Measuring Systemic Risk: A Financial Statement-Based Approach for Insurance Firms and Banks*

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ABSTRACT

We introduce CRISK, a financial statement-based measure, to assess the systemic risk contribution of a financial firm. CRISK measures the capital shortfall of a financial firm conditional on severe distress in the entire system. Our measure complements the market-based measure, SRISK, introduced by Acharya et al. (2012) and Brownlees and Engle (2017), in identifying systemically risky financial firms. While SRISK provides a timelier assessment using real-time stock market data, CRISK offers a more nuanced approach using accounting information and is tailored to the distinct characteristics of insurance firms and commercial banks. Our empirical analysis shows that: (1) compared to CRISK, SRISK tends to overestimate capital shortfalls for insurance firms and for banks that hold a substantial portion of FDIC-insured deposits, while underestimating capital shortfalls for banks heavily reliant on uninsured deposits; (2) CRISK estimates of capital shortfall closely align with the actual capital injections received by financial firms during the financial crisis of 2007-2009; and (3) CRISK exhibits a significant positive correlation with short interest. Based on our findings, we recommend using SRISK as an initial screening tool to identify potential systemically risky financial firms, followed by refining the list and validating the expected capital shortfall using CRISK.

Keywords: Systemic Risk, Financial Crisis, Fundamental Analysis, Financial Institutions, Deposit Insurance, Stress Testing

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1. Introduction

The undercapitalization of large financial institutions during the financial crisis of 2007-2009 imposed significant negative externalities on the entire financial system. This was mainly attributed to their interconnectedness with other entities. In response, policymakers recognized the importance of monitoring large, complex, and interconnected financial firms, designating them as systemically important financial institutions (SIFIs).[1] However, recent events, such as the collapse of Silicon Valley Bank (SVB) and Signature Bank, have revealed that vulnerabilities at mid-sized banks can also precipitate systemic events. The failures of these mid-sized banks posed a significant threat to the stability of the entire financial system, not primarily due to their interconnectedness, but because they raised concerns that other banks might be suffering from similar losses, thereby increasing the risk of widespread bank runs. Hence, there is a need to expand regulatory oversight beyond the "too big to fail" institutions. However, mandating stress tests for all financial firms entails substantial costs. This realization has prompted us to propose a large sample measure to screen potential systemically risky firms, regardless of their size.

The current state-of-the-art measure for assessing the systemic risk contribution of a financial firm is SRISK, which was proposed by Acharya et al. (2012) and Brownlees and Engle (2017). SRISK is a market-based measure that is widely used in finance and accounting literature.

[1] Under the Dodd-Frank Act, all bank holding companies (BHCs) with assets exceeding $50 billion were subjected to enhanced prudential regulations (EPR). However, the 2018 Economic Growth, Regulatory Relief, and Consumer Protection Act (P.L. 115-174) eliminated most EPR requirements for banks with assets between $50 billion and $100 billion, with the Federal Reserve having the discretion to apply EPR provisions to banks with assets between $100 billion and $250 billion, while banks with assets over $250 billion remain subject to all EPR requirements. In 2019, the Fed implemented changes included in P.L. 115-174 by categorizing banks based on their size and complexity and imposing progressively more stringent requirements. Category I banks are subject to the most stringent requirements, while Category IV banks are subject to the least. SVB Financial Group, with $211 billion in total assets at the end of 2022, was first listed as a Category IV BHC in November 2021. P.L. 115-174 exempted Category IV BHCs from company-run stress tests and reduced the frequency of Fed-run stress tests from annual to biannual. Due to recent classification as a Category IV BHC and the biannual nature of its stress tests, SVB Financials had not undergone a stress test prior to its failure (Congressional Research Service, 2023a, 2023b).

However, similar to other market-based measures, SRISK is vulnerable to the possibility of stock prices deviating from their underlying fundamentals. The value of fundamental analysis in predicting firm distress is well documented in accounting literature. Motivated by this literature, we propose a complementary measure to SRISK that is based on fundamental analysis. Our measure, CRISK, can be computed for both private and public financial firms on a quarterly basis, using information from audited financial statements and regulatory reports. The sum of CRISK across all financial firms at any given time provides an estimate of overall systemic risk in the financial system. It can be interpreted as the total capital infusion required from the government to stabilize the financial system in the event of a crisis.

We believe that a fundamental analysis-based measure like CRISK can complement a market-based measure like SRISK in identifying troubled entities that significantly contribute to systemic risk, thus warranting timely regulatory attention and supervision. Below, we present a brief overview of SRISK, discuss its limitations, and subsequently introduce CRISK to address some of these limitations.

Brownlees and Engle (2017) define SRISK as an estimate of capital shortfall that a firm would experience conditional on a systemic event. Capital shortfall is computed as the capital that the firm needs to hold (due to regulation and/or prudential management) minus the market value of the firm's equity. The market value of a firm's equity, conditional on systemic distress, is estimated using the firm's beta and the projected decline in the broad equity market. The capital requirement is computed as 8% of the sum of the book value of on-balance sheet debt and the reduced market value of equity.

SRISK suffers from several shortcomings. First, SRISK relies on equity market prices to estimate conditional capital shortfall and hence cannot be computed for private firms. Moreover,

it assumes that stock prices adequately and timely reflect the balance sheet risk. However, volatility in stock prices can introduce significant noise into the measure, and hence may not accurately reflect changes in the firm's economic capital. Second, SRISK implicitly assumes that the underlying business is marked to market daily. This could be a valid assumption for businesses with instantly callable liabilities (e.g., investment banks). However, this assumption may not be entirely applicable for insurance firms and commercial banks funded by liabilities such as future policy obligations or FDIC insured deposits, which are relatively less likely to be called during a systemic event. Third, SRISK estimates the prudent level of capital as 8% of a firm's total assets instead of risk-weighted assets. For instance, SRISK does not distinguish between a financial firm that holds a substantial portion of its assets in safe investments like U.S. treasuries and one that holds riskier loans. As a result, SRISK may indicate misstated amounts of capital that would be required to withstand a systemic event.

To address the limitations of SRISK mentioned above, we propose a financial statement-based approach to estimating the systemic risk contribution of a financial firm, introducing a new measure named CRISK. Our methodology involves conducting a what-if analysis on the firm's balance sheet conditional on a systemic event, defined by a prolonged and severe market decline, similar to SRISK.

To compute CRISK, we first estimate the total amount of callable liabilities by evaluating the likelihood of each liability (whether on or off-balance sheet) being called in case of a systemic event. Next, we identify assets that the firm could liquidate to cover these callable liabilities by ranking all assets based on their likelihood of being sold during a systemic event. We assume that in a distress situation, firms would prioritize selling their most liquid and high-quality assets to minimize the total realized losses. We then estimate the extent of losses likely to be realized

upon the sale of these assets by applying appropriate crisis-period haircuts to the expected sale amount for each asset type. We further assume that goodwill and other intangible assets will become worthless due to the systemic event.

After liquidating the required assets to cover the callable liabilities, we estimate post-crisis losses for the remaining assets by applying loss rates consistent with those observed during normal business conditions. Finally, the sum of expected losses from liquidation of assets, amount written off from intangible assets and other assets, and expected post-crisis losses on the remaining assets is charged to the firm's book value of equity. Any excess of these expected losses over the firm's book value of equity represents CRISK, our measure of the expected capital shortfall the firm is likely to experience in case of a systemic event.

Unlike SRISK, CRISK takes into account the variations in liability structures across different business models, allowing for a more comprehensive assessment of balance sheet risk. For instance, CRISK considers banks with a larger proportion of uninsured deposits as being riskier. While we acknowledge that depositors may also run on insured deposits during times of extreme panic, we argue that the risk of deposit runs increases with the level of uninsured deposits for two main reasons. Firstly, uninsured depositors are more likely to panic than insured depositors, as uninsured deposits are not guaranteed by the government in the event of a bank failure. Secondly, a higher percentage of uninsured deposits indicates concentration risk in deposits. Given that the FDIC insures deposits up to $250,000 per depositor, per bank, and per ownership category, the higher the percentage of uninsured deposits, the greater the concentration of deposits at the depositor or depositor type level. This exposes the bank to deposit runs triggered by adverse conditions affecting a particular depositor type.[2]

[2] For instance, one of the major reasons for the collapse of Silicon Valley Bank in 2023 was the concentration of its deposits in the technology industry. The bank's customers primarily consisted of startups and technology companies,

For insurance companies, SRISK treats all liabilities on the balance sheet as obligations that require additional capital provisions. However, there are certain liabilities such as "separate account liabilities" for which equivalent offsetting assets ("separate account assets") are earmarked, and the market risk of these assets is generally borne by the policyholders. Additionally, liabilities such as "future policy benefits" include unearned profits from policy sales, which are recognized as earned profits over the life of the policies, and unpaid loss reserves, which are specifically earmarked to cover claims resulting from events such as floods. CRISK acknowledges that these obligations may not require capital provisions.

To operationalize the above insights for a large sample, we devise a systematic approach to measure CRISK using 10-Q filings for insurance companies, quarterly Y-9C reports for bank holding companies (BHC), and quarterly call reports for commercial and savings banks. To facilitate comparison with SRISK, our sample consists of 76 listed insurance firms and 325 listed banks, with financial statement data spanning 2007 to 2022.

We validate our methodology by examining whether pre-crisis CRISK aligns with the capital injections conducted by the Federal Reserve between 2007 and 2009. Based on the financial statements as of December 31, 2007, CRISK indicates a capital shortfall of $70.8 billion for JP Morgan Chase, $122.3 billion for Bank of America, $113.9 billion for Citigroup, $44.8 billion for Wachovia, and $36.5 billion for Wells Fargo. These estimates closely align with the maximum level of borrowing from the government by these firms during the financial crisis, which were $68.6 billion, $91.4 billion, $99.5 billion, $50 billion, and $45 billion, respectively. Additionally, CRISK for AIG indicates a capital shortfall of $82.1 billion, which closely

including venture capital firms. Due to its unique business model of attracting large-ticket deposits from a concentrated group of customers, the percentage of uninsured deposits at SVB was consistently higher than 95%. This level of deposit concentration left the bank vulnerable to significant withdrawals when economic conditions worsened for the technology industry.

corresponds to the $85 billion loan commitment announced by the US government for AIG on September 16, 2008. Furthermore, utilizing a larger sample and regression analysis, we find that CRISK outperforms SRISK in assessing both the likelihood and the amount of capital injections received by financial firms during the 2007-2009 financial crisis.

To further validate our measure, we investigate whether CRISK is correlated with the actions of short sellers, who are key intermediaries and sophisticated users of financial statement information. We find a significant positive correlation between CRISK and the level of short interest (a measure of sophisticated investors' bearish sentiment towards a stock). Together, these findings validate CRISK as a credible measure of conditional capital shortfall.

In summary, while SRISK is easy to compute and can be estimated on a near real-time basis using stock market data, CRISK is more complex and can be estimated less frequently (quarterly). However, a financial statement-based approach offers valuable insights by (i) incorporating essential first-order attributes of a firm’s business model that may be overlooked by a broad-market-based measure, and (ii) explicitly stating the underlying assumptions in the computation, which can enable further critical evaluation of the firm's capital requirements. Given the merits of both approaches, a potential strategy could involve using SRISK to create a shortlist of suspect SIFIs, which can then be refined through fundamental analysis, as advocated by our approach.

This paper contributes to the literature on systemic risk measurement. Previous studies in this literature proposed market-based indices of systemic distress, which link systemic risk contribution of a financial institution to the likelihood of simultaneous distress among a significant number of financial firms (Adrian & Brunnermeier, 2016; Allen, Bali, & Tang, 2012; Huang, Zhou, & Zhu, 2012). Surveys by Bisias et al. (2012) and Benoit et al. (2017) provide

insights into this literature. Our measure, CRISK, is closely related to SRISK (Acharya et al., 2012; Brownlees and Engle, 2017) and Systemic Expected Shortfall (SES) (Acharya et al., 2017). Both these measures estimate the capital shortfall of a firm conditional on a systemic event. However, while SRISK and SES are market-based measures, CRISK estimates the conditional capital shortfall by conducting a comprehensive fundamental analysis of the firm's balance sheet.

This paper also contributes to the literature on the usefulness of financial statement information in predicting firm distress. Beaver (1966) was the earliest study to highlight the usefulness of financial ratios in predicting firm failure. Subsequently, this paper inspired numerous studies exploring the significance of signals derived from financial statements in predicting future accounting and stock return performance (Abarbanell & Bushee, 1997; Lev & Thiagarajan, 1993; Mohanram, 2005; Ou & Penman, 1989; Piotroski, 2000). While most of these studies focus on non-financial firms, Mohanram et al. (2018) examines the usefulness of financial statement signals in screening U.S. bank stocks by developing an index (BSCORE) based on fourteen bank-specific signals. They document a positive association between BSCORE and future profitability changes, as well as current and one-year-ahead stock returns, suggesting that BSCORE captures forward-looking information not yet reflected in market prices. Furthermore, Badertscher et al. (2018) explore the role of regulatory reports in the information environment of banks. They find that granular and standardized information in regulatory reports informs market prices.

These studies provide evidence supporting the significance of a financial statement-based measure like CRISK. However, such a measure cannot replace a market-based measure like SRISK. Beaver (1968) argues that financial ratios and market prices should not be viewed as

mutually exclusive or competing predictors of failure, as both can complement each other. Therefore, CRISK and SRISK can complement each other in identifying troubled entities that significantly contribute to systemic risk.

The remainder of the paper proceeds as follows. Section 2 discusses the methodology and advantages/limitations of SRISK. Section 3 outlines the methodology and limitations of CRISK. Section 4 presents empirical estimation and descriptive statistics of CRISK. Section 5 examines the validity of CRISK, and section 6 concludes.

2. Systemic Risk Measurement Using SRISK

2.1 The Construct of SRISK

Brownlees and Engle (2017) define SRISK as the expected capital shortfall of a financial firm conditional on a systemic event, characterized by a prolonged and severe market decline. Capital shortfall (CS) is computed as the capital the firm needs to hold (because of regulation and/or prudential management) minus the market value of the firm's equity. Formally, the capital shortfall of firm i on day t is defined as

$$CS_{i\,t} = kA_{i\,t} - W_{i\,t} = k(D_{i\,t} + W_{i\,t}) - W_{i\,t}, \quad (1)$$

where $W_{i\,t}$ is the market value of equity, $D_{i\,t}$ is the book value of debt, $A_{i\,t}$ is the value of "quasi assets" (equivalent to sum of $W_{i\,t}$ and $D_{i\,t}$) and k is the prudential capital fraction, usually set at 8%. A firm is in distress when CS computed from the equation above yields a positive value, whereas it is deemed to have a capital surplus when CS is negative.

In Brownlees and Engle's (2017) model, a systemic event is defined as an event where the arithmetic market return 'R_m' over horizon 'h' falls below a threshold 'C' ($R_{mt+1:t+h} < C$).[3] Accordingly, SRISK can be formally represented as shown in equation (2):

[3] To compute SRISK in an extremely stressed scenario, the model assumes the horizon 'h' to be one month and the threshold 'C' (market decline) to be -40%.

$$SRISK_{i\,t} = E_t(CS_{i\,t+h}|R_{mt+1:t+h} < C) \quad (2)$$

Using equation (1) and (2) and assuming that a firm's debt cannot be renegotiated during a systemic event, SRISK is computed as:

$$SRISK_{i\,t} = kD_{i\,t} - (1-k)W_{i\,t}(1 - LRMES_{i\,t}), \quad (3)$$

where $LRMES_{i\,t}$ is the Long Run Marginal Expected Shortfall defined as the expectation of the firm's multi-period arithmetic equity return between period $t+1$ and $t+h$ $(R_{it+1:\,t+h})$ conditional on the systemic event. That is:

$$LRMES_{i\,t} = -E_t(R_{it+1:\,t+h}|R_{mt+1:t+h} < C)$$

The projected capital injection needed to bail out the firm is given by the maximum of SRISK (in equation 3) and zero. Aggregate SRISK, which is the sum of $max(SRISK, 0)$ for all financial institutions, represents the total amount of capital that the government would need to provide for bailing out the entire financial system in the event of a crisis.

2.2 Advantages of SRISK

SRISK is widely used in academic literature as a measure of conditional capital shortfall for financial firms. New York University (NYU)'s V-Lab computes SRISK daily for various listed financial firms and makes them publicly available at https://vlab.stern.nyu.edu/srisk.

There are several advantages of SRISK that contribute to its popularity. First, SRISK is relatively easy to compute, requiring only three inputs: the market value of equity, the book value of debt and an appropriate LRMES estimator. Second, this measure can be computed for all listed firms across all industries, including the financial services sector. Third, it can be assessed in real-time at a high frequency (daily), making it more timely for evaluating the vulnerability of a financial institution and the entire financial system conditional on a systemic event. Fourth, by using market value of equity as market's estimate of the future value of firm's

assets, SRISK potentially incorporates forward-looking information that may not yet be reflected on the balance sheet. Additionally, by employing the LRMES estimator, SRISK potentially takes into account the correlation between the firm's market value and that of the broader financial system during systemic events.

2.3 Limitations of SRISK

Brownlees and Engle (2017) acknowledge that SRISK does not explicitly incorporate off-balance-sheet information and may also inadequately capture the on-balance-sheet asset and liability structure of a firm. Below, we briefly discuss additional limitations in SRISK's methodology that have motivated us to propose our measure, CRISK.

2.3.1 SRISK is volatile and cannot be computed for private firms.

SRISK relies on equity market prices to estimate conditional capital shortfall and hence cannot be computed for private firms. For public firms, SRISK is likely to underestimate capital shortfall if stock prices do not adequately and timely reflect the balance sheet risk. Furthermore, volatility in stock prices can introduce significant noise into the measure, causing it to deviate from the firm's economic capital. For instance, J.P. Morgan's SRISK has fluctuated dramatically between $37 billion and $90 billion in the six months ending March 3, 2017. These fluctuations are primarily driven by stock market volatility and may not adequately reflect changes in J.P. Morgan's economic capital.

2.3.2 SRISK implicitly marks firms' assets to market during a systemic event without considering the heterogeneity in asset and liability structures across different business models.

The formulation of SRISK implicitly assumes that a decline in stock prices during a systemic event indicates a permanent loss of value in assets, requiring an immediate markdown of assets. This assumption can lead to overestimation of losses and the capital needed to cover them, as

systemic events are often characterized by crash risk in stock prices. By marking a firm's assets to market during a systemic event, SRISK assumes that most of its liabilities are called immediately during a crisis forcing the firm to liquidate its assets at sharp discounts. However, we argue that this assumption fails to consider the differences in business models and asset & liability structures among various firms such as commercial banks, investment banks, life insurers, and property and casualty (P&C) insurers.

First, not all assets are fair valued. Loans, which constitute a major portion of a bank's balance sheet, are not marked to market primarily because they have longer maturities and are not due in the short term. Second, certain liabilities may not be called during a systemic event. For example, FDIC-insured deposits are less likely to be called than uninsured deposits. Banks differ in the proportion of FDIC-insured deposits in their overall deposit obligations, leading to varying risks of deposit runs. In the case of life insurance companies, a notable example of liabilities that are less likely to be called during a systemic event is "future policy benefits". These long-term obligations owed to policyholders in the event of their death are unlikely to be affected by a systemic event, as policyholder mortality is not expected to coincide with a significant decline in the stock market index. Moreover, these liabilities also include unearned profits from the sale of policies, which are recognized as earned profits over the life of the policies and do not become due during a systemic event. Third, certain liabilities, even when called, are unlikely to cause distress during a systemic event. For example, a significant portion of a life insurer's liabilities consists of "separate account liabilities," which, when called, can be paid off using the corresponding "separate account assets." Since the insurer generally does not

bear the market risk associated with these assets, forced liquidation of these assets is unlikely to cause financial distress during a systemic event.[4]

SRISK is perhaps well-suited for assessing the financial vulnerability of a pure investment bank, given that its assets and liabilities typically have a short horizon and are marked-to-market daily. Due to the short-term nature of its liabilities, an investment bank's balance sheet is particularly vulnerable to a bank run, necessitating the liquidation of assets to fulfill these obligations. Consequently, the market value of the bank's equity, particularly during a systemic event, can effectively approximate its book value of equity.

2.3.3 SRISK ignores the notion of risk-weighted Assets.

SRISK estimates prudent capital as 8% of the financial institution's quasi-assets, which is calculated by summing the book value of debt and the reduced market value of equity after a systemic event. However, this approach overlooks the concept of risk-weighted assets (RWA) for banks or risk-based capital (RBC) for insurance firms, which are used to determine statutory capital requirements. As a result, there can be significant differences between the prudent capital computed as a percentage of quasi-assets and that computed as a percentage of RWA or RBC. For instance, SRISK does not distinguish between a financial institution that holds a substantial portion of its assets in safe investments like U.S. treasuries and one that holds riskier loans. However, under the RWA calculation, the weight assigned to U.S. treasuries would be zero. Consequently,

[4] Separate account assets are reported at fair value and represent segregated funds that are invested for certain policyholders, pension funds and other customers. The assets of each account are legally segregated and are not subject to claims that arise out of any other business of the Company. Investment risks associated with market value changes are borne by the customers, except to the extent of minimum guarantees made by the Company with respect to certain accounts. Separate account liabilities primarily represent the contract holder's account balance in separate account assets and to a lesser extent borrowings of the separate account and will be equal and offsetting to total separate account assets. The investment income and realized investment gains or losses from separate account assets generally accrue to the policyholders and are not included in the Company's results of operations. (See page 216 of Prudential Financial Inc.'s 2015 10-K)

in most cases, the prudent capital computed as 8% of quasi-assets would exceed the amount computed as 8% of RWA or RBC.

3. CRISK: An Alternative Approach to Measuring Systemic Risk

The limitations of SRISK, as outlined in section 2.3, provide a strong motivation to explore a suitable alternative. We argue that an ideal measure for assessing a firm's contribution to systemic risk should possess three key characteristics: (i) a measure of immediately callable liabilities; (ii) a systematic approach to evaluate financial vulnerability conditional on a systemic event; and (iii) consideration of interconnectedness among market participants. We introduce CRISK, a financial statement-based measure, to address the first two characteristics mentioned above. The assessment of interconnectedness requires access to detailed data on counterparties, which is complex and not readily accessible (Harris, Herz, & Nissim, 2013).

Our methodology to compute CRISK involves the following steps: (i) Estimate callable liabilities by considering all the contractual obligations (on- or off-balance sheet) likely to be called in case of a systemic event; (ii) Identify the different types of assets on the balance sheet that can be sold to pay off callable liabilities; (iii) Estimate the losses likely to be incurred upon the liquidation of these assets and other potential asset write-downs caused by the systemic event; (iv) Estimate post-crisis losses for the remaining assets on the balance sheet by applying appropriate loss rates to each asset class. These “loss rates” represent “business as usual” losses/defaults after the crisis abates; and (v) Compute CRISK as the excess of all the above losses over the firm’s book value of equity. This represents the expected capital shortfall of a financial firm conditional on a systemic event. We elaborate on each of these steps below.

3.1 Estimating Callable Liabilities

The first step in computing CRISK involves estimating liabilities that are likely to be called immediately during a systemic event, referred to as callable liabilities. As discussed in section 2, the methodology of SRISK implicitly assumes that most liabilities listed on the balance sheet are likely to be called immediately during a systemic event. In contrast, our methodology begins by considering those liabilities—both on- and off-balance-sheet—that are due within the next year, referred to as contractual obligations. From these contractual obligations, we estimate callable liabilities by excluding obligations that are less likely to be called during the systemic event or for which equivalent assets are earmarked to fulfill these claims.

We manually collect data on contractual obligations for a sample of 23 insurance companies and contractual obligations excluding deposits for 23 bank holding companies (BHCs) from 2007 to 2020.[5] Using this data, we compute the average ratio of contractual obligations to total assets across different business models. Multiplying this ratio by the total assets of each firm for a given quarter provides an estimate of contractual obligations, referred to as adjusted contractual obligations, for that firm-quarter.

For insurance firms, we assume that the adjusted contractual obligations provide a reasonable estimate of the total callable liabilities. However, it is important to note that some of these liabilities may have equivalent assets earmarked and may not be considered callable. For example, in life insurance companies, separate account liabilities due within one year may have equivalent assets earmarked and should be excluded from the adjusted contractual obligations. Unfortunately, insurance firms do not disclose these liabilities separately. However, our measure

[5] Rule 303(a)(5) of Regulation S-K mandates that firms disclose contractual obligations in a tabular format within the footnotes of their financial reports. However, this disclosure was only available annually (in Form 10-K filings) and has been discontinued since 2021. Additionally, data from disclosures prior to 2021 are not machine-readable, as the regulation did not stipulate a standardized format for disclosure. Furthermore, Banks differ in the way they disclose their deposit obligations. Some banks report the maturity profile of all deposits, while others either disclose the maturity profile of only time deposits or none at all.

of callable liabilities only includes the portion of separate account liabilities due within one year, while SRISK considers all such liabilities as callable, thereby minimizing the impact of this data limitation.

For banks, the estimated adjusted contractual obligations do not include any deposit obligations. Hence, we compute total callable liabilities by estimating the deposits that are likely to be called during the systemic event and adding them to the adjusted contractual obligations. These deposits include total non-US deposits and total domestic (US) deposits maturing within a year, which collectively account for approximately 90% of the total deposits.[6] However, a significant portion of domestic deposits are insured by the Federal Deposit Insurance Corporation (FDIC), a government agency. [7] We exclude insured portion of these deposits from callable liabilities for two reasons.[8] First, insured depositors are less likely to panic, as their deposits are guaranteed by the government. Second, a higher percentage of insured deposits indicates less concentration within depositors and depositor types, thereby decreasing the risk of bank runs.

3.2 Identifying Assets for Liquidation

The next step in our methodology entails identifying assets that the firm could liquidate to cover immediately callable liabilities during a systemic event. We assume that in a distress situation, firms would prioritize selling their most liquid and high-quality assets to minimize the total realized losses. Consequently, we rank all assets based on their likelihood of being sold

[6] Total domestic deposits maturing within a year is computed as Total domestic deposits minus Total time deposits plus Time deposits maturing within a year. Time deposits maturing within a year is estimated by multiplying total time deposits with the ratio of jumbo time deposits (>$250,000) maturing within a year to total jumbo time deposits.
[7] FDIC deposit insurance covers all deposit accounts at insured banks up to the insurance limit, currently $250,000 per depositor, per bank, per ownership category.
[8] Institutions that file call reports are required to report "percentage of uninsured domestic deposits" every quarter at an individual filer level. SNL (now known as Market Intelligence) uses this data to provide an estimate of "percentage of uninsured domestic deposits" at the bank holding company (BHC) level since the fourth calendar quarter of 2007.

during a systemic event. Assets are initially classified into three categories based on their liquidity: liquid, semi-liquid, and illiquid. Within each category, assets of higher quality are assigned higher rankings.

For banks, we adhere to the classification outlined by Berger and Bouwman (2009), categorizing "total cash & balances due from depository institutions & fed funds sold," "fixed-income securities," and "trading assets" as the most liquid assets.[9] Within fixed-income securities, we assign higher ranks to US Treasury and other government securities due to their perceived higher quality, followed by mortgage-backed and asset-backed securities, corporate debt, and other trading securities.[10] Loans and leases are classified as semi-liquid assets and are assumed to be available for sale after liquid assets. Within this category, residential real estate loans, consumer loans, credit card loans, other revolving credit loans and loans to depositories and governments are assigned higher rankings, followed by commercial real estate loans, commercial & industrial loans, loans to finance agricultural production, and other loans and leases. Other assets on the balance sheet, which include intangible assets, fixed assets, and investments in subsidiaries, are categorized as illiquid assets that cannot be easily sold to meet callable liabilities. A similar procedure is followed to rank the assets of insurance companies.

3.3 Estimating Losses on Liquidation of Assets

After determining the amount to be liquidated under each asset category to cover the callable liabilities, the next step is to estimate the losses likely to be incurred upon the sale of these assets. Considering that these assets are to be liquidated during a systemic event, it is essential to

[9] Banks are required to maintain reserve balances with the central bank in the form of vault cash or deposits. Although these reserves aren't practically available to meet callable liabilities, for computational simplicity, we do not exclude them from available assets as they represent only around 1-2% of the total deposits.

[10] Within fixed income securities, we should ideally consider the liquidation of trading securities first followed by available for sale and then held to maturity securities. The disclosure of this classification is not uniform across insurance firms and banks. Hence, we ignore this classification in our methodology.

anticipate that they are likely to be sold at a significant discount to their book value. Total liquidation losses are estimated by applying appropriate crisis-period haircuts to the expected sale amount for each asset type.

Cash and cash equivalents are assumed to be available to cover callable liabilities without any haircut. For fixed-income securities, we refer to the haircuts experienced by different types of securities during the 2007-2009 financial crisis. Online Appendix S1 provides a list of haircuts on securities sold in June 2009, based on data gathered by the Bank of International Settlements (2010). While future systemic events may result in different outcomes, we assume that the financial crisis haircuts provide the most conservative estimates. Within the portfolio of mortgage-backed securities (MBS), we assume that the sale of agency MBS (issued or guaranteed by government-sponsored enterprises (GSE)) incurs far fewer losses than the sale of non-agency MBS. For equity and mutual fund securities, we apply a 40% haircut to the entire portfolio, irrespective of whether they are liquidated or not, assuming that a systemic event would result in a 40% decline in the broad market index.[11]

For loans and leases, we first estimate the total losses on the entire loan portfolio resulting from likely defaults caused by the systemic event. To do this, we use the average loan loss rates under the severely adverse scenario published annually by the Federal Reserve since 2013 (Board of Governors of The Federal Reserve System, 2022). The Online Appendix S2 provides a list of average loss rates for various types of loans under the severely adverse scenario from 2013 to 2022.[12] Additionally, we apply a liquidity discount of 5% for the portion of loans expected to be liquidated in order to cover the remaining callable liabilities.

[11] The beta of the combined portfolio of equity securities for every firm is assumed to be equal to one.
[12] The Federal Reserve estimates loan loss rates for each loan type under the severely adverse scenario through annual stress tests for large banks in the US, providing a more accurate reflection of the current market conditions. For instance, due to significant stress in the commercial real estate market post-Covid-19, the average loss rates for

Among the other assets, some are written off completely assuming that a systemic event would eliminate any potential future benefits from these assets. These assets include goodwill and intangible assets for all firms, as well as the value of business acquired (VOBA) and acquired insurance portfolios, and deferred policy acquisition costs (DAC) for insurance firms.

Appendices 1 and 2 provide asset classifications (in the order of priority for servicing callable liabilities) and the corresponding haircuts applied to the portion sold for insurance firms and banks, respectively.

3.4 Estimating Post-Crisis Losses.

After the liquidation of required assets to meet the callable liabilities, we expect that the remaining assets will incur losses at rates consistent with those typically observed during normal business conditions. We use the historical S&P corporate default rates (Online Appendix S3) to estimate post-crisis expected losses for the remaining assets.

For insurance firms, we use a weighted-average default rate as the post-crisis loss rate for the remaining fixed maturity securities. The weights are based on the firm-specific distribution of these securities across various NAIC ratings.[13] Specifically, we calculate the weighted average of the "investment grade" default rate (1.73%) and the "speculative grade" default rate (18.62%) using the percentage of securities rated NAIC 1 to 2 and NAIC 3 to 6 as weights, respectively. For other assets, we apply the average "all rated" default rate of 7.62%.

For banks, we do not have access to data on the rating classification of fixed maturity securities. Therefore, we apply the average "AAA rated" default rate of 0.53% to all government-related securities and the average "all rated" default rate of 7.62% to non-

loans in this segment jumped from 6.3% in 2019 to 12.6% in 2020, 10.5% in 2021, and 9.8% in 2022. Due to non-availability of these estimates, we use the loan loss rates of 2013 for all years prior to 2013.

[13] NAIC ratings are assigned to securities in accordance with the Purpose and Procedures manual of the Securities Valuation Office of the NAIC. The rating scale runs from NAIC-1 (lowest risk) to NAIC-6 (highest risk).

government securities and other assets, except loans. As discussed in section 3.3, we have already accounted for the losses likely to occur on the entire loan portfolio during a systemic event. Post-crisis, we assume that banks would need to maintain a loan loss reserve equivalent to two percent of the remaining loans on the balance sheet.[14]

Appendices 1 and 2 provide detailed information on the asset-specific post-crisis loss rates used for insurance firms and banks, respectively.[15]

3.5 Computing CRISK

We calculate the total losses incurred during the crisis by summing the expected losses from selling assets to cover callable liabilities, the write-offs from assets such as intangible assets and loans (net of loss reserves), and the balance in Accumulated Other Comprehensive Income (AOCI). These losses are then deducted from the firm's book value of equity to determine the post-crisis book value of equity, which represents the capital available to sustain the business after the crisis. The objective of CRISK is to assess whether a financial institution can emerge from a crisis with sufficient capital to endure potential losses on its remaining assets, expected during normal business conditions. Therefore, CRISK is computed as the difference between the expected post-crisis losses on the remaining assets and the anticipated post-crisis book value of equity. This difference indicates the expected capital shortfall the firm is likely to face in case of a systemic event. A negative conditional capital shortfall suggests that the firm is more likely to survive the crisis with sufficient capital to continue its operations as usual.

Online Appendices S4 and S5 provide illustrations of CRISK computations for Prudential Financial Inc. and J.P. Morgan Chase, respectively, using their 2015 annual financial statements.

[14] Two percent is the historical average percentage of loan loss reserve to total loans for all US banks (https://fred.stlouisfed.org/series/USLLRTL).
[15] The default rates for "investment grade", "speculative grade", “AAA rated” and “all rated” securities are assumed to be equal to their average historical loss rates observed over a fifteen-year period (see Online Appendix S3).

3.6 Limitations of CRISK

CRISK, although grounded in fundamental analysis, faces certain challenges primarily stemming from data availability and computational complexity. First, we assume that the contractual obligations provide a reasonable estimate of callable liabilities. However, this information is only disclosed annually in 10-K filings and is not machine readable. Moreover, starting from 2021, firms are no longer required to disclose contractual obligations separately. Consequently, we estimate the adjusted contractual obligations for each firm-quarter by extrapolating from a limited sample of historical data. This limitation is less concerning for banks as data on deposit obligations, which form a significant portion of callable liabilities, can be obtained from quarterly regulatory filings.

Second, we assume that in a distress situation, firms would prioritize selling their most liquid and high-quality assets to minimize realized losses. The haircuts applied to the liquidated portion of these assets or securities should ideally depend on factors such as their type, maturity profile, and credit rating. However, for computational simplicity, we consider only the type of security or asset (e.g., US Treasury, mortgage-backed securities, corporate debt, etc.) and do not consider their maturity profile or credit rating.

Third, a critical component of our methodology involves determining benchmark haircuts for different assets that are expected to be liquidated in a systemic event. Due to lack of a better alternative, we have applied the haircuts observed during the 2007-2009 financial crisis to fixed-income securities. Although future systemic events may lead to different outcomes, we assume that the financial crisis haircuts provide the most conservative estimates. However, for loans, we rely on current expected loss rates obtained from the Federal Reserve's annual published data.

Finally, we do not distinguish between available-for-sale, trading, and held-to-maturity (HTM) securities while applying haircuts. We group these securities by security type and apply the corresponding haircuts. HTM securities represent approximately 3% and 14% of total securities for insurance companies and banks, respectively. These securities are reported on the balance sheet at historical cost, and any unrealized losses due to market price changes are not charged to equity. After the 2007-2009 financial crisis, the accounting rule makers merely required firms to disclose the unrealized losses and the fair value of HTM securities in a separate footnote in financial reports. We ignore this information for insurance companies because CRISK computations for this sector rely on balance sheet data from 10-Q filings, and the footnote data on HTM securities is not machine readable. However, for banks, we extract information on unrealized losses and fair value of HTM securities from regulatory reports (Y-9C and call reports). Consequently, CRISK computations for banks account for the liquidation of HTM securities at fair value, with related unrealized losses charged to the book value of equity.

The limitations mentioned above primarily stem from data availability issues rather than conceptual deficiencies. Therefore, we believe that CRISK offers an intuitive and practical approach to measuring a financial firm's contribution to systemic risk.

4. Data and CRISK Estimation

Although CRISK can be computed for both private and public financial firms, our empirical analysis specifically focuses on a panel of listed US financial firms to facilitate comparison with SRISK. We obtain the list of firms in the insurance and banking sectors for which SRISK data is available from March 2008 to March 2023.[16] The balance sheet data needed to compute CRISK for this sample is obtained from the 10-Q filings for insurance companies, quarterly Y-9C reports

[16] The data on uninsured deposits for bank holding companies is available from calendar quarter 4, 2007, which is used to compute CRISK for March 2008.

for bank holding companies (BHC), and quarterly call reports for commercial and savings banks.[17]

The final sample consists of 76 listed insurance firms (3,051 firm-quarters) and 325 depositories (11,738 firm-quarters). Table 1 illustrates the sample distribution across various business models in insurance and banking sectors. Firms specializing in life & health, property & casualty, and multiline collectively represent 80% of the sample observations in the insurance sector, while banks comprise 94% of the sample observations in the banking sector.

4.1 Descriptive Statistics of Balance Sheet Composition

Table 2 presents descriptive statistics of balance sheet composition for firms in insurance and banking sectors. Panel A reports the mean value of each asset on the balance sheet as a percentage of total assets. For insurance firms, primary assets include securities (both fixed income and equity securities) at 53%, reinsurance assets at 8%, and separate account assets at 8%. "Separate account assets" constitute a substantial portion of assets for Life & Health (L&H) insurance firms, comprising around 20% of total assets (Online Figure S1). Also, L&H firms allocate a larger portion of their securities portfolio to corporate debt, while the securities portfolio of Property & Casualty (P&C) insurance firms mainly consists of corporate debt, state & municipal debt, and equity securities (Online Figure S2).

For banks, the primary assets include loans and leases at 66.5%, securities (both fixed income and equity securities) at 19% and total cash & balances due from depository institutions at 5.5%. Within total securities, mortgage-backed securities constitute the largest group at 11.5% of total assets followed by state & municipal securities at 3.4%, and government agency securities at 2.1% (Online Figure S3).

[17] Data from regulatory reports is obtained from the SNL database (now known as Market Intelligence). Since listed insurance companies are not required to file regulatory reports, we had to rely on their 10-Q fillings.

Panel B of Table 2 shows the composition of loans for firms in the banking sector. A typical bank's loan portfolio comprises of semi-liquid loans (46%) and illiquid loans (54%). Semi-liquid loans include residential real estate loans (38.7%), consumer loans (5%), credit card loans (1.4%), other revolving credit loans (0.5%), and loans to governments and other depositories (0.2%). Illiquid loans include commercial real estate (CRE) loans (29%), commercial & industrial loans (18%), and other loans & leases (7%).

Panel C of Table 2 reports the mean value of each liability account on the balance sheet as a percentage of total liabilities. The most significant liability on an insurance firm's balance sheet is policy reserves, which account for 68% of total liabilities. These reserves represent the estimated amount required to cover future claims and other policy benefits for policyholders. Another notable liability is "separate account liabilities", which account for 9% of total liabilities for all insurance companies and approximately 20% for L&H companies (Online Figure S4). Debt accounts for 10% of total liabilities, while other liabilities constitute 12%. As for banks, the primary liabilities are deposits, accounting for 86% of total liabilities, followed by debt at 8.6%, and federal funds purchased & repos at 3%.

4.2 Descriptive Statistics of Callable Liabilities

To estimate callable liabilities, we hand-collect data on *"contractual obligations"* for a sample of 23 insurance firms and *"contractual obligations excluding deposits"* for 23 bank holding companies (BHCs) from 2007 to 2020. Panel A of Table 3 reports the average ratio of contractual obligations to total assets for various business models. Among insurance firms, P&C insurers have the highest ratio at 12.7% followed by L&H insurers at 9.7%. For banks, this ratio is lower at 4.0% since deposit obligations are not included. We then estimate adjusted

contractual obligations for each firm-quarter by multiplying the average ratio of contractual obligations to total assets for each business model by the total assets of that firm-quarter.

For insurance firms, we consider the estimate of adjusted contractual obligations to be a reliable measure of callable liabilities. On average, these callable liabilities represent 9.6% of total assets across all firm-quarters in our insurance sample (Panel B of Table 3). In comparison, adjusted contractual obligations (excluding deposits) account for 4.9% of total assets in our bank sample. However, these adjusted contractual obligations do not include deposit obligations. Therefore, to determine total callable liabilities, we add an estimate of callable deposits to the adjusted contractual obligations. Callable deposits, consisting of non-US deposits and the uninsured portion of domestic (US) deposits, account for an average of 32.1% of total deposits.[18] Consequently, the total callable liabilities, including callable deposits, represent 29.6% of total assets for the firm-quarters in our bank sample.

4.3 Descriptive Statistics and Time Trend of CRISK

In this section, we present the descriptive statistics of CRISK, compare firm rankings based on CRISK and SRISK, and describe the time-series evolution of aggregate CRISK in comparison to that of aggregate SRISK. The mean value of CRISK for the entire sample is $858.8 million, with a maximum value of $150.5 billion (Panel A of Table 4). However, if we consider only observations with a positive capital shortfall, the mean value of CRISK increases to $3.8 billion. Panel B of Table 4 reports the top five financial institutions based on CRISK and SRISK rankings for the month of June each year from 2008 to 2022. We compare CRISK measured using financial statements of a specific quarter to SRISK measured three months after the end of that quarter. For example, we compare CRISK computed using the Y-9C report as of December

[18] On average, the uninsured portion of domestic deposits is 33%.

31, 2022, with SRISK computed on March 31, 2023. This ensures that the financial statement information is publicly available at the time of computing SRISK. Panel C of Table 4 reports Spearman's correlation between CRISK and SRISK rankings for each quarter in the sample period. The correlation coefficient is often significantly positive, with a mean of 0.27 and a maximum value of 0.55.

Figure 1 illustrates the time trend of aggregate CRISK, which represents the total conditional capital shortfall for all firms in the sample at any given point in time. The financial crisis that began in 2007 reached its peak by September 2008 and showed signs of recovery by March 2009. Consistent with this timeline, aggregate CRISK indicated a peak capital shortfall of $800 billion (in 2012 prices) at the end of March 2008. The top contributors are Bank of America Corporation, Citigroup, AIG, JP Morgan, and MetLife. Aggregate CRISK started to decline by the end of 2008 and has mostly remained under $200 billion since then. However, from 2018 onwards, there is a noticeable upward trend in aggregate CRISK, which eventually surpassed the $200 billion threshold in September 2022. During this period, the top contributors among banks are Bank of America Corporation, Wells Fargo, and SVB Financial Group. This trend of aggregate CRISK can be partially attributed to the trend of FDIC-insured deposits in the US over time. Figure 2 shows that the mean percentage of uninsured deposits for the sample firms declined from 37% in 2008 to 20% in 2013. However, it has risen steadily since then, reaching 42% in 2021, indicating a significant increase in the risk of bank runs.

In comparison, aggregate SRISK exhibits a relatively erratic pattern. Aggregate SRISK stood at $420 billion in March 2008 and surged to $850 billion by March 2009, by which time the crisis was already on the mend. In the recent past, aggregate SRISK experienced a spike during the initial phase of Covid-19. It then declined to below $200 billion by March 2021, but

subsequently rose to $800 billion in March 2023. These fluctuations closely mirror those of the broad stock market and may not necessarily reflect changes to firms' economic capital.

5. Validation of CRISK

In this section, we examine the validity of our measure, CRISK, by assessing whether CRISK's estimate of conditional capital shortfall correlates with (i) the capital injections received by financial firms during the 2007-2009 financial crisis, and (ii) the short interest in these firms during the sample period spanning 2008-2023.

5.1 CRISK and Fed Capital Injections

We first compare the conditional capital shortfall, as indicated by CRISK, for a few large financial firms with the actual capital injections received by these firms from the Federal Reserve during the 2007-2009 financial crisis. Based on the financial statements as of December 31, 2007, CRISK indicates a capital shortfall of $70.8 billion for JP Morgan Chase, $122.3 billion for Bank of America, $113.9 billion for Citigroup, $44.8 billion for Wachovia, and $36.5 billion for Wells Fargo. These estimates closely correspond to the maximum borrowing level of these firms from the government during the financial crisis, which were $68.6 billion, $91.4 billion, $99.5 billion, $50 billion, and $45 billion, respectively. Additionally, based on the financial statements as of December 31, 2007, AIG's CRISK of $82.1 billion aligns closely with the $85 billion loan commitment announced by the US government on September 16, 2008.

We further examine the correlation of CRISK with Fed capital injections between 2007 and 2009 using a large sample comprising 194 firms from the insurance and banking sectors. Specifically, we conduct the following Tobit regression.

$$log\ (CI_i) = \alpha_0 + \alpha_1\, log(1 + CRISK_i) + \alpha_2\, log(1 + SRISK_i) + \beta' controls_i + \varepsilon_i \qquad (4)$$

Following Brownlees and Engle (2017), we utilize the Bloomberg Loan Crisis Data, a dataset compiled by Bloomberg, which contains records of all financial firms that received capital injections from the Fed during the financial crisis. We measure *Fed capital injection* as the maximum level of firm borrowing after March 2008. We assume that the capital injection is carried out only if the amount to be injected is positive. Therefore, $log(CI_i)$ is defined as

$$log(CI_i) = \begin{cases} log(Fed\ capital\ injection_i) & if\ Fed\ capital\ injection > 0 \\ 0 & Otherwise \end{cases} \quad (5)$$

CRISK is computed using the latest balance sheet information available before the end of March 2008, while *SRISK* is obtained for end of March 2008 from V-Lab. We include *log of total assets*, *return volatility*, and *equity fall* as control variables. *Equity fall* represents the change in market value of equity between July 2007 and March 2008, scaled by recent total assets. The period of July 2007 approximately corresponds to the peak in equity valuations before the financial crisis. *Return volatility* is measured as the standard deviation of monthly stock returns from CRSP over the last 24 months preceding the latest fiscal year-end before March 2008. We also include a dummy variable (*bank dummy*) which takes the value of one for banks and zero for insurance firms.

Table 5 reports the estimation results of equation (4). The coefficient for *CRISK* is positive at 0.685 and statistically significant at the 1% level, after controlling for *total assets*, *return volatility*, and *equity fall*. Furthermore, the coefficient on *CRISK* remains positive and statistically significant even after including *SRISK* in the regression. These results show that our methodology or framework closely corresponds to the estimation of actual capital shortfalls by the troubled firms or the regulator during the financial crisis. [19]

[19] Validating CRISK using capital injections during the financial crisis may raise concerns of potential lookahead bias. This is because we use haircuts observed during this period to compute CRISK for the same period. We acknowledge this concern, and therefore, refrain from interpreting the results in Table 5 as indicative of out-of-

5.2 CRISK and Short Interest

We further investigate whether CRISK, a financial statement-based measure of potential distress, correlates with the activities of short sellers.

Short sellers are considered key intermediaries and sophisticated users of financial statement information. Prior studies have shown that short sellers are capable of identifying overvalued stocks (P. Dechow, 2001; Desai, Ramesh, Thiagarajan, & Balachandran, 2002; Hirshleifer, Teoh, & Yu, 2011), anticipating negative news and financial misconduct (Christophe, Ferri, & Angel, 2004; Christophe, Ferri, & Hsieh, 2010; P. M. Dechow, Sloan, & Sweeney, 1996; Desai, Krishnamurthy, & Venkataraman, 2006; Efendi, Kinney, & Swanson, 2004; Karpoff & Lou, 2010), and forecasting impending distress in banks (Desai, Rajgopal, & Yu, 2016). Specifically, Desai et al. (2016) reported (i) an increase in the mean abnormal short interest of banks from 0.66 percent in March 2005 to 2.4 percent in March 2007 and (ii) a significant correlation between short interest and leading financial statement indicators during the financial crisis.

We examine whether the level of short interest is positively related to our measure of distress, CRISK, using the below regression.

$$Short\ interest\ ratio_{it} = \alpha_0 + \alpha_1\ CRISK\_ind_{it} + \alpha_2 SRISK\_ind_{it} + \beta' controls_{it} + \varepsilon_{it} \qquad (6)$$

Short interest ratio (SIR) is computed by dividing the monthly short interest by the number of shares outstanding. *SIR* is measured in the third month following the end of the financial quarter, allowing short sellers approximately a month to take positions after the quarterly financial statements are made public.[20] *CRISK_ind* (*SRISK_ind*) is a binary variable that equals

sample predictive power of CRISK. However, these haircuts are only applied to fixed income securities, which represent just 19% of total assets for banks. This concern is more significant for the Insurance sector, where fixed income securities (primarily corporate debt and state & municipal securities) account for 49% of total assets.

[20] Banks are required to submit their consolidated financial statements using Form Y-9C within 40 days after each quarter end for the first three calendar quarters, and within 45 days after the fourth calendar quarter end.

one if *CRISK* (*SRISK*) indicates a positive capital shortfall (measured in the same month as short interest), and zero otherwise. The sample period extends from March 2008 to March 2023, with data collected every quarter. Prior research by Dechow et al. (2001), Asquith et al. (2005), and Duarte et al. (2006) has shown that short interest correlates with *size*, *book-to-market ratio*, and *momentum return*. Therefore, our control variables include these three variables, along with two additional variables associated with short-sale constraints: *turnover* and *institutional ownership*. Additionally, we include *current return* during the recent financial quarter and *profitability* for the trailing twelve-month period as control variables.

Panel A of Table 6 reports the univariate analysis of short interest and CRISK. The mean *short interest ratio* for observations with a positive capital shortfall (*CRISK_ind=1*) is 4.10%, compared to 2.96% for observations with *CRISK_ind=0*. The difference in means is 1.14% and is statistically significant at the 1% level. For firm-quarters with the largest capital shortfalls, which are represented by the highest (above the 90th percentile) CRISK values scaled by total assets, the average *short interest ratio* is 4.28%.

Panel B of Table 6 reports the results of the multivariate regression in equation (6). The coefficient on *CRISK_ind* is positive and significant at the 1% level, even after including *SRISK_ind* and all relevant controls. We also examine this relationship after excluding the 2007-2009 financial crisis period and continue to find similar results.

In Panel C of Table 6, we replace *short interest ratio* with *abnormal short interest ratio*, defined as the firm's short interest ratio for a particular month minus its average short interest ratio over the past 12 months. The binary variables, *CRISK_first* and *SRISK_first*, in this regression indicate the first time a firm has been flagged as having a conditional capital shortfall. We find similar results indicating a positive relationship between *CRISK* and *abnormal short*

interest. Overall, the above findings provide compelling evidence suggesting that CRISK holds promise as an early warning indicator for conditional financial distress.

6. Conclusion

In this paper, we introduce CRISK, a financial statement-based measure, to assess systemic risk contribution of financial firms. CRISK estimates the capital shortfall conditional on a systemic event. Our measure, which is based on fundamental analysis, provides a compelling alternative to the market-based measure, SRISK, introduced by Acharya et al. (2012) and Brownlees and Engle (2017).

While SRISK offers several advantages, such as ease of computation and the use of forward-looking information in equity prices, it relies on relatively simplistic assumptions and does not capture the differences in business models and asset & liability structures among institutions such as commercial banks, investment banks, life insurers, and property and casualty insurers. Specifically, SRISK assumes that the decline in stock prices during a crisis represents a permanent loss of value in assets, which necessitates an immediate markdown of all assets. However, it is important to note that not all assets of financial firms are fair valued. Also, the market prices of assets during a crisis are influenced by simultaneous forced sales of these assets by multiple firms, often driven by the pressures that these firms face on their liabilities side. By marking the assets to market, SRISK implicitly assumes that most liabilities are likely to be called immediately during a crisis forcing the firm to sell its assets at sharp discounts.

Our measure, CRISK, adheres to the same definition of conditional capital shortfall as SRISK, but it delves deeper into identifying which liabilities are likely to be called during a systemic event and which assets are likely to be sold to meet these liabilities. In doing so, CRISK accounts for the diverse business models of financial institutions, a consideration that a broad

market-based measure like SRISK may overlook. For instance, CRISK acknowledges that not all liabilities are equally susceptible to being called during a crisis, such as FDIC-insured deposits. Moreover, CRISK incorporates specific nuances of different business models. For example, in the case of life insurance firms, certain seemingly significant on-balance-sheet liabilities (e.g., separate accounts liabilities) are backed by separately earmarked assets (separate accounts assets) that can be used to settle these liabilities when called upon, without incurring any market risk.

We compute CRISK on a quarterly basis for a large sample of financial firms for the period 2008 to 2023. We analyze each individual firm's contribution to the overall systemic risk and discuss the time trend of aggregate CRISK relative to aggregate SRISK. Multivariate regression analysis indicates that CRISK's estimate of conditional capital shortfall closely aligns with the actual capital injections received by financial firms from the Federal Reserve during the 2007-2009 financial crisis. Furthermore, we observe a significant positive correlation between CRISK and short interest, indicating CRISK's potential as an early warning indicator of conditional financial distress. [21]

Overall, we recommend combining the strengths of both approaches. SRISK, with its real-time availability and accessibility, serves as a valuable tool for generating a shortlist of potential systemically important financial institutions. This compilation can be further refined using CRISK, which offers a more nuanced estimate of conditional capital shortfall through fundamental analysis.

[21] In untabulated results, we find a significant negative correlation between risk-based capital (RBC) ratios and CRISK for insurance firms, as expected.

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Figure 1: Time trend of aggregate CRISK and SRISK (denominated in 2012 prices)

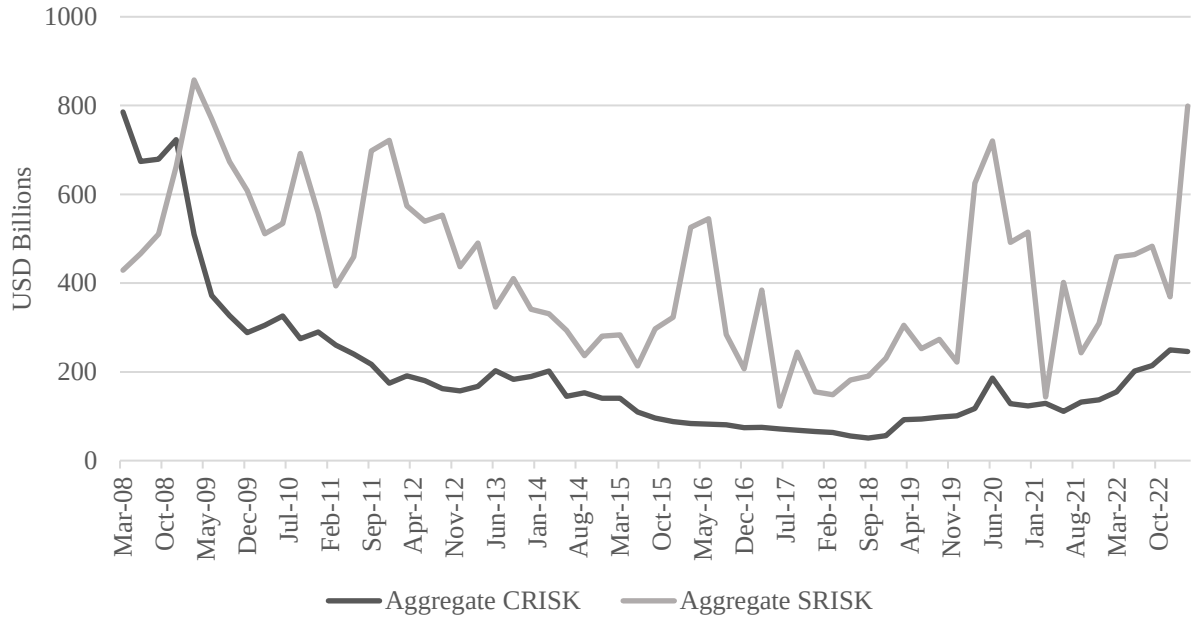

Figure 2: Time trend of uninsured domestic deposits

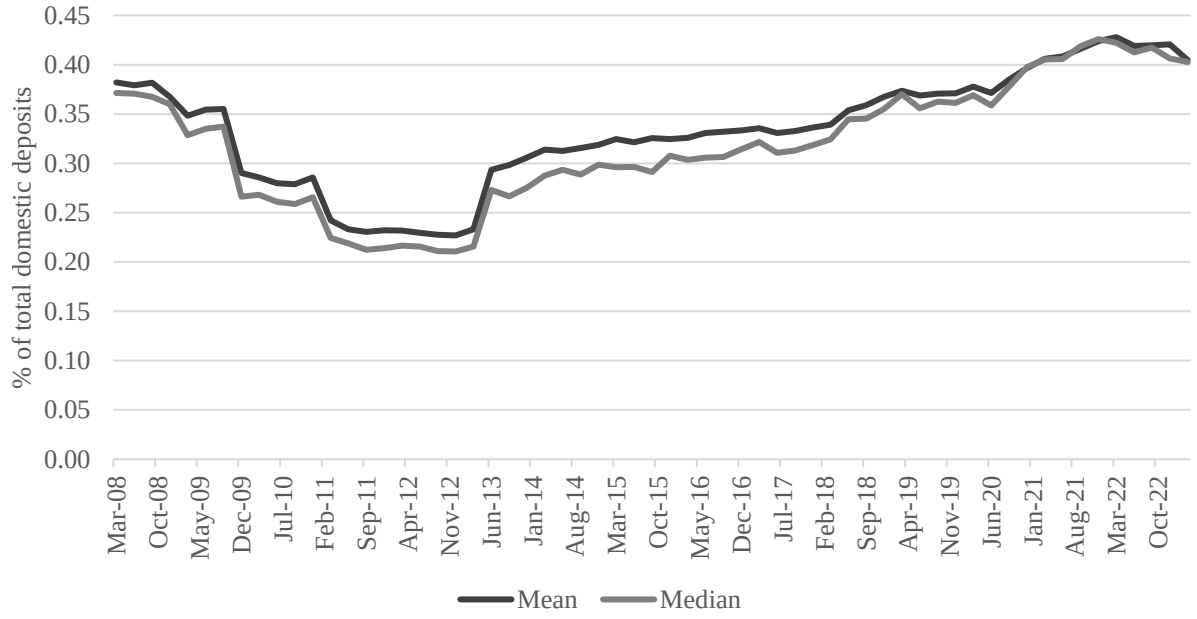

TABLE 1 Sample for computing CRISK

Insurance Sector	Unique firms	Firm-quarters
Life and Health	20	835
Managed Care	6	272
Multiline	9	343
Property and Casualty	35	1,346
Reinsurance	4	142
Title	2	113
	76	3,051

Banking Sector	Unique firms	Firm-quarters
Bank	301	11,062
Broker-Dealer	5	222
Financial Technology	2	19
Regulated Depository	2	18
Savings Bank/Thrift/Mutual	12	281
Specialty Lender	3	136
	325	11,738

Total	401	14789

Notes: Table 1 presents the count of distinct firms and firm-quarters categorized by industry that were used in the computation of CRISK from March 2008 to March 2023. These firms have total assets equal to or exceeding USD 1 billion and were listed on major stock exchanges in the US throughout the sample period.

TABLE 2 Descriptive statistics of balance sheet composition

Panel A: Asset composition

Insurance Sector			Banking Sector		
Asset Accounts	Firm-quarters	Mean (%)	Asset Accounts	Firm-quarters	Mean (%)
US govt. securities	3051	3.1	US govt. securities	11738	0.9
other govt. securities	3051	2.2	govt ags securities	11738	2.1
state & muni securities	3051	10.5	state & muni securities	11738	3.4
MBS & ABS securities	3051	8.6	MBS securities	11738	11.5
public utilities securities	3051	1.2	ABS securities	11738	0.4
corp debt securities	3051	21.9	struc fin securities	11738	0.3
other inv securities	3051	1.6	corp debt securities	11738	1.1
total equity securities	3051	3.5	trading securities (loans)	11738	0.0
total securities	3051	52.6	other trading securities	11738	0.3
cash & cash equivalents	3051	3.2	equity securities	11738	0.3
policy loans	3051	0.6	total securities	11738	19.3
short term investments	3051	2.1	total cash deps	11738	5.5
investment partnerships	3051	1.3	fed funds sold	11738	0.2
investment real estate	3051	0.3	reverse repos	11738	0.7
mortgage loans	3051	2.6	other assets	11738	4.1
other inv assets	3051	2.0	loans & leases	11738	66.5
cash investments	3051	64.5	Premises & fixed assets	11738	1.3
accrued invest income	3051	0.4	invest subs	11738	0.1
reinsurance assets	3051	8.1	real estate JVs	11738	0.1
premiums receivable	3051	3.8	total OREO	11738	0.3
VOBA & DPAC	3051	3.4	total intangible assets	11738	2.2
total intangible assets	3051	4.4			
fixed assets	3051	1.4			
total other assets	3051	6.1			
separate account assets	3051	7.9			

Panel B: Loan composition

Loans	Firm-quarters	Mean (%)	Median (%)
residential real estate loans	11738	38.7	38.7
consumer loans	11738	5.0	1.8
credit card loans	11738	1.4	0.0
other revolving credit loans	11738	0.5	0.2
depositories & govt loans	11738	0.2	0.0
total semi liquid loans	11738	45.7	46.6
commercial real estate loans	11738	29.2	30.0
commercial & industrial loans	11738	18.0	15.7
other loans & leases	11738	7.1	3.8
total illiquid loans	11738	54.3	53.4

Panel C: Liability composition

Insurance Sector			Banking Sector		
Liability Accounts	Firm-quarters	Mean (%)	Liability Accounts	Firm-quarters	Mean (%)
policy reserves	3051	68.2	total deposits	11738	86.0
reinsurance liabilities	3051	0.8	fed funds purchased & repos	11738	2.9
total debt	3051	10.1			
other liabilities	3051	12.2	trading liabilities	11738	0.4
separate account liabilities	3051	8.7	total debt	11738	8.6
			other liabilities	11738	2.1

Notes: Table 2 presents the descriptive statistics of balance sheet composition for Insurance and Banking sectors. Panel A reports the average proportion of each asset category on the balance sheet, expressed as a percentage of total assets, for the Insurance and Banking sectors. Panel B reports the average proportion of each loan type, expressed as a percentage of total loans and leases, for the Banking sector. Panel C presents the average proportion of each liability account on the balance sheet, expressed as a percentage of total liabilities, for the Insurance and Banking sectors. Policy reserves include future policy benefits and policyholder accounts for Life & Health (L&H) insurance firms and unpaid losses and loss expenses for Property & Casualty insurance firms. Separate account liabilities primarily apply to L&H firms.

TABLE 3 Descriptive statistics of contractual obligations & callable liabilities

Panel A: Contractual obligations as a percentage of total assets				
Industry		Mean (%)	Median (%)	Std Dev (%)
Life and Health		9.7	9.2	3.5
Managed Care		7.1	6.4	3.7
Multiline		8.6	8.0	3.3
Property and Casualty		12.7	11.5	3.7
Title		7.1	6.9	2.1
Banks (excl. deposits)		4.0	2.6	3.9
Panel B: Callable liabilities				
Insurance Sector				
		N	Mean (%)	Median (%)	Std Dev (%)
total callable liabilities	% of total assets	3051	9.6	10.0	2.8
Banking Sector				
		N	Mean (%)	Median (%)	Std Dev (%)
adjusted contractual obligations (excl. deposits)	% of total assets	11738	4.9	5.0	1.2
callable deposit liabilities	% of total deposits	11738	32.1	29.5	18.6
total callable liabilities	% of total assets	11738	29.6	27.6	14.4

Notes: Table 3 presents the descriptive statistics of contractual obligations and callable liabilities. Panel A reports the descriptive statistics of contractual obligations due within a year, expressed as a percentage of total assets, for both banks and insurance firms. This data is manually collected from the footnotes of the annual reports (10-Ks) for a sample consisting of 23 insurance firms and 23 bank holding companies spanning from 2007 to 2020. These contractual obligations do not include deposits for banks. Panel B reports the total callable liabilities as a percentage of total assets for insurance firms and banks. For insurance firms, the total callable liabilities are equivalent to the adjusted contractual obligations. These adjusted contractual obligations are estimated by extrapolating the average values of contractual obligations for each business model reported in Panel A. For banks, the total callable liabilities consist of the adjusted contractual obligations and callable deposits. Callable deposits are calculated as the sum of total non-US deposits and the uninsured portion of domestic (US) deposits due within a year.

TABLE 4 Comparative Analysis of *CRISK* and *SRISK*

Panel A: Descriptive statistics of *CRISK* and *SRISK*

in $ millions	N	Mean	p50	SD	p5	p25	p75	p95
CRISK	14789	858.8	0.0	6,056.0	0.0	0.0	0.0	2,930.4
SRISK	14789	1,845.3	0.0	10,213.6	0.0	0.0	122.2	5,757.1

Panel B: Top five rankings based on *CRISK* and *SRISK*

	Top five by CRISK			Top five by SRISK		
Year-Month	Name	CRISK ($ Millions)	% CRISK	Name	SRISK ($ Millions)	% SRISK
2008-06	Citigroup Inc.	141,297	0.22	Citigroup Inc	125,307	0.28
2008-06	Bank of America Corporation	99,024	0.15	Bank of America Corp	80,365	0.18
2008-06	JPMorgan Chase & Co.	94,645	0.15	JPMorgan Chase & Co	80,009	0.18
2008-06	MetLife, Inc.	51,067	0.08	American International Group Inc	43,273	0.10
2008-06	Wells Fargo & Company	40,174	0.06	Wells Fargo & Co	11,780	0.03
2009-06	JPMorgan Chase & Co.	68,385	0.19	Bank of America Corp	132,163	0.18
2009-06	Wells Fargo & Company	57,453	0.16	Citigroup Inc	128,842	0.18
2009-06	Citigroup Inc.	35,053	0.10	JPMorgan Chase & Co	101,999	0.14
2009-06	Bank of America Corporation	34,750	0.10	Wells Fargo & Co	55,757	0.08
2009-06	American International Group, Inc.	28,594	0.08	American International Group Inc	52,097	0.07
2010-06	JPMorgan Chase & Co.	98,581	0.31	Bank of America Corp	100,486	0.20
2010-06	Wells Fargo & Company	40,396	0.13	Citigroup Inc	94,492	0.18
2010-06	MetLife, Inc.	28,255	0.09	JPMorgan Chase & Co	72,971	0.14
2010-06	Citigroup Inc.	21,046	0.07	Morgan Stanley	44,600	0.09
2010-06	The Hartford Financial Services Group, Inc.	18,158	0.06	American International Group Inc	42,186	0.08
2011-06	JPMorgan Chase & Co.	110,833	0.47	Bank of America Corp	107,041	0.24
2011-06	MetLife, Inc.	28,098	0.12	JPMorgan Chase & Co	78,574	0.17
2011-06	The Hartford Financial Services Group, Inc.	13,891	0.06	Citigroup Inc	78,207	0.17
2011-06	Wells Fargo & Company	12,051	0.05	Morgan Stanley	44,353	0.10
2011-06	Lincoln National Corporation	9,461	0.04	Goldman Sachs Group Inc/The	27,483	0.06

2012-06	JPMorgan Chase & Co.	111,898	0.62	Bank of America Corp	124,480	0.23
2012-06	The Hartford Financial Services Group, Inc.	13,679	0.08	Citigroup Inc	113,322	0.21
2012-06	MetLife, Inc.	10,153	0.06	JPMorgan Chase & Co	107,751	0.20
2012-06	Lincoln National Corporation	8,023	0.04	Goldman Sachs Group Inc/The	47,660	0.09
2012-06	State Street Corporation	6,171	0.03	MetLife Inc	29,237	0.05
2013-06	JPMorgan Chase & Co.	95,608	0.46	Bank of America Corp	80,176	0.23
2013-06	Wells Fargo & Company	14,771	0.07	Citigroup Inc	69,629	0.20
2013-06	Prudential Financial, Inc.	10,382	0.05	JPMorgan Chase & Co	63,206	0.18
2013-06	State Street Corporation	10,307	0.05	Morgan Stanley	36,328	0.10
2013-06	The Bank of New York Mellon Corporation	8,571	0.04	Goldman Sachs Group Inc/The	35,513	0.10
2014-06	JPMorgan Chase & Co.	77,005	0.51	Bank of America Corp	79,501	0.26
2014-06	Prudential Financial, Inc.	12,927	0.09	JPMorgan Chase & Co	71,200	0.23
2014-06	State Street Corporation	10,039	0.07	Citigroup Inc	57,854	0.19
2014-06	The Bank of New York Mellon Corporation	7,725	0.05	Goldman Sachs Group Inc/The	29,366	0.10
2014-06	Lincoln National Corporation	6,730	0.04	Prudential Financial Inc	14,915	0.05
2015-06	JPMorgan Chase & Co.	48,994	0.43	Bank of America Corp	51,009	0.23
2015-06	State Street Corporation	17,514	0.15	JPMorgan Chase & Co	44,596	0.20
2015-06	Prudential Financial, Inc.	13,074	0.11	Citigroup Inc	36,252	0.16
2015-06	The Bank of New York Mellon Corporation	7,815	0.07	Morgan Stanley	22,281	0.10
2015-06	Lincoln National Corporation	6,366	0.06	Prudential Financial Inc	16,925	0.08
2016-06	JPMorgan Chase & Co.	20,851	0.24	Bank of America Corp	106,586	0.18
2016-06	UnitedHealth Group Incorporated	18,429	0.21	Citigroup Inc	88,744	0.15
2016-06	Prudential Financial, Inc.	10,970	0.13	JPMorgan Chase & Co	80,894	0.14
2016-06	State Street Corporation	8,534	0.10	Morgan Stanley	44,092	0.08
2016-06	Lincoln National Corporation	7,222	0.08	Goldman Sachs Group Inc/The	34,574	0.06
2017-06	UnitedHealth Group Incorporated	16,213	0.21	Bank of America Corp	31,201	0.24
2017-06	Prudential Financial, Inc.	10,821	0.14	Goldman Sachs Group Inc/The	23,105	0.17
2017-06	JPMorgan Chase & Co.	8,904	0.12	Morgan Stanley	19,331	0.15
2017-06	Lincoln National Corporation	7,046	0.09	Prudential Financial Inc	12,491	0.09
2017-06	Ameriprise Financial, Inc.	6,041	0.08	Citigroup Inc	12,407	0.09
2018-06	UnitedHealth Group Incorporated	14,776	0.24	Citigroup Inc	51,233	0.25
2018-06	JPMorgan Chase & Co.	12,293	0.20	Goldman Sachs Group Inc/The	29,828	0.15

2018-06	Voya Financial, Inc.	7,067	0.12	Morgan Stanley	26,563	0.13
2018-06	Prudential Financial, Inc.	6,298	0.10	Prudential Financial Inc	18,711	0.09
2018-06	Lincoln National Corporation	5,960	0.10	Bank of America Corp	17,355	0.09
2019-06	The Cigna Group	45,530	0.43	Citigroup Inc	71,895	0.25
2019-06	JPMorgan Chase & Co.	14,296	0.14	Bank of America Corp	37,279	0.13
2019-06	UnitedHealth Group Incorporated	12,618	0.12	Goldman Sachs Group Inc/The	32,738	0.12
2019-06	Lincoln National Corporation	9,540	0.09	Morgan Stanley	32,572	0.11
2019-06	Assurant, Inc.	7,402	0.07	Prudential Financial Inc	20,845	0.07
2020-06	JPMorgan Chase & Co.	60,127	0.28	Citigroup Inc	125,913	0.15
2020-06	The Cigna Group	40,849	0.19	Bank of America Corp	104,309	0.13
2020-06	Bank of America Corporation	22,116	0.10	Wells Fargo & Co	103,917	0.13
2020-06	Wells Fargo & Company	16,546	0.08	JPMorgan Chase & Co	103,110	0.13
2020-06	UnitedHealth Group Incorporated	13,463	0.06	Goldman Sachs Group Inc/The	51,562	0.06
2021-06	The Cigna Group	36,620	0.28	Citigroup Inc	107,257	0.22
2021-06	UnitedHealth Group Incorporated	13,241	0.10	Wells Fargo & Co	57,798	0.12
2021-06	Lincoln National Corporation	11,895	0.09	Bank of America Corp	47,527	0.10
2021-06	Assurant, Inc.	8,651	0.07	JPMorgan Chase & Co	44,796	0.09
2021-06	State Street Corporation	7,957	0.06	Goldman Sachs Group Inc/The	41,765	0.09
2022-06	The Cigna Group	36,681	0.14	Citigroup Inc	124,075	0.21
2022-06	Bank of America Corporation	34,173	0.13	JPMorgan Chase & Co	89,344	0.15
2022-06	Wells Fargo & Company	31,368	0.12	Bank of America Corp	81,699	0.14
2022-06	Lincoln National Corporation	19,757	0.08	Wells Fargo & Co	61,804	0.10
2022-06	Jackson Financial Inc.	16,982	0.07	Goldman Sachs Group Inc/The	58,801	0.10

Panel C: Spearman's correlation (rho) between *CRISK* and *SRISK*

year month	rho	year month	rho	year month	rho	year month	rho
2008-03	0.54***	2012-03	0.20***	2016-03	0.18***	2020-03	0.17***
2008-06	0.56***	2012-06	0.28***	2016-06	0.22***	2020-06	0.25***
2008-09	0.52***	2012-09	0.27***	2016-09	0.28***	2020-09	0.19***
2008-12	0.55***	2012-12	0.34***	2016-12	0.28***	2020-12	0.11
2009-03	0.43***	2013-03	0.26***	2017-03	0.23***	2021-03	0.17**
2009-06	0.32***	2013-06	0.29***	2017-06	0.34***	2021-06	0.10
2009-09	0.33***	2013-09	0.26***	2017-09	0.31***	2021-09	0.19***
2009-12	0.28***	2013-12	0.28***	2017-12	0.26***	2021-12	0.14**
2010-03	0.22***	2014-03	0.33***	2018-03	0.27***	2022-03	0.20***
2010-06	0.32***	2014-06	0.27***	2018-06	0.20***	2022-06	0.24***
2010-09	0.40***	2014-09	0.27***	2018-09	0.23***	2022-09	0.32***
2010-12	0.24***	2014-12	0.36***	2018-12	0.14**	2022-12	0.35***
2011-03	0.20***	2015-03	0.32***	2019-03	0.22***	2023-03	0.33***
2011-06	0.26***	2015-06	0.33***	2019-06	0.23***		
2011-09	0.34***	2015-09	0.27***	2019-09	0.18***		
2011-12	0.25***	2015-12	0.18***	2019-12	0.15**		

Notes: Table 4 presents a comparative analysis of *CRISK* and *SRISK*. Panel A reports the descriptive statistics of *CRISK* and *SRISK* for the sample period from March 2008 to March 2023. Both measures are calculated as the maximum of conditional capital shortfall and zero. Panel B reports the top five rankings based on *CRISK* and *SRISK* for the month of June each year between 2008 and 2022. To compute *CRISK* at the end of every quarter (year-month), financial statement data is sourced for the reporting periods ending at least three months prior to the respective year-month. This ensures that the financial statement information is publicly available at the time of computing SRISK, enabling comparison between two measures. Panel C reports the Spearman's correlation (rho) between *CRISK* and *SRISK* at the end of each quarter from March 2008 to March 2023. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

TABLE 5 CRISK and Fed Capital Injections

	Dependent Variable: $log(CI_i)$			
log(1+CRISK)			0.685***	0.657**
			(2.78)	(2.57)
log(1+SRISK)		0.268		0.092
		(1.21)		(0.42)
Bank dummy	7.088***	6.261***	5.837***	5.624***
	(4.43)	(3.70)	(3.70)	(3.41)
log(total assets)	3.212***	2.859***	2.131***	2.054***
	(8.41)	(6.28)	(4.51)	(4.07)
Return volatility	0.363	0.265	0.289	0.258
	(1.23)	(0.88)	(1.02)	(0.88)
Equity fall	0.686	3.045	-6.011	-5.052
	(0.08)	(0.32)	(-0.69)	(-0.56)
Intercept	-40.770***	-36.896***	-31.973***	-31.030***
	(-7.48)	(-6.16)	(-5.87)	(-5.32)
N	194	194	194	194
Pseudo R2	0.186	0.189	0.203	0.204

Notes: Table 5 presents the results of the Tobit regression analysis to examine the relationship between the capital injection received from the Federal Reserve during the financial crisis and *CRISK*. The dependent variable is defined as

$$log(CI_i) = \begin{cases} log(Fed\ capital\ injection_i)\ if\ Fed\ capital\ injection > 0 \\ 0 \qquad\qquad Otherwise \end{cases}$$

Fed capital injection is the maximum level of capital injection received by the firm after March 2008. *CRISK* is computed using the latest balance sheet information available before the end of March 2008, while *SRISK* is obtained for end of March 2008 from V-Lab. *Equity fall* is the change in market value of equity between July 2007 and March 2008, scaled by recent total assets. *Return volatility* is measured as the standard deviation of monthly stock returns from CRSP over the last 24 months preceding the latest fiscal year end before March 2008. *Bank dummy* is equal to 1 for banks and zero for insurance firms. The balance sheet data is sourced from the most recent financial statements filed prior to the end of March 2008. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

TABLE 6 CRISK and Short Interest

Notes: **Panel A** reports the univariate analysis of *CRISK* and *short interest ratio*. *CRISK_ind* is equal to one if the conditional capital shortfall indicated by *CRISK* is positive, and zero otherwise. *SIR* is the *short interest ratio* computed by dividing the monthly short interest by the number of shares outstanding. The *Low CRISK* group consists of observations where *CRISK* scaled by total assets is greater than zero and less than the 90th percentile. The *High CRISK* group consists of observations where *CRISK* scaled by total assets is greater than the 90th percentile. "Difference in mean *SIR"* represents the difference between average *SIR* of each group and the average *SIR* for firms with *CRISK_ind*=0. **Panel B** reports the results of the multivariate regression below for the sample period - March 2008 to March 2023. The dependent variable is *short interest ratio (SIR)*, and the main independent variable is *CRISK_ind*, defined in panel A. *SRISK_ind* is an indicator variable that equals one if the conditional capital shortfall indicated by SRISK is positive, and zero otherwise.

$$Short\ interest\ ratio\ (SIR)_{it} = \alpha_0 + \alpha_1\ CRISK\_ind_{it} + \alpha_2 SRISK\_ind_{it} + \beta' controls_{it} + \varepsilon_{it}$$

Size is defined as the natural logarithm of total assets. *BTM*, or book-to-market ratio, is computed as the book value of equity divided by the market value of equity. *Momentum return* and *current return* represent the cumulative stock return over the last six months and three months ending on the short interest report date, respectively. *Instown perc* represents institutional ownership computed as the total number of shares held by institutions (from Thomson Reuters Institutional Holdings file) divided by the number of shares outstanding. *Profitability* is the ratio of trailing twelve-month net income to average total assets. *Turnover* is the average volume of shares traded in the last one year. **Panel C** reports the results of the multivariate regression in panel B where the dependent variable, *abnormal short interest ratio*, is measured as firm's monthly *short interest ratio (SIR)* minus its average *SIR* over the past 12 months. The main independent variable, *CRISK_first* (*SRISK_first*) is equal to one if *CRISK* (*SRISK*) indicates positive capital shortfall for the first time during the sample period, and zero otherwise. The control variables are defined in panel B. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

Panel A:

	N	Mean CRISK (% of total assets)	Mean SIR (%)	Diff in Mean SIR (%)	t-stat
CRISK_ind=0	11263	0.00	2.96		
CRISK_ind=1	3348	2.79	4.10	1.14	13.20***
Low CRISK	3013	1.82	4.08	1.12	12.64***
High CRISK	335	11.56	4.28	1.31	4.29***

Panel B:

	Dependent Variable = Short Interest Ratio (SIR)							
	Full Sample				*Excluding financial crisis period*			
CRISK_ind	0.011***	0.011***	0.006***	0.006***	0.005***	0.004***	0.004***	0.004***
	(4.02)	(4.02)	(5.81)	(6.29)	(4.21)	(4.43)	(6.25)	(6.41)
SRISK_ind		0.002		0.001		0.001		-0.001
		(1.39)		(0.81)		(0.71)		(-0.95)
Size	-0.006***	-0.006***	-0.005***	-0.005***	-0.004***	-0.004***	-0.004***	-0.004***
	(-10.03)	(-9.83)	(-10.26)	(-9.74)	(-14.97)	(-13.99)	(-14.20)	(-13.67)
BTM	-0.001	-0.002	-0.001	-0.001	-0.002**	-0.002**	-0.002**	-0.002**
	(-1.04)	(-1.17)	(-0.96)	(-1.01)	(-2.30)	(-2.46)	(-2.34)	(-2.31)
Momentum return	-0.015***	-0.015***	-0.013***	-0.013***	-0.008	-0.007	-0.008	-0.008
	(-3.50)	(-3.52)	(-3.82)	(-3.84)	(-1.33)	(-1.32)	(-1.48)	(-1.48)
Current return	-0.000	-0.000	0.003	0.003	0.003	0.003	0.008	0.008
	(-0.06)	(-0.01)	(0.39)	(0.41)	(0.29)	(0.30)	(0.81)	(0.80)
Instown perc	0.017***	0.017***	0.026***	0.026***	0.016***	0.016***	0.022***	0.022***
	(5.34)	(5.28)	(7.78)	(7.69)	(6.98)	(6.78)	(7.87)	(7.73)
Profitability	-0.154***	-0.143***	-0.160***	-0.155***	-0.163***	-0.158***	-0.137***	-0.141***
	(-4.93)	(-4.43)	(-6.44)	(-6.30)	(-5.13)	(-5.09)	(-5.17)	(-5.27)
Turnover	2.653***	2.649***	2.191***	2.192***	2.422***	2.420***	2.111***	2.112***
	(6.38)	(6.39)	(5.68)	(5.69)	(6.70)	(6.71)	(5.54)	(5.52)
Intercept	0.064***	0.064***	0.054***	0.054***	0.052***	0.052***	0.045***	0.045***
	(12.61)	(12.76)	(15.43)	(15.61)	(16.10)	(16.27)	(17.81)	(17.81)
Quarter FE	N	N	Y	Y	N	N	Y	Y
N	13629	13629	13629	13629	11952	11952	11952	11952
Adj. R-sq	0.220	0.221	0.285	0.285	0.166	0.166	0.206	0.206

Panel C:

	Dependent Variable = Abnormal Short Interest Ratio							
	Full Sample				*Excluding financial crisis period*			
CRISK_first	0.013***	0.013***	0.005**	0.004**	0.004**	0.004**	0.004**	0.004**
	(3.70)	(3.72)	(2.44)	(2.36)	(2.08)	(2.09)	(2.23)	(2.21)
SRISK_first		0.001		0.001**		0.001		0.001**
		(0.86)		(2.03)		(1.28)		(2.29)
Size	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.80)	(0.64)	(0.84)	(0.52)	(0.79)	(0.64)	(0.73)	(0.46)
BTM	0.000	0.000	0.001	0.001	-0.000	-0.000	-0.000	-0.000
	(0.41)	(0.31)	(0.75)	(0.60)	(-0.28)	(-0.42)	(-0.08)	(-0.25)
Momentum return	-0.003	-0.002	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002
	(-1.13)	(-1.13)	(-1.30)	(-1.30)	(-1.19)	(-1.16)	(-0.77)	(-0.77)
Current return	-0.002	-0.002	0.001	0.002	0.000	0.000	0.006	0.006
	(-0.61)	(-0.56)	(0.42)	(0.49)	(0.03)	(0.07)	(1.27)	(1.33)
Instown perc	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002
	(1.23)	(1.35)	(1.41)	(1.53)	(1.58)	(1.63)	(1.47)	(1.55)
Profitability	0.052***	0.057***	0.039**	0.050***	0.050***	0.056**	0.048***	0.058***
	(3.36)	(3.53)	(2.27)	(2.88)	(2.69)	(2.64)	(2.74)	(2.87)
Turnover	-0.160	-0.162	-0.175	-0.173	-0.388*	-0.390*	-0.375*	-0.374*
	(-0.85)	(-0.86)	(-1.06)	(-1.05)	(-1.94)	(-1.92)	(-1.92)	(-1.91)
Intercept	-0.004	-0.004	-0.004**	-0.004**	-0.003	-0.003	-0.003	-0.003
	(-1.33)	(-1.34)	(-2.08)	(-2.08)	(-1.29)	(-1.27)	(-1.52)	(-1.49)
Quarter FE	N	N	Y	Y	N	N	Y	Y
N	13629	13629	13629	13629	11952	11952	11952	11952
Adj. R-sq	0.016	0.016	0.086	0.087	0.019	0.019	0.040	0.041

Appendix 1: Asset composition and the respective haircuts applied for insurance firms.

Asset	Asset sub-category	During Crisis		Post Crisis	
		Haircut (%)	Average of	Haircut (%)	Average of
Cash & Cash equivalents		0.00		0.00	
Fixed Maturity Securities (AFS, HTM & Trading)	U.S. Government	1.50	US Agencies: Prime (Short & long term)		Weighted avg of Investment grade (1.73%) & Speculative grade (18.62%) securities over 15 years. Weights are based on proportion of securities rated NAIC 1-2 and rated NAIC 3-6 respectively.
	Other Governments	0.75	G7 Govt bonds: Prime (Short & long term)		
	State & Municipal	1.50	US Agencies: Prime (Short & long term)		
	Mortgage backed & Asset backed securities				
	Agency	10.00	MBS: Prime (AAA rated)		
	Non-Agency	55.00	MBS: Prime (AAA, AA and A rated)		
	Public Utilities	11.00	Investment grade and high yield bonds: Prime		
	Corporate Debt	11.00	Investment grade and high yield bonds: Prime		
	Other Securities	17.22	Investment grade and high yield bonds: Prime, Non-prime & Unrated		
Equity Securities (AFS & Trading)		40.00	40% decline in the stock market	0.00	
Short-Term Investments		11.00	Investment grade and high yield bonds: Prime	7.62	
Other Investments		11.00	Investment grade and high yield bonds: Prime	7.62	Average loss rate for "all rated" securities over 15 years
Other Assets		10.00		7.62	
Policy Loans		0.00		7.62	
Investment in Partnerships		0.00		7.62	
Total Investment in Real Estate		0.00		7.62	
Mortgage Loans		0.00		7.62	
Accrued Investment Income		0.00		7.62	
Reinsurance Assets		0.00		7.62	
Premiums Receivable		0.00		7.62	
VOBA & Acquired Insurance Portfolios		100.00		0.00	
Deferred Policy Acquisition Costs		100.00		0.00	
Separate Account Assets		0.00		0.00	
Intangible Assets (Incl Goodwill)		100.00		0.00	
Fixed Assets		0.00		0.00	

Appendix 2: Asset composition and the respective haircuts applied for banks.

Asset	Asset sub-category	During Crisis		Post Crisis	
		Haircut (%)	Average of	Haircut (%)	
Total Cash & Balances due from Depository institutions		0.00		0.00	
Fed Funds Sold		0.00		0.00	
Reverse Repos		3.75	US Agencies; G7 Govt bonds; MBS (AAA) & Investment grade bonds (AAA and AA): Prime	0.00	
Fixed Maturity Securities (AFS, HTM & Trading)	US Treasury	1.50	US Agencies: Prime (Short & long term)	0.53	Avg loss rate for AAA rated securities over 15 years
	Govt Agencies	0.75	G7 Govt bonds: Prime (Short & long term)	0.53	
	State & Municipal	1.50	US Agencies: Prime (Short & long term)	0.53	
	Mortgage-backed securities			7.62	Average loss rate for "all rated" securities over 15 years
	Agency	10.00	MBS: Prime (AAA rated)		
	Non-Agency	55.00	MBS: Prime (AAA, AA and A rated)		
	Asset backed securities	25.00	ABS: Prime	7.62	
	Structured Finance	100.00	Structured products: Prime, Non-prime and Unrated	7.62	
	Other debt securities	11.00	Investment grade and high yield bonds: Prime	7.62	
	Loans trading securities	11.00	Investment grade and high yield bonds: Prime	7.62	
	Other trading securities	17.22	Investment grade and high yield bonds: Prime, Non-prime & Unrated	7.62	
Equity Securities (AFS & Trading)		40.00	Applied on the entire portfolio	0.00	
Loans & Leases (Incl HFS)		Weighted avg loss rate using different loan types and the corresponding loss rates from Online Appendix S2 applied to the entire portfolio. An additional 5% haircut is applied on the loans required to be sold.		2.00	Reserves required to absorb future losses
Other Assets		10.00		7.62	Avg loss rate for "all rated" securities over 15 years
Total OREO		0.00		7.62	
Invest in unconsolidated subsidiaries		0.00		7.62	
Real Estate JVs		0.00		7.62	
Intangible Assets (Incl Goodwill)		100.00		0.00	
Premises & Fixed Assets		0.00		0.00	

Online Appendix for

"Measuring Systemic Risk: A Financial Statement-Based Approach for Insurance Firms and Banks"

VENKAT PEDDIREDDY, China Europe International Business School[†]

SHIVA RAJGOPAL, Columbia University

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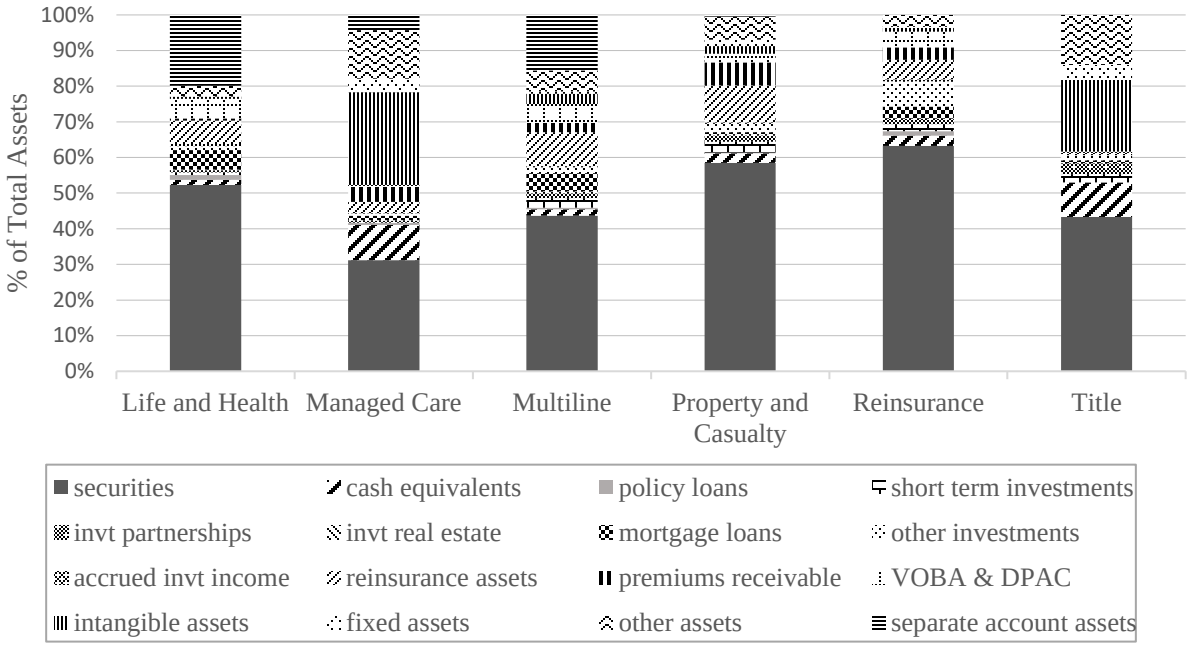
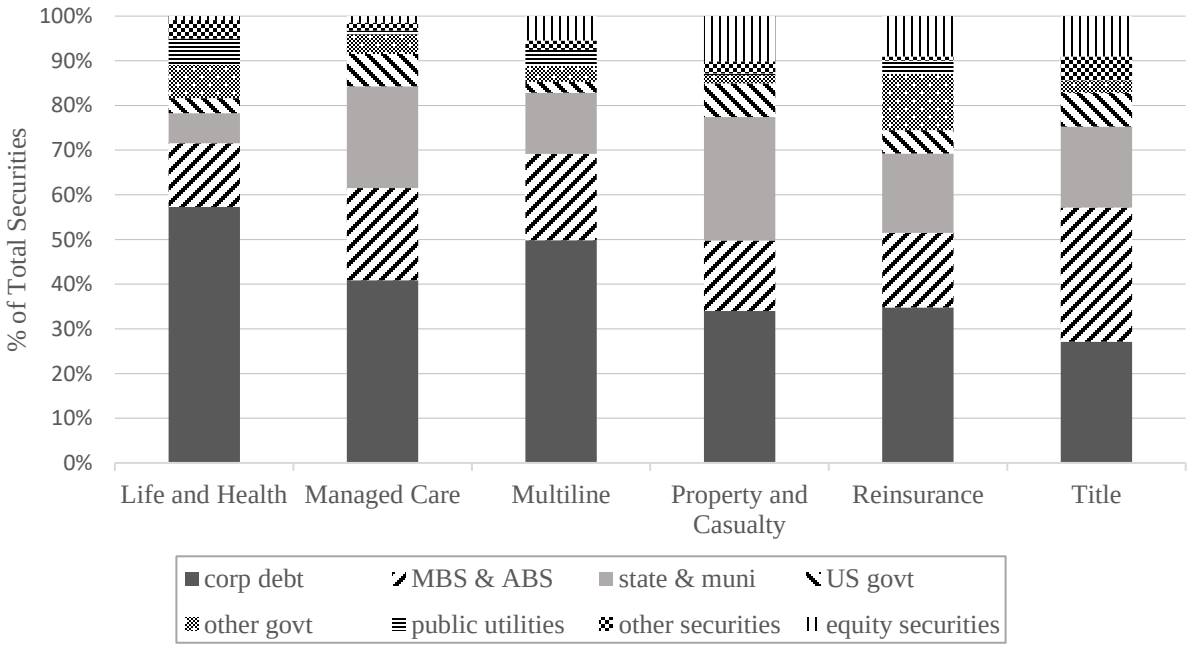
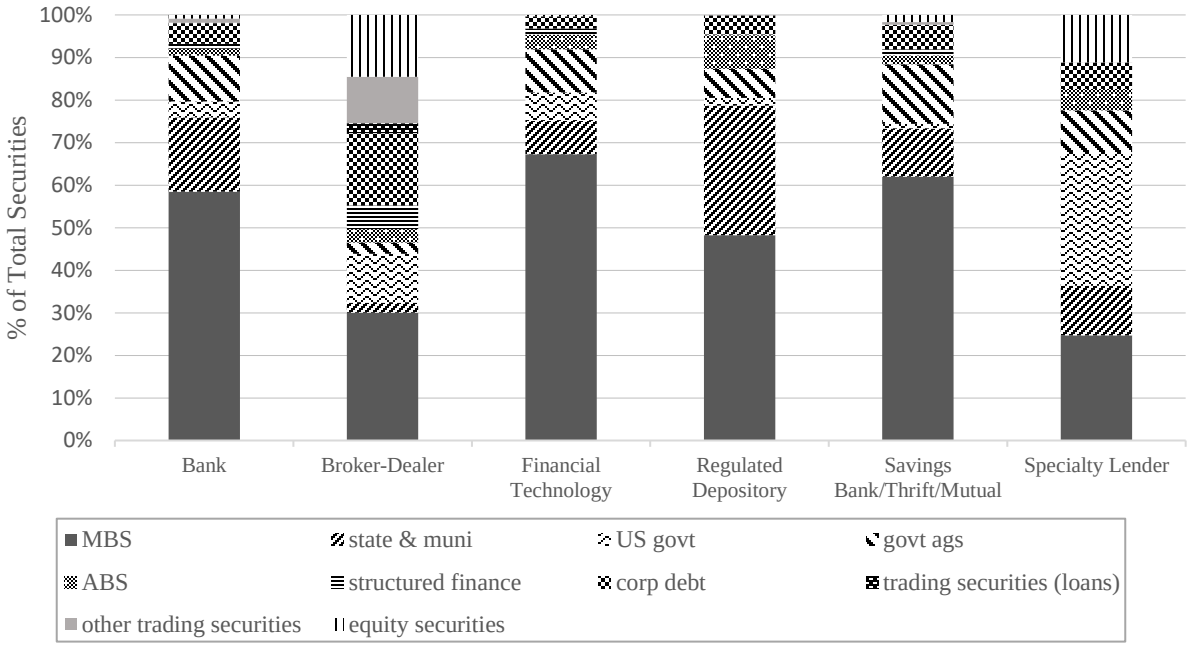
Online Figure S1: Asset accounts for Insurance firms



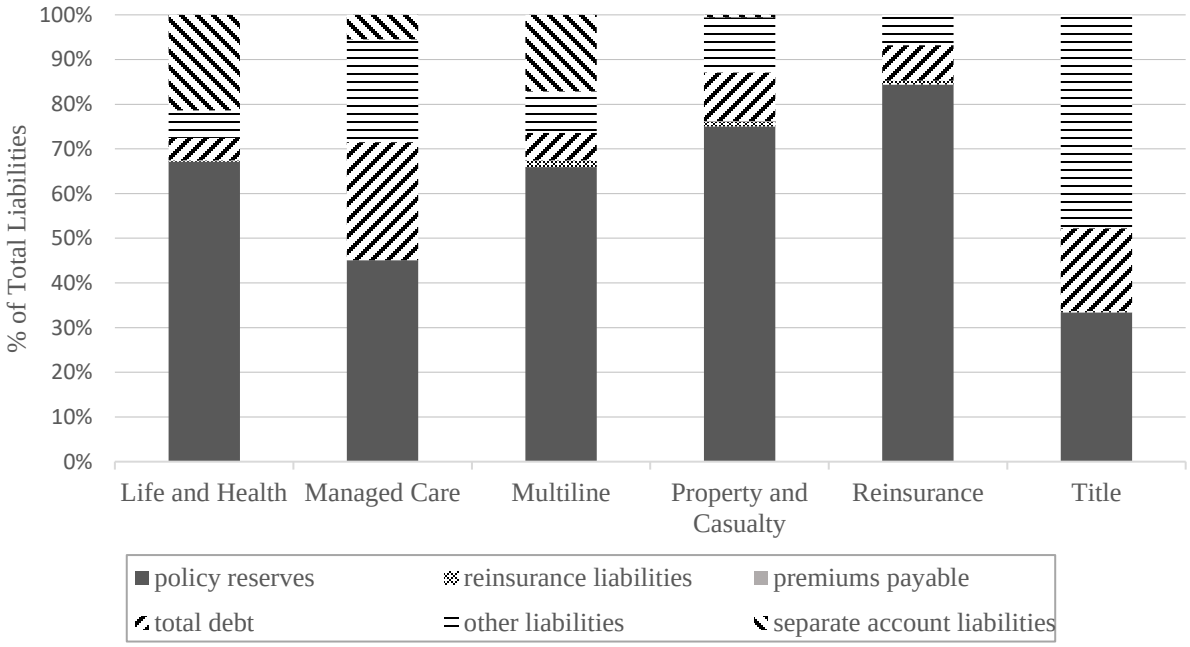
Online Figure S2: Securities portfolio for Insurance firms



Online Figure S3: Securities portfolio for Banks



Online Figure S4: Liability accounts for Insurance firms



Online Appendix S1: Average loss rates during crisis for Fixed Income Securities

This table shows the haircuts or loss rates observed on sales of different types of fixed income securities during the 2007-2009 financial crisis. These haircuts are assumed to be representative of losses that would be incurred upon liquidation of these securities during future systemic events.

Security Type	Average Loss Rates During Crisis (%)		
	Prime	***Non-prime***	***Unrated***
G7 Government bonds			
Short term	0.5	1	2
Long term	1	2	3
US agencies			
Short term	1	2	3
Long term	2	5	7
Prime MBS			
AAA Rated	10	20	65
AA- and A- Rated	100	100	100
ABS	25	50	100
Structured products	100	100	100
Investment grade bonds			
AAA and AA Rated	8	12	15
A and BBB Rated	10	15	20
High yield bonds	15	20	40

Online Appendix S2: Average loss rates during severely adverse scenario for various types of loans

This table shows the average loss rates expected to be realized for various types of loans during a severely adverse scenario. This data is published by the Federal Reserve in their annual stress test reports. These loss rates are the average rates for all the bank holding companies (BHCs) that participated in the stress test each year. We use these loss rates by loan type to compute CRISK in the following year (applied year) of the report date. Panel B of Table 2 lists the different types of loans in the portfolio of a typical bank. We apply First lien mortgage rate to "residential real estate loans"; Junior lien and HELOCs rate to "other revolving credit loans"; CRE rate to "commercial real estate loans"; Other loans rate to "depositories and government loans" and "other loans and leases"; Other consumer loans rate, Credit card loans rate and Commercial & Industrial loans rate to "consumer loans", "credit card loans" and "commercial & industrial loans" respectively.

Applied Year	Report Date	No. of BHCs	Average Loan Loss Rates (%)							
			All Loans	***First Lien Mortgages***	***Junior Lien & HELOCs***	***Commercial & Industrial Loans***	***CRE Loans***	***Credit Card Loans***	***Other Consumer Loans***	***Other Loans***
2013	9/30/2012	18	7.5	6.6	9.6	6.8	8.0	16.7	6.1	1.8
2014	9/30/2013	30	6.9	5.7	9.6	5.4	8.4	15.2	6.0	2.7
2015	9/30/2014	31	6.1	3.6	8.0	5.4	8.6	13.1	5.8	2.9
2016	12/31/2015	33	6.1	3.2	8.1	6.3	7.0	13.4	5.7	3.4
2017	12/31/2016	34	5.8	2.2	4.5	6.4	7.0	13.7	5.9	3.6
2018	12/31/2017	35	6.4	2.7	4.9	7.3	8.3	14.4	5.5	4.0
2019	12/31/2018	18	5.7	1.4	2.6	6.3	6.4	16.8	4.7	3.6
2020	6/30/2020	33	7.7	2.1	3.1	7.5	12.6	22.3	6.4	4.0
2021	12/31/2020	23	6.2	1.5	3.4	7.8	10.5	16.2	4.5	3.8
2022	12/31/2021	33	6.4	1.3	3.9	7.9	9.8	15.6	5.7	4.1

Online Appendix S3: Average post-crisis loss rates for Fixed Income Securities

This table shows the average loss rates realized in the next one to fifteen years for securities of different ratings. This data is obtained from S&P corporate default rates for the period 1981 to 2015. We assume that these loss rates represent the expected losses during normal business conditions. We use these loss rates to compute the post-crisis expected losses on assets and securities that remained on the balance sheet after meeting the callable liabilities. These losses are then charged to the post-crisis book value of equity to compute CRISK.

Rating/ Year	***Average Loss Rates (1981 – 2015) (%)***														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AAA	0.00	0.03	0.14	0.25	0.35	0.47	0.52	0.61	0.67	0.73	0.76	0.79	0.82	0.89	0.96
AA+	0.00	0.06	0.06	0.11	0.17	0.23	0.29	0.35	0.41	0.47	0.54	0.61	0.68	0.75	0.82
AA	0.02	0.04	0.09	0.23	0.38	0.50	0.64	0.75	0.85	0.96	1.05	1.11	1.23	1.30	1.38
AA-	0.03	0.10	0.21	0.30	0.38	0.49	0.57	0.62	0.69	0.75	0.82	0.89	0.92	0.97	1.03
A+	0.06	0.12	0.25	0.40	0.52	0.62	0.75	0.89	1.04	1.21	1.36	1.53	1.73	1.96	2.14
A	0.07	0.18	0.28	0.42	0.57	0.77	0.97	1.16	1.38	1.63	1.84	2.00	2.14	2.22	2.41
A-	0.09	0.22	0.36	0.49	0.68	0.87	1.14	1.34	1.50	1.64	1.78	1.93	2.07	2.21	2.33
BBB+	0.15	0.41	0.70	0.98	1.26	1.59	1.84	2.11	2.41	2.71	3.00	3.20	3.46	3.80	4.19
BBB	0.23	0.56	0.85	1.26	1.67	2.08	2.46	2.83	3.23	3.63	4.07	4.47	4.79	4.92	5.16
BBB-	0.36	1.06	1.83	2.67	3.44	4.13	4.76	5.35	5.84	6.32	6.87	7.32	7.75	8.37	8.84
BB+	0.49	1.38	2.48	3.53	4.51	5.49	6.31	6.91	7.65	8.35	8.83	9.41	9.96	10.41	11.03
BB	0.76	2.25	4.25	6.01	7.68	9.01	10.22	11.20	12.12	12.91	13.69	14.37	14.70	14.93	15.27
BB-	1.22	3.70	6.17	8.50	10.52	12.49	14.14	15.73	17.03	18.17	19.04	19.69	20.39	21.09	21.68
B+	2.51	6.64	10.54	13.76	16.15	18.03	19.74	21.23	22.61	23.87	24.85	25.61	26.34	27.00	27.60
B	5.59	11.77	16.40	19.42	21.61	23.67	25.08	26.08	26.90	27.72	28.42	29.05	29.63	30.19	30.85
B-	8.74	16.36	21.49	25.01	27.82	29.82	31.46	32.51	33.18	33.76	34.56	35.17	35.44	35.75	36.10
CCC/C	27.22	36.41	41.59	44.64	46.99	47.84	48.79	49.59	50.48	51.12	51.61	52.24	53.08	53.74	53.74
Investment grade	0.12	0.32	0.54	0.80	1.06	1.32	1.56	1.79	2.02	2.25	2.47	2.66	2.84	3.02	3.21
Speculative grade	4.29	8.28	11.61	14.19	16.25	17.93	19.36	20.54	21.60	22.55	23.34	24.00	24.60	25.13	25.65
All rated	1.59	3.12	4.44	5.51	6.40	7.16	7.80	8.35	8.85	9.32	9.72	10.05	10.36	10.64	10.92

Online Appendix S4: Estimating CRISK for Prudential Financial, Inc as on December 31st, 2015.

STEP:1 Compute Callable Liabilities

Liabilities (in $ billions)	Book Value
Insurance liabilities	41.6
Other liabilities	11.4
Investment Commitments	3.0
Short-term and Long-term	2.2
Commercial mortgage	1.6
Operating leases	0.1
Total Callable liabilities	**59.9**

Contractual Obligations

The table below summarizes the future estimated cash payments related to certain contractual obligations as of December 31, 2015. The estimated payments reflected in this table are based on management's estimates and assumptions about these obligations. Because these estimates and assumptions are necessarily subjective, the actual cash outflows in future periods will vary, possibly materially, from those reflected in the table. In addition, we do not believe that our cash flow requirements can be adequately assessed based solely upon an analysis of these obligations, as the table below does not contemplate all aspects of our cash inflows, such as the level of cash flow generated by certain of our investments, nor all aspects of our cash outflows.

	Estimated Payments Due by Period				
	Total	2016	2017-2018	2019-2020	2021 and thereafter
	(in millions)				
Short-term and long-term debt obligations(1)	$ 41,678	$ 2,219	$ 4,921	$ 4,549	$ 29,989
Operating and capital lease obligations(2)	665	131	209	127	198
Purchase obligations:					
Commitments to purchase or fund investments(3)	3,879	3,010	443	289	137
Commercial mortgage loan commitments(4)	2,272	1,619	600	30	23
Other liabilities:					
Insurance liabilities(5)	1,121,869	41,598	69,030	71,005	940,236
Other(6)	11,602	11,405	63	53	81
Total	$ 1,181,965	$ 59,982	$ 75,266	$ 76,053	$ 970,664

(1) The estimated payments due by period for long-term debt reflects the contractual maturities of principal, as disclosed in Note 14 to the Consolidated Financial Statements, as well as estimated future interest payments. The payment of principal and estimated future interest for short-term debt are reflected in estimated payments due in 2016. The estimate for future interest payments includes the effect of derivatives that qualify for hedge accounting treatment. See Note 14 to the Consolidated Financial Statements for additional information concerning our short-term and long-term debt.

(2) The estimated payments due by period for operating and capital leases reflect the future minimum lease payments under non-cancelable operating and capital leases, as disclosed in Note 23 to the Consolidated Financial Statements.

(3) As discussed in Note 23 to the Consolidated Financial Statements, we have commitments to purchase or fund investments, some of which are contingent upon events or circumstances not under our control, including those at the discretion of our counterparties. The timing of the fulfillment of certain of these commitments cannot be estimated, therefore the settlement of these obligations are reflected in estimated payments due in less than one year. Commitments to purchase or fund investments include $92 million that we anticipate will ultimately be funded from our separate accounts.

(4) As discussed in Note 23 to the Consolidated Financial Statements, loan commitments of our commercial mortgage operations, which are legally binding commitments to extend credit to a counterparty, have been reflected in the contractual obligations table above principally based on the expiration date of the commitment; however, it is possible these loan commitments could be funded prior to their expiration date. In certain circumstances the counterparty may also extend the date of the expiration in exchange for a fee.

(5) The estimated cash flows due by period for insurance liabilities reflect future estimated cash payments to be made to policyholders and others for future policy benefits, policyholders' account balances, policyholder's dividends, reinsurance payables and separate account liabilities, net of premium receipts and reinsurance recoverables. These future estimated cash flows for current policies in force generally reflect our best estimate economic and actuarial assumptions. These cash flows are undiscounted with respect to interest. The sum of the cash flows shown for all years in the table of $1,122 billion exceeds the corresponding liability amounts of approximately $654 billion included in the Consolidated Financial Statements as of December 31, 2015. Separate account liabilities are legally insulated from general account obligations, and it is generally expected these liabilities will be fully funded by separate account assets and their related cash flows. We have made significant assumptions to determine the future estimated cash flows related to the underlying policies and contracts. Due to the significance of the assumptions used, actual cash flows will differ, possibly materially, from these estimates.

(6) The estimated payments due by period for other liabilities includes securities sold under agreements to repurchase, cash collateral for loaned securities, liabilities for unrecognized tax benefits, bank customer liabilities, and other miscellaneous liabilities. Amounts presented in the table also exclude $8,597 billion of notes issued by consolidated VIE's which recourse for these obligations is limited to the assets of the respective VIE and do not have recourse to the general credit of the company.

We also enter into agreements to purchase goods and services in the normal course of business; however, these purchase obligations are not material to our consolidated results of operations or financial position as of December 31, 2015.

Figure: Contractual obligations disclosure of Prudential Financial, Inc.

STEP:2 Identifying assets to liquidate, and computing during and post crisis losses.

Asset (in $ billions)	Asset sub-category	Book Value	Assets Sold	Crisis Haircuts on Assets Sold	Liquidation Value of Assets Sold	Crisis Haircuts on Remaining Assets	Book Value before Post-Crisis losses	Post-Crisis losses	Book Value after Post-Crisis losses
Cash & Cash equivalents		17.6	17.6	0.0	17.6		0.0	0.00	0.0
Fixed Maturity Securities (AFS, HTM & Trading)		**321.9**	**42.8**	**0.5**	**42.3**	**0.0**	**279.1**	**7.6**	**271.5**
	U.S. Government	18.9	18.9	0.3	18.6		0.0		
	Other Governments	85.2	23.9	0.2	23.7		61.3		
	State & Municipal	8.8	0.0	0.0	0.0		8.8		
	MBS & ABS securities	31.2	0.0	0.0	0.0		31.2		
	Public Utilities	22.2	0.0	0.0	0.0		22.2		
	Corporate Debt	144.9	0.0	0.0	0.0		144.9		
	Other Securities	10.8	0.0	0.0	0.0		10.8		
Equity Securities (AFS & Trading)		11.6	0.0	0.0	0.0	4.7	7.0	0.00	7.0
Short- Term Investments		8.9	0.0	0.0	0.0		8.9	0.68	8.2
Other Investments		4.6	0.0	0.0	0.0		4.6	0.35	4.2
Other Assets		8.2	0.0	0.0	0.0		8.2	0.63	7.6
Policy Loans		11.7					11.7	0.89	10.8
Investment in Partnerships		7.5					7.5	0.57	7.0
Total Investment in Real Estate		1.5					1.5	0.11	1.3
Mortgage Loans		49.6					49.6	3.78	45.8
Accrued Investment Income		3.1					3.1	0.24	2.9
Reinsurance Assets		3.7					3.7	0.28	3.4
Premiums Receivable		0.0					0.0	0.00	0.0
VOBA & Acquired Insurance Portfolios		2.8				2.8	0.0	0.00	0.0
Deferred Policy Acquisition Costs		17.9				17.9	0.0	0.00	0.0
Separate Account Assets		285.6					285.6	0.00	285.6
Intangible Assets (Incl Goodwill)		1.1				1.1	0.0	0.00	0.0
Fixed Assets		0.0					0.0	0.00	0.0
Total Assets		**757.3**	**60.4**	**0.5**	**59.9**	**26.5**	**670.3**	**15.1**	**655.2**

STEP:3 Compute CRISK

Adjustments	Value (in $ billions)
Book Equity	41.9
less During crisis losses on assets sold	0.5
less During crisis write-offs on intangible assets	26.5
less Post crisis losses on remaining assets	15.1
less AOCI	12.3
CRISK (Shortfall)	**(12.5)**

Description:

The contractual obligations disclosure from 2015 10-K of Prudential Financial, Inc. reveals that $59.98 billion is the total amount of on- and off-balance-sheet obligations due one year out. We assume that all of these contractual obligations will be callable in the case of a systemic event. STEP 1 provides a break-up of these liabilities. The largest obligation is the $41.6 billion obligation due in 2016 related to insurance liabilities. As the note indicates, this obligation includes liabilities due under future policy benefits, policyholder account balances, policyholder dividends, reinsurance payables and separate account liabilities.

The second largest obligation due in 2016 is the $11.4 billion obligation related to "other liabilities." This obligation includes securities sold under agreements to repurchase, cash collateral for loaned securities, and other miscellaneous liabilities. The remaining items in this disclosure include a $2.22 billion obligation related to current portion of long-term debt and short-term debt; investment commitments of $3.01 billion; operating and capital lease obligations of $131 million and commercial mortgage loan commitments $1.62 billion.

In the next step, we identify assets that can be potentially liquidated to meet these contractual obligations. STEP 2 shows the list of assets used and the respective haircuts applied. To meet callable liabilities of $59.98 billion, Prudential will need to liquidate $60.4 billion worth of its most liquid and high-quality assets. These assets include $17.6 billion in cash and cash

equivalents, $18.9 billion in US government and agency securities and $23.9 billion in other government securities. The potential loss that would result from this liquidation is $0.5 billion, comprising of $0.3 billion haircut on US government and agency securities and $0.2 billion haircut on other government securities. Prudential would also have to write down certain securities/assets due to the systemic event. These write-offs include $4.7 billion for equity securities (40% haircut) and a complete write-off of VOBA, deferred policy acquisition costs, goodwill and intangible assets adding up to $21.8 billion. Therefore, the total expected loss to be incurred during the crisis is $27.0 billion ($0.5 billion + $4.7 billion + $21.8 billion), which will be charged to the book value of equity.

After the liquidation of assets and the potential write-offs, prudential would be left with a book value of equity of $14.9 billion ($41.9 billion -$27.0 billion), which is further reduced by accumulated other comprehensive income (AOCI) of $12.3 billion. Therefore, Prudential would likely emerge from the crisis with an expected capital of $ 2.6 billion ($14.9 billion -$12.3 billion).

To measure CRISK for Prudential at the end of 2015, we need to compare Prudential's expected post-crisis book value of equity with the expected post-crisis losses on its remaining assets. STEP 2 shows the post-crisis default rates applied to the remaining assets. The total expected post-crisis loss on all the remaining assets is $15.1 billion. This includes the expected post-crisis loss of $7.6 billion on the remaining fixed maturity securities computed using the NAIC rating distribution of these securities. Therefore, CRISK for Prudential at the end of 2015 (STEP 3), computed as the expected post-crisis losses minus expected post-crisis book equity, is $12.5 billion ($15.1 billion - $2.6 billion). This indicates that if a systemic event were to occur at the end of 2015, Prudential would have a capital shortfall of $12.5 billion.

Online Appendix S5: Estimating CRISK for JPMorgan Chase & Co.as on December 31st, 2015.

STEP:1 Compute Callable Liabilities

Liabilities (in $ billions)	Book Value
Total on-balance sheet obligations	1507.2
Total off-balance sheet obligations	54.7
Less estimated FDIC insured deposits	-352.9
Total Callable liabilities	**1208.8**

Contractual cash obligations

By remaining maturity at December 31, (in millions)	2015					2014
	2016	2017-2018	2019-2020	After 2020	Total	Total
On-balance sheet obligations						
Deposits[a]	$ 1,262,865	$ 5,166	$ 3,553	$ 4,555	$ 1,276,139	$ 1,361,597
Federal funds purchased and securities loaned or sold under repurchase agreements	151,433	811	3	491	152,738	192,128
Commercial paper	15,562	–	–	–	15,562	66,344
Other borrowed funds[a]	11,331	–	–	–	11,331	15,734
Beneficial interests issued by consolidated VIEs	16,389	18,480	3,093	3,130	41,092	50,200
Long-term debt[a]	45,972	82,293	59,669	92,272	280,206	262,888
Other[b]	3,659	1,201	1,024	2,488	8,372	8,355
Total on-balance sheet obligations	1,507,211	107,951	67,342	102,936	1,785,440	1,957,246
Off-balance sheet obligations						
Unsettled reverse repurchase and securities borrowing agreements[c]	42,482	–	–	–	42,482	40,993
Contractual interest payments[d]	8,787	9,461	6,693	21,208	46,149	48,038
Operating leases[e]	1,668	3,094	2,388	4,679	11,829	12,441
Equity investment commitments[f]	387	–	75	459	921	1,108
Contractual purchases and capital expenditures	1,266	886	276	170	2,598	2,832
Obligations under affinity and co-brand programs	98	275	80	43	496	2,303
Total off-balance sheet obligations	54,688	13,716	9,512	26,559	104,475	107,715
Total contractual cash obligations	$ 1,561,899	$ 121,667	$ 76,854	$ 129,495	$ 1,889,915	$ 2,064,961

(a) Excludes structured notes on which the Firm is not obligated to return a stated amount of principal at the maturity of the notes, but is obligated to return an amount based on the performance of the structured notes.
(b) Primarily includes dividends declared on preferred and common stock, deferred annuity contracts, pension and postretirement obligations and insurance liabilities.
(c) For further information, refer to unsettled reverse repurchase and securities borrowing agreements in Note 29.
(d) Includes accrued interest and future contractual interest obligations. Excludes interest related to structured notes for which the Firm's payment obligation is based on the performance of certain benchmarks.
(e) Includes noncancelable operating leases for premises and equipment used primarily for banking purposes and for energy-related tolling service agreements. Excludes the benefit of noncancelable sublease rentals of $1.9 billion and $2.2 billion at December 31, 2015 and 2014, respectively.
(f) At December 31, 2015 and 2014, included unfunded commitments of $50 million and $147 million, respectively, to third-party private equity funds, and $871 million and $961 million of unfunded commitments, respectively, to other equity investments.

Figure: Contractual obligations disclosure of JPMorgan Chase & Co.

STEP:2 Identifying assets to liquidate, and computing during and post crisis losses.

Asset (in $ billions)	Asset sub-category	Book Value	Assets Sold	Crisis Haircuts on Assets Sold	Liquidation Value of Assets Sold	Crisis Haircuts on Remaining Assets	Book Value before Post-Crisis losses	Post-Crisis losses	Book Value after Post-Crisis losses
Total Cash & Balances due from Depository institutions		363.1	363.1	0.0	363.1		0.0	0.00	0.0
Fed Funds Sold		0.7	0.7	0.0	0.7		0.0	0.00	0.0
Reverse Repos		310.6	310.6	11.6	299.0		0.0	0.00	0.0
Fixed Maturity Securities (AFS, HTM & Trading)		**537.0**	**537.0**	**102.2**	**434.8**	**0.0**	**0.0**	**0.0**	**0.0**
	US Treasury	29.4	29.4	0.4	28.9		0.0	0.00	0.0
	Govt Agencies	0.7	0.7	0.0	0.7		0.0	0.00	0.0
	State & Municipal	54.0	54.0	0.8	53.2		0.0	0.00	0.0
	MBS Securities	166.6	166.6	35.8	130.8		0.0	0.00	0.0
	ABS Securities	9.1	9.1	2.3	6.8		0.0	0.00	0.0
	Structured Finance	31.0	31.0	31.0	0.0		0.0	0.00	0.0
	Other debt securities	141.3	141.3	15.5	125.8		0.0	0.00	0.0
	Loans trading securities	28.8	28.8	3.2	25.6		0.0	0.00	0.0
	Other trading securities	76.1	76.1	13.1	63.0		0.0	0.00	0.0
Equity Securities (AFS & Trading)		97.1	97.1	38.8	58.2	0.0	0.0	0.00	0.0
Net Loans & Leases (Incl HFS)		837.2							
	Semi Liquid Loans (gross)	525.9	59.6	6.6	53.0	28.4	437.9	8.76	429.2
	Illiquid Loans (gross)	324.8	0.0	0.0	0.0	14.7	310.1	6.20	303.9
Other Assets		122.8	0.0	0.0	0.0		122.8	9.36	113.5
Total OREO		0.7					0.7	0.05	0.6
Invest in unconsolidated subsidiaries		6.9					6.9	0.52	6.4
Real Estate JVs		8.5					8.5	0.65	7.9
Intangible Assets (Incl Goodwill)		54.9				54.9	0.0	0.00	0.0
Premises & Fixed Assets		12.2					12.2	0.00	12.2
Total Assets		**2351.7**	**1368.1**	**159.3**	**1208.8**	**98.0**	**899.1**	**25.5**	**873.6**

STEP:3 Compute CRISK

Adjustments	Value (in $ billions)
Book Equity	247.6
Add Loan Reserves	13.6
less During crisis losses on assets sold	159.3
less During crisis write-offs on intangible assets and loans	98.0
less Post crisis losses on remaining assets	25.5
less AOCI	0.2
CRISK (Shortfall)	**(21.9)**

Description:

The contractual obligations disclosure from 2015 10-K of JPMorgan Chase & Co. (JPM) reveals that JPM owes $1.56 trillion in the near term due to on-balance-sheet obligations of $1.51 trillion and off-balance-sheet obligations of $54.7 billion. STEP 1 provides a break-up of these liabilities. The largest contractual obligation is deposits, which amount to $1.26 trillion. To measure callable liabilities, we subtract the amount of FDIC insured deposits from the total contractual liabilities, assuming that insured deposits are less likely to be called during a systemic event. For the year ending 2015, JPM reported total deposits of $1.28 trillion, with 27.6% of these deposits insured by the FDIC. We use this ratio to estimate the amount of insured deposits included in the contractual obligations. Therefore, the total amount of callable liabilities is $1.208 trillion ($1.56 trillion - $352.9 billion (27.6% of $1.28 trillion)).

Next, we identify assets that can be liquidated to meet these contractual obligations. STEP 2 shows the breakdown of assets to be sold and the respective haircuts applied. To meet callable liabilities of $1.208 trillion, JPM will need to liquidate $1.37 trillion worth of its most liquid and high-quality assets. These assets include $363 billion in cash and cash equivalents, $0.7 billion in federal funds sold, $311 billion in reverse repos, $537 billion in fixed maturity securities, $97 billion in equity securities, and $60 billion in loans. The potential loss that would result from this

liquidation is $159 billion, comprising of $11.6 billion haircut on reverse repos[24], $102 billion haircut on fixed maturity securities, $39 billion haircut on equity securities, and $6.6 billion haircut on loans.[25] JPM would also need to write down certain assets due to the systemic event. These write-offs include $55 billion of goodwill and intangible assets, as well as $43 billion resulting from the expected defaults on the entire loan portfolio due to the systemic event. The average default rate for the loan portfolio is computed as the weighted average loss rate using different loan types and the corresponding loss rates from Online Appendix S2. Therefore, the total expected loss to be incurred during the crisis is $257 billion ($159 billion + $55 billion + $43 billion), which will be charged to the book value of equity.

After the liquidation of assets and the potential write-offs, JPM would be left with a book value of equity of -$9.7 billion ($247.6 billion - $257.3 billion), which is further reduced by accumulated other comprehensive income (AOCI) of $0.2 billion. After including the loan loss reserves, JPM would likely emerge from the crisis with an expected capital of $3.7 billion (-$9.7-$0.2 + $13.6 billion).

To measure CRISK for JPM at the end of 2015, we need to compare JPM's expected post-crisis book value of equity with the expected post-crisis losses on its remaining assets. STEP 2 shows the list of post-crisis default rates applied to the remaining assets. The total expected post-crisis loss on the remaining assets is $25.5 billion. This includes the expected post-crisis loss of $15 billion on the loan portfolio computed as 2% of the remaining loans on the balance sheet.

[24] We do not have information on repos and reverse repos regarding the underlying pledged securities. However, they are very short term in nature and are mainly backed by high quality liquid securities. Hence this asset is liquidated next with a haircut of 3.75%, which is the average crisis haircut for US & G7 Govt bonds, mortgage-backed securities (AAA) and Investment grade bonds (AAA and AA).

[25] The haircuts expected to be realized on the sale of loans is the weighted average loss rate using different loan types and the corresponding loss rates from Online Appendix S2 plus an additional 5% to account for illiquidity discount.

Therefore, CRISK for JPM for the year ending 2015 (STEP 3), computed as the expected post-crisis losses minus expected post-crisis book equity, is -$22 billion ($3.7 billion - $25.5 billion). This indicates that if a systemic event were to occur at the end of 2015, JPM would have a capital shortfall of $22 billion.