.239***	0.230***	0.177**
	(1.911)	(1.537)	(2.224)	(1.122)	(1.529)	(2.190)	(0.0874)	(0.0597)	(0.0749)	(0.0889)	(0.0587)	(0.0719)
own	-11.74	-24.67	-32.82**	2.061	-14.95	-20.53*	-0.196	-0.736	-1.224	-0.123	-0.214	-0.522
	(19.68)	(16.59)	(14.02)	(10.69)	(16.37)	(10.54)	(0.939)	(0.652)	(0.799)	(0.883)	(0.638)	(0.660)
age	0.562*	0.417	0.393	0.223	0.457*	0.453	0.0231	0.0259**	0.0206	0.0229	0.0266***	0.0233**
	(0.315)	(0.260)	(0.300)	(0.181)	(0.252)	(0.278)	(0.0148)	(0.0101)	(0.0127)	(0.0147)	(0.0097)	(0.0110)
ibk				-22.16***	-23.60***	-28.08***				-1.324***	-1.203***	-1.427***
				(4.628)	(6.591)	(4.553)				(0.381)	(0.255)	(0.316)
ins				-7.454	-3.767	-1.921				-0.141	0.0392	0.0342
				(6.573)	(9.369)	(10.26)				(0.488)	(0.358)	(0.283)
Constant	-46.22*	-26.93	-23.16	-5.602	-14.48	-13.04	1.078	0.543	0.464	0.999	0.872	0.872
	(25.63)	(20.75)	(29.22)	(14.77)	(20.43)	(29.07)	(1.188)	(0.811)	(0.914)	(1.189)	(0.787)	(0.834)
Observations	223	223	223	223	223	223	221	221	221	221	221	221
R-squared		0.111	0.099		0.160	0.146		0.165	0.154		0.246	0.252

Appendix J

Firm size (total asset) and risk taking, separated for commercial banks, investment banks and life insurance.

The dependent variable is raw Z-score for the first 3 regressions and logarithm of Z-score for the second 3. Results from three estimation methods are presented: Median means median quantile regression (QREG in STATA), Robust means robust regression or iteratively reweighted least squares (RREG in STATA), OLS regressions are based on heteroskedasticity-consistent standard errors (White 1980). Sample consists of 238 commercial banks. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. *Ln(Z-score)* is natural logarithm of Z-score. *ln(at)* is the logarithm of total asset. *mb* is the average market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A: commercial banks only (total assets)

	Z-score			ln(Z-score)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-5.301**	-5.602***	-7.377***	-0.245***	-0.193***	-0.184***
	(2.058)	(1.704)	(1.948)	(0.086)	(0.060)	(0.056)
mb	59.430*	42.908	50.064*	1.983	1.671	1.831*
	(34.923)	(30.711)	(29.174)	(1.437)	(1.090)	(1.055)
dir	3.019	5.015***	5.845**	0.173**	0.194***	0.177***
	(2.023)	(1.643)	(2.425)	(0.083)	(0.058)	(0.068)
own	-28.141	-29.788	-39.049**	-2.098	-1.656	-1.545
	(32.772)	(29.174)	(17.729)	(1.497)	(1.036)	(0.980)
age	0.403	0.521**	0.605**	0.020	0.019**	0.020**
	(0.305)	(0.250)	(0.293)	(0.013)	(0.009)	(0.009)
Constant	-40.827	-46.321	-48.430	0.444	0.061	-0.037
	(37.974)	(32.862)	(34.926)	(1.563)	(1.167)	(1.121)
Observations	238	238	238	238	238	238
R-squared		0.072	0.080		0.084	0.082

Commercial Banks only (total market cap)

	Z-score			ln(Z-score)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(mkv)	-4.480*	-4.430**	-5.869***	-0.152	-0.168***	-0.158***
	(2.537)	(1.722)	(1.947)	(0.092)	(0.062)	(0.060)
mb	68.270	57.365*	68.887**	2.021	2.321*	2.414**
	(46.882)	(33.778)	(32.367)	(1.701)	(1.215)	(1.184)
dir	3.311	4.717***	5.511**	0.132	0.189***	0.173**
	(2.430)	(1.650)	(2.451)	(0.088)	(0.059)	(0.069)
own	-31.491	-29.708	-39.343**	-1.472	-1.661	-1.563
	(43.121)	(29.084)	(17.955)	(1.564)	(1.046)	(1.006)
age	0.288	0.388	0.427	0.010	0.016*	0.017*
	(0.366)	(0.249)	(0.300)	(0.013)	(0.009)	(0.010)
Constant	-67.444	-73.284*	-83.472**	0.119	-1.034	-1.040
	(51.838)	(37.211)	(39.670)	(1.880)	(1.339)	(1.324)
Observations	238	238	238	238	238	238
R-squared		0.056	0.059		0.072	0.071

Panel B: Investment banks only

	Z-score			ln(Z-score)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	1.815	1.729***	1.879***	0.088	0.144**	0.290*
	(1.097)	(0.516)	(0.524)	(0.084)	(0.067)	(0.143)
mb	-1.437	-1.275	-1.345	-0.274	-0.215	0.025
	(2.319)	(1.304)	(0.813)	(0.197)	(0.158)	(0.251)
dir	1.311	0.297	-0.027	0.257*	0.094	-0.099
	(1.787)	(1.040)	(0.902)	(0.145)	(0.128)	(0.201)
own	14.773	10.333*	10.122*	0.923	1.417*	1.182
	(12.045)	(6.058)	(5.429)	(0.977)	(0.762)	(0.759)
age	0.050	0.073	0.127	0.029	0.014	0.021
	(0.228)	(0.125)	(0.137)	(0.018)	(0.015)	(0.015)
Constant	-21.885	-7.168	-3.958	-2.163	-0.321	0.523
	(20.254)	(12.116)	(10.707)	(1.710)	(1.500)	(1.583)
Observations	38	38	38	36	36	36
R-squared		0.402	0.420		0.331	0.297

Panel C: Insurance companies only

	Z-score			ln(Z-score)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.398	-0.524	-5.147	-0.013	0.029	-0.184
	(1.306)	(1.305)	(3.386)	(0.044)	(0.052)	(0.107)
mb	12.613	22.030	3.866	0.740	1.879	-0.844
	(22.819)	(30.684)	(41.820)	(0.765)	(1.213)	(2.162)
dir	3.432*	3.829**	5.905**	0.161***	0.171**	0.240***
	(1.652)	(1.577)	(2.278)	(0.055)	(0.062)	(0.083)
own	-23.323	-46.379	-108.314*	-1.296	-1.962	-2.899*
	(27.499)	(40.188)	(62.187)	(0.922)	(1.589)	(1.454)
age	-0.059	0.029	0.042	-0.002	0.006	-0.004
	(0.188)	(0.189)	(0.447)	(0.006)	(0.007)	(0.012)
Constant	-28.280	-42.329	1.189	0.497	-1.328	2.849
	(36.200)	(35.210)	(60.327)	(1.214)	(1.392)	(3.087)
Observations	24	24	24	24	24	24
R-squared		0.364	0.291		0.549	0.335

Appendix K

Change in CAR around Basel II Accord (2004)

This table tests whether there is a significant change in CAR around Basel II Accord. I divided the period 2000—2008 into two sub-periods: 2000—2003 (before) and 2005—2008 (after). Year 2004 is excluded because that is the event time. Columns 1 through 4 show the results from simple comparison of CAR in the before and after period. These results are separated by each category. Last column shows the results from a differences-in-differences model where commercial banks are in the treatment group and investment banks in the control group. CAR is calculated as the average CAR over the two sub-periods using annual data. After is a dummy that equals 1 if it is the 2005—2008 period, and 0 otherwise. cbk is a dummy for commercial banks. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	Dependent variable: CAR				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	cbk	ibk	ins	all	diff-in-diff
after	-0.001	-0.016	0.009	-0.001	-0.016
	(0.002)	(0.071)	(0.025)	(0.009)	(0.070)
cbk					-0.263***
					(0.050)
cbk*after					0.016
					(0.070)
Constant	0.090***	0.353***	0.116***	0.116***	0.353***
	(0.002)	(0.050)	(0.011)	(0.006)	(0.050)
Observations	702	78	76	856	780
R-squared	0.000	0.001	0.002	0.000	0.363

Appendix L

Two-Stage Least Square (2SLS) IV regression of firm size on risk-taking for commercial banks only.

This table reports the results from the second-stage regressions of risk-taking on firm size and control variables, in which firm size, instrumented by Delaware, is treated as an endogenous variable. Sample consists of 238 commercial banks. Regression variables are computed as the averages over 1998-2008, unless otherwise noted. *Delaware* is dummy, which equals 1 if a firm is incorporated in Delaware. Z-score = (ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 1998-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher Z-score implies more stability. *Ln(Z-score)* is natural logarithm of *Z-score*. *σ(RETY)* is the standard deviation of annual stock return over 1998-2008. *σ(RETM)* is the standard deviation of monthly stock return over 1998-2008. *ln(at)* is the logarithm of total asset. *mb* is the market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. *Leverage* is debt/asset ratio. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

IV for commercial banks only

	(1)	(2)	(3)	(4)
VARIABLES	Z-score	ln(Z-score)	σ(RETY)	σ(RETM)
ln(at)	-15.992*	-0.556**	0.242*	0.197**
	(9.258)	(0.272)	(0.146)	(0.090)
mb	95.164	3.779**	-1.120	0.144
	(59.010)	(1.854)	(1.201)	(0.729)
dir	8.398**	0.288**	-0.079	-0.063*
	(3.504)	(0.112)	(0.055)	(0.035)
own	-45.399*	-1.819*	0.163	0.676**
	(23.230)	(0.968)	(0.925)	(0.332)
age	1.580	0.063**	-0.037**	-0.023**
	(1.074)	(0.031)	(0.017)	(0.010)
roa			-5.448	-19.695***
			(9.000)	(4.707)
leverage			2.158	0.700
			(1.849)	(1.089)
Constant	-82.965	-1.529	-2.058	-3.351**
	(51.141)	(1.683)	(2.478)	(1.462)
Observations	238	238	238	238

Appendix M

Fixed effect: two periods (quarterly data)

This table shows the effect of firm size on risk taking based on quarterly data from 1998-2008, except for stock return volatility which uses monthly stock return data. This period is further divided into two sub-periods, 1998-2003 and 2004-2008. Using quarterly data or monthly data, regression variables are computed as the averages over each of the two 4-year periods, unless otherwise noted. The dependent variable is raw Z-score, log of Z-score, and monthly stock return volatility, respectively. Sample consists of 675 financial firms or 1,210 firm-periods. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio. σ(ROA) is the standard deviation of ROA. Higher Z-score implies more stability. *Ln(Z-score)* is natural logarithm of Z-score. *ln(at)* is the logarithm of total asset. *mb* is the average market-to-book asset ratio. *Period2* is a dummy variable which equals 1 if it is second period, zero otherwise. *Leverage* is debt/asset ratio. Standard errors, clustered at firm level, are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)
VARIABLES	Z-score	ln(Z-score)	σ(RET)
ln(at)	-19.93*	-0.281**	0.390
	(11.67)	(0.138)	(0.965)
mb	7.663	-0.220	5.191**
	(7.857)	(0.170)	(2.482)
period2	8.397	0.0503	-1.206**
	(9.377)	(0.0822)	(0.479)
roa			-75.85
			(50.16)
leverage			4.942
			(8.427)
Constant	245.2***	6.461***	-2.537
	(79.96)	(1.020)	(11.83)
Observations	1,210	1,206	1,210
R-squared	0.004	0.016	0.147
Number of firms	675	674	675

Appendix N

Fixed effect: four periods (quarterly data)

This table shows the effect of firm size on risk taking based on quarterly data from 1998-2008, except for stock return volatility which uses monthly stock return data. This period is further divided into four sub-periods, 1998-2000, 2001-2003, 2004-2006 and 2007-2008. Using quarterly data or monthly data, regression variables are computed as the averages over each of the four 3-year periods, unless otherwise noted. The dependent variable is raw Z-score, log of Z-score, and monthly stock return volatility, respectively. Sample consists of 674 financial firms or 2,207 firm-periods. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio. σ(ROA) is the standard deviation of ROA. Higher Z-score implies more stability. *Ln(Z-score)* is natural logarithm of Z-score. *ln(at)* is the logarithm of total asset. *mb* is the average market-to-book asset ratio. *Period2* is a dummy variable which equals 1 if it is second period, zero otherwise. *Period3* and *period4* are defined accordingly. *Leverage* is debt/asset ratio. Standard errors, clustered at firm level, are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)
VARIABLES	Z-score	ln(Z-score)	σ(RET)
ln(at)	21.989**	0.062	-0.419
	(10.896)	(0.101)	(0.557)
mb	3.418	-0.215	4.584***
	(9.842)	(0.290)	(1.609)
period2	38.258***	0.415***	-1.577***
	(10.075)	(0.065)	(0.240)
period3	61.278***	0.601***	-3.738***
	(12.750)	(0.090)	(0.383)
period4	-68.392***	-0.516***	1.610***
	(15.641)	(0.112)	(0.489)
roa			-85.888***
			(31.988)
leverage			9.437*
			(5.466)
Constant	2.975	4.236***	0.010
	(75.147)	(0.806)	(6.915)
Observations	2,207	2,198	2,207
R-squared	0.124	0.213	0.329
Number of firms	674	674	674

Appendix O

Cross-sectional regression using quarterly data from 2005-2008

The dependent variable is logarithm of Z-score (ln(Z-score)) for the first three regressions, and standard deviation of monthly stock return (σ(RET)) for the second three. Results from three estimation methods are presented: Median means median quantile regression (QREG in STATA), Robust means robust regression or iteratively reweighted least squares (RREG in STATA), OLS regressions are based on heteroskedasticity-consistent standard errors (White 1980). Regression variables are computed as the quarterly averages over 2005-2008, unless otherwise noted. Z-score =(ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR=E/A is capital-asset ratio, both averaged over 2005-2008. σ(ROA) is the standard deviation of ROA over 2005-2008. Higher Z-score implies more stability. *ln(at)* is the logarithm of total asset. *mb* is the average market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database. *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A: baseline regression

	ln(Z-score)			σ(RET)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.172***	-0.159***	-0.130***	0.003*	0.004***	0.005***
	(0.058)	(0.051)	(0.047)	(0.002)	(0.002)	(0.002)
mb	0.162	0.496	0.154	0.053***	0.056***	0.050***
	(0.617)	(0.535)	(0.653)	(0.020)	(0.017)	(0.016)
dir	0.228***	0.235***	0.216***	-0.003	-0.004**	-0.004**
	(0.076)	(0.066)	(0.069)	(0.002)	(0.002)	(0.002)
own	-1.384*	-1.226	-0.812	0.068**	0.046*	0.049*
	(0.821)	(0.791)	(0.688)	(0.029)	(0.024)	(0.026)
age	0.013	0.015*	0.015**	-0.001**	-0.001***	-0.001***
	(0.009)	(0.008)	(0.007)	(0.000)	(0.000)	(0.000)
ibk	-0.518*	-0.792***	-0.826***	0.027**	0.027***	0.024***
	(0.313)	(0.282)	(0.236)	(0.011)	(0.009)	(0.009)
ins	0.133	0.132	0.045	0.021**	0.012	0.005
	(0.318)	(0.284)	(0.203)	(0.010)	(0.008)	(0.009)
roa				-3.712***	-3.253***	-3.359***
				(0.487)	(0.414)	(0.502)
leverage				0.055	0.076***	0.077***
				(0.035)	(0.029)	(0.029)
Constant	2.163**	1.516*	1.863*	0.010	-0.000	0.004
	(1.063)	(0.912)	(0.951)	(0.049)	(0.040)	(0.041)
Observations	266	266	266	272	272	272
R-squared		0.130	0.133		0.330	0.316

Panel B: baseline regression with industry-size interaction

	ln(Z-score)			σ(RET)		
	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.314***	-0.259***	-0.228***	0.004	0.005***	0.006***
	(0.083)	(0.065)	(0.056)	(0.003)	(0.002)	(0.002)
mb	1.404**	1.042*	0.748	0.052*	0.048***	0.044**
	(0.692)	(0.573)	(0.674)	(0.027)	(0.018)	(0.018)
dir	0.235***	0.227***	0.214***	-0.004	-0.004**	-0.004**
	(0.083)	(0.065)	(0.068)	(0.003)	(0.002)	(0.002)
own	-1.146	-0.734	-0.356	0.043	0.043*	0.048*
	(0.872)	(0.799)	(0.690)	(0.037)	(0.024)	(0.026)
age	0.027**	0.024***	0.024***	-0.001*	-0.001***	-0.001***
	(0.011)	(0.009)	(0.008)	(0.000)	(0.000)	(0.000)
ibk	-3.388***	-3.148***	-3.077***	0.082	0.079**	0.060
	(1.096)	(0.886)	(0.867)	(0.054)	(0.037)	(0.038)
ins	-0.985	-1.227	-0.681	-0.053	0.021	0.019
	(1.600)	(1.346)	(1.252)	(0.058)	(0.039)	(0.046)
roa				-3.008***	-2.936***	-3.191***
				(0.678)	(0.450)	(0.577)
leverage				0.097*	0.104***	0.098***
				(0.053)	(0.036)	(0.032)
ibk*size	0.302**	0.270***	0.264***	-0.006	-0.006	-0.004
	(0.122)	(0.099)	(0.092)	(0.005)	(0.004)	(0.004)
ins*size	0.153	0.157	0.092	0.007	-0.001	-0.002
	(0.163)	(0.136)	(0.136)	(0.006)	(0.004)	(0.005)
Constant	1.627	1.670*	1.876*	-0.027	-0.021	-0.014
	(1.121)	(0.910)	(0.955)	(0.066)	(0.044)	(0.043)
Observations	266	266	266	272	272	272
R-squared		0.157	0.159		0.330	0.318

Appendix P

Decomposition of Z-score using quarterly data from 2005-2008

The dependent variables are CAR, ROA, and σ(ROA), respectively. Results from three estimation methods are presented: Median is median quantile regression, Robust is robust regression or iteratively reweighted least squares, OLS is ordinary least squares with White heteroskedasticity-robust standard error. Regression variables are computed as the quarterly averages over 2005-2008, unless otherwise noted Following Houston et al (2010), ROA is return on assets and CAR is capital-asset ratio, both are averaged over 2005-2008. σ(ROA) is the standard deviation of ROA over 1998-2008. Higher of ROA and CAR imply more stability. The ROA multiplied by 100 is used in regressions. *ln(at)* is the logarithm of total asset. *mb* is the market-to-book asset ratio. *dir* is the logarithm of median director dollar stockholding as of the last year in our sample period. *own* is CEO stock percentage ownership as of the last year in our sample period. *age* is firm age as proxied by the difference between 2008 and the year that the firm first appear in Compustat monthly stock return database *ibk* is dummy for investment banks, and *ins* is dummy for insurance companies. *Leverage* is debt/asset ratio. Standard errors are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A: baseline decomposition

	ROA			CAR			σ(ROA)		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS
ln(atq)	-0.007	-0.008	0.036	-0.005***	-0.002**	-0.018***	0.107*	0.164***	0.160***
	(0.006)	(0.006)	(0.033)	(0.002)	(0.001)	(0.004)	(0.065)	(0.050)	(0.042)
mb	1.496***	1.477***	1.101	0.252***	0.206***	0.218***	1.503**	1.153**	1.181**
	(0.053)	(0.062)	(0.692)	(0.017)	(0.011)	(0.065)	(0.700)	(0.541)	(0.594)
dir	0.034***	0.026***	0.051**	-0.003	-0.002	-0.001	-0.118	-0.169***	-0.165***
	(0.007)	(0.007)	(0.026)	(0.002)	(0.001)	(0.004)	(0.080)	(0.060)	(0.060)
own	-0.329***	0.081	0.287	0.190***	-0.060***	0.248***	0.127	0.411	0.362
	(0.084)	(0.091)	(0.707)	(0.026)	(0.016)	(0.079)	(0.898)	(0.748)	(0.600)
age	0.002***	0.002***	0.002	0.001**	0.000*	0.001***	-0.006	-0.010	-0.011*
	(0.001)	(0.001)	(0.004)	(0.000)	(0.000)	(0.001)	(0.010)	(0.007)	(0.006)
ibk	-0.022	-0.018	-0.252	0.074***	-0.008	0.153***	0.323	0.296	0.312
	(0.034)	(0.034)	(0.181)	(0.009)	(0.006)	(0.038)	(0.379)	(0.296)	(0.259)
ins	0.027	0.066**	0.001	0.020**	-0.010*	0.048***	-0.025	-0.114	-0.102
	(0.031)	(0.031)	(0.103)	(0.009)	(0.006)	(0.014)	(0.341)	(0.260)	(0.184)
roa				-2.229***	-5.440***	-2.850	-0.844***	-1.002***	-1.029***
				(0.478)	(0.283)	(1.794)	(0.165)	(0.133)	(0.146)
leverage	0.656***	0.666***	1.026				-3.489***	-3.571***	-3.476***
	(0.085)	(0.094)	(0.719)				(1.190)	(0.933)	(0.891)
Constant	-2.432***	-2.323***	-2.966***	-0.112***	-0.076***	-0.015	-4.074**	-3.240**	-3.331***
	(0.122)	(0.133)	(1.071)	(0.031)	(0.019)	(0.078)	(1.652)	(1.287)	(1.246)
Observations	272	271	272	272	272	272	266	266	266
R-squared		0.736	0.177		0.778	0.691		0.442	0.478

Panel B: decomposition with interaction term

	ROA			CAR			σ(ROA)		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
VARIABLES	Median	Robust	OLS	Median	Robust	OLS	Median	Robust	OLS
ln(at)	-0.015***	-0.009	-0.037*	0.002	0.001	0.002	0.179**	0.190***	0.175***
	(0.005)	(0.006)	(0.021)	(0.002)	(0.001)	(0.003)	(0.088)	(0.060)	(0.051)
mb	1.484***	1.580***	1.481**	0.010	0.071***	0.050	1.270	1.230**	1.292**
	(0.041)	(0.056)	(0.608)	(0.019)	(0.012)	(0.055)	(0.803)	(0.577)	(0.638)
dir	0.032***	0.017***	0.053**	-0.002	-0.002*	-0.003	-0.133	-0.169***	-0.164***
	(0.005)	(0.006)	(0.024)	(0.002)	(0.001)	(0.004)	(0.089)	(0.059)	(0.060)
own	-0.269***	0.195**	0.398	0.079***	-0.011	0.135	0.266	0.453	0.414
	(0.065)	(0.080)	(0.638)	(0.026)	(0.016)	(0.085)	(0.868)	(0.744)	(0.599)
age	0.003***	0.002***	0.008**	-0.000	-0.000	-0.001	-0.013	-0.012	-0.013*
	(0.001)	(0.001)	(0.003)	(0.000)	(0.000)	(0.000)	(0.012)	(0.008)	(0.007)
ibk	-0.847***	-1.375***	-3.270***	0.698***	0.646***	0.693***	1.463	0.144	-0.097
	(0.097)	(0.115)	(1.062)	(0.032)	(0.019)	(0.096)	(1.742)	(1.233)	(1.066)
ins	-0.018	-0.190	-0.051	0.100**	0.037	0.163**	2.194	1.643	1.349
	(0.111)	(0.130)	(0.412)	(0.041)	(0.027)	(0.063)	(1.812)	(1.234)	(0.984)
roa				0.425	0.536*	1.039	-0.763***	-1.032***	-1.069***
				(0.505)	(0.312)	(1.646)	(0.212)	(0.147)	(0.174)
leverage	-0.029	-0.447***	-0.667				-3.158**	-3.690***	-3.739***
	(0.104)	(0.120)	(1.053)				(1.601)	(1.142)	(1.028)
ibk*size	0.069***	0.113***	0.322***	-0.063***	-0.064***	-0.062***	-0.131	0.012	0.039
	(0.010)	(0.012)	(0.103)	(0.003)	(0.002)	(0.009)	(0.173)	(0.124)	(0.107)
ins*size	0.008	0.026*	0.019	-0.011***	-0.005*	-0.016**	-0.215	-0.181	-0.147
	(0.011)	(0.013)	(0.045)	(0.004)	(0.003)	(0.006)	(0.183)	(0.125)	(0.109)
Constant	-1.721***	-1.275***	-1.412	0.090***	0.043**	0.061	-4.422**	-3.365**	-3.317**
	(0.123)	(0.146)	(1.342)	(0.030)	(0.019)	(0.063)	(1.951)	(1.382)	(1.287)
Observations	272	271	272	272	272	272	266	266	266
R-squared		0.790	0.315		0.945	0.800		0.451	0.482

Appendix Q

Differences-in-differences model

This table provides the regression results of the following differences-in-differences model (similar to Purnanandam (2010, RFS)):

$$risk_{it} = \beta_0 + \beta_1 after + \beta_2 size_i + \beta_3 after * size_i + \sum_{k=1}^{k=K} \beta X + \varepsilon_{it}$$

We divide the 2005-2008 period into two sub-periods: 2005Q1-2007Q1, the before-crisis period, and 2007Q2-2008Q4, the crisis period, and compare the risk-taking in these two distinct periods. The dependent variable, $risk_{it,}$ is either Z-score or volatility of monthly stock return, calculated using either quarterly or monthly data for firm *i* for both periods. *after* is a dummy that is set to one for the crisis period, and zero before-crisis period. $size_i$ is the average total asset over quarters before the crisis. X stands for a set of control variables. *mb* is the average market-to-book ratio for firm i; *roa* is average return on asset for firm i; *leverage* is average debt to asset ratio for firm i. Since we have balanced panel, we take the difference between these two periods and instead estimate the following simplified model:

$$\Delta risk_{it} = \beta_1 + \beta_3 size_i * after + \sum_{k=1}^{k=K} \Delta\beta X + \Delta\varepsilon_{it}$$

	(1)	(2)	(3)	(4)
VARIABLES	ln(Z-score)		σ(RET)	
Δsize*after	-0.121***	-0.113***	0.010***	0.010***
	(0.030)	(0.030)	(0.001)	(0.002)
Δmb		-0.387**		0.012
		(0.150)		(0.011)
Δroa				-0.248
				(0.264)
Δleverage				0.130
				(0.135)
Constant	-0.310	-0.405*	-0.012	-0.011
	(0.221)	(0.223)	(0.010)	(0.015)
Observations	524	524	524	524
R-squared	0.029	0.036	0.102	0.120