WORKING PAPER NO. 17-05
MARKET DISCIPLINE IN THE SECONDARY BOND MARKET: THE CASE OF SYSTEMICALLY IMPORTANT BANKS

Elyas Elyasiani
Temple University

Jason M. Keegan
Supervision, Regulation, and Credit
Federal Reserve Bank of Philadelphia

March 10, 2017

RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA
Ten Independence Mall, Philadelphia, PA 19106-1574 • www.philadelphiafed.org/research-and-data/

Market Discipline in the Secondary Bond Market: The Case of Systemically Important Banks*

Elyas Elyasiani
Fox School of Business
Temple University
elyas@temple.edu

Jason M. Keegan
Supervision, Regulation, and Credit
Federal Reserve Bank of Philadelphia
jason.keegan@phil.frb.org

This Version:
March 10, 2017

JEL Classification: G01, G2, G21, G28

Keywords: Bank Risk, Financial Crisis, U.S. Bank Holding Companies, Risk Management, Market Discipline

*The views expressed here are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of Philadelphia, the Board of Governors of the Federal Reserve System, or the Federal Reserve System. This paper is available free of charge at www.philadelphiafed.org/research-and-data/publications/working-papers.

Abstract

We investigate the association between the yields on debt issued by U.S. systemically important banks (SIBs) and their idiosyncratic risk factors, macroeconomic factors, and bond features, in the secondary market. Although greater SIB risk levels are expected to increase debt yields (Evanoff and Wall, 2000), prevalence of government safety nets complicates the market discipline mechanism, rendering the issue an empirical exercise. Our main objectives are twofold. First, we study how bond buyers reacted to elevation of SIB-specific and macroeconomic risk factors over the recent business cycle. Second, we investigate the degree to which the proportion of variance in yields explained by SIB and macroeconomic risk factors changed across the phases of the cycle. Our data include over 8 million bond trades across 26 SIBs. We divide our sample period into the pre-crisis (2003:Q1 to 2007:Q3), crisis (2007:Q4 to 2009:Q2), and post-crisis (2009:Q3 to 2014:Q3) sub-periods to contrast the findings. We obtain several results. First, bond buyers do react to changes in the SIB-specific risk factors (leverage, credit risk, inefficiency, lack of profitability, illiquidity, and interest rate risk) by demanding higher yields. Second, bond buyers' responses to risk factors are sensitive to the phase of the business cycle. Third, the proportion of variance in yields driven by SIB-specific and bond-specific risk factors increased from 23 percent in the pre-crisis period to 47 percent and 73 percent, respectively, during the crisis and post-crisis periods. These findings indicate that the force of market discipline improved greatly during the crisis and post-crisis periods, at the expense of macroeconomic factors. The strengthening of market discipline in the crisis and post-crisis periods, despite the unprecedented regulatory intervention in the form of quantitative easing programs, the Troubled Asset Relief Program, large bail outs, and generally accommodative fiscal and monetary policies adopted during these periods, demonstrates that regulatory intervention and market discipline can work in tandem.

1. Introduction

We investigate how the yield spreads[1] on the debt issued by U.S. systemically important banks (SIBs) in the secondary market are associated with their idiosyncratic risk, macroeconomic risk factors, and bond-specific features across the pre-crisis (2003:Q1 to 2007:Q3), crisis (2007:Q4 to 2009:Q2), and post-crisis (2009:Q3 to 2014:Q3) phases of the recent business cycle.[2] We focus on the SIB population because, if mandatory debt issuance were to become a part of the regulatory framework, it would likely impact this group of bank holding companies (BHCs) to the greatest extent.[3] The SIB designation is an indication that the failure of these institutions could have serious adverse effects on the global financial markets and, thus, could elevate systemic risk.

Appendix A provides a list of the current SIBs, broken out by global (G-SIBs) and domestic (D-SIBs) designations. G-SIB is an official designation of the Financial Stability Board (FSB) and the Basel Committee on Banking Supervision (BCBS) based on a framework that accounts for the contribution to systemic risk. The methodology equally weights each of the five categories of systemic importance: [1] size, [2] cross-jurisdictional activity, [3] interconnectedness, [4] substitutability/financial institution infrastructure, and [5] complexity.[4] D-SIB is not an official designation of the FSB or BCBS, yet it is implicitly assumed that these

[1] The yield spread is the difference between the yield to maturity on a bond and the rate on a U.S. Treasury security with an identical maturity and similar other features.

[2] According to the National Bureau of Economic Research (NBER), the 2001 recession reached its trough in November 2001, and the business cycle reference dates indicate that the peak and trough of the most recent business cycle are December 2007 and June 2009, respectively. The NBER list of U.S. business cycle expansions and contractions can be found at www.nber.org/cycles.html.

[3] Mandatory debt issuance was recommended, for example, by the joint report submitted to Congress by the Board of Governors of the Federal Reserve System and the Secretary of the Treasury (Board of Governors of the Federal Reserve System and United States Department of the Treasury, 2000) and by Lang and Robertson (2002).

[4] See the updated assessment methodology and the higher loss absorbency requirements at www.bis.org/publ/bcbs255.pdf.

other large U.S.-based BHCs that participate in the Dodd–Frank Act Stress Test (DFAST) and Comprehensive Capital Analysis and Review (CCAR) are systemically important within the U.S., if not globally. Thus, we include these institutions in our analysis.

The crux of this paper, from a policy perspective, is to examine the level as well as the change in the explained variation of the SIB debt yields attributed to SIB risk factors versus that driven by the macroeconomic factors across the phases of the business cycle. The fundamental question we seek to answer is: Do bond investors respond to SIB-specific risk factors, and, if so, to what extent are these factors responsible for bond yield movements compared with macroeconomic factors? The relative power of SIB-specific and macroeconomic risk factors is important because, even if bond buyers do show sensitivity to firm risk characteristics, when the market-wide factors largely dominate the yield-spread behavior the role of market discipline will be diminished. By examining the proportions of explained variance in yield spreads attributed to macroeconomic and idiosyncratic risk factors, we also shed light on the extent of complementarity versus substitutability of regulation and market discipline. Our findings help policymakers and regulators in understanding bond investor behavior in response to increased SIB-specific and macroeconomic risks in an environment similar to that of the recent business cycle.

The question of whether, and to what extent, bond investors respond to SIB-specific risks is an important empirical issue because, if it is shown that bond traders do respond to bank risk levels, then yield spreads of bank debt could help the regulators, bank managers, and investors in the bond market understand how markets react to changes in risk and help them with their decisions. From a policy perspective, regulators could use yield spreads on bank debt as early warning signs and could set thresholds for yield spreads as a trigger for regulatory action.

Investors and bank managers could also use the information in their choice of a portfolio composition and the timing of, and yield offering on, debt issuance. The bank-specific risk measures used here are CAMELS proxies, described in more detail in Section 3. CAMELS ratings, designed and monitored by the Federal Reserve and other bank regulators, characterize **C**apital adequacy, **A**sset quality, **M**anagement, **E**arnings, **L**iquidity, and **S**ensitivity to interest rate risk. This rating system provides a holistic assessment of a bank's financial conditions and level of risk. It is used by regulators to form a composite rating indicating the overall performance and risk management practices of a financial institution.[5]

We obtain data on all SIB trades from 2003:Q1 through 2014:Q3. We begin the analysis in 2003 because our interest lies in the most recent business cycle. In this way, we also avoid the impact of the 2001 recession, such as the market disturbances and systemic shocks associated with the 9/11 terrorist attacks as well as the changes in accounting rules associated with the Sarbanes–Oxley Act of 2002. We segment the data into subordinated notes and debentures (SND) and senior bonds (non-SND). It is necessary to separate the two bond types because of their differential repayment status in the case of BHC failure. Table 1 reports the number of trades in the sample by bond type.[6]

We focus on the secondary bond market because the high volume of transactions in this market (liquidity) provides wide variations in yields and allows us to determine whether secondary market participants behaved "rationally" during the sample period, in response to

[5] DeYoung et al. (2001) establish the link between CAMELS ratings and market prices of subordinated notes and debentures. Since CAMELS ratings are private information produced by bank examiners, one would expect that bond traders would proxy for CAMELS ratings using publicly available information.

[6] We exclude junior (and junior subordinated) debt as well as senior secured debt due to low levels of liquidity compared with the other categories (together, the categories comprise less than 0.01 percent of all secondary market trades over the period of study).

change in SIB-specific and macroeconomic risk factors. The choice of the 2003:Q1 through 2014:Q3 sample period allows us to determine the proportion of explained variance in yield spreads that can be attributed to macroeconomic factors versus the proportion driven by SIB-specific and bond-specific features and to investigate how this proportion changed over the pre-crisis, crisis, and post-crisis periods. This variance decomposition is of special interest to regulators because the greater the force of the SIB-specific factors and market discipline, which is beyond the regulators' control, the less powerful they will be in influencing bond yields. Moreover, if yield spreads are used as early warning indicators of SIB risk, the thresholds that trigger regulatory action will need to be tailored to the phase of the business cycle.

[Insert Table 1 Here]

We obtain several results. First, we find strong evidence of market discipline with respect to SIB-specific risks in the secondary bond market. This finding is important because of its policy implications on mandatory SND issuance by banks. Second, we find that the strength of market discipline varied considerably across the phases of the business cycle. Specifically, market discipline in the form of sensitivity of debt yields to bond-specific and SIB-specific risk was at a relatively low scale during the pre-crisis period compared with the crisis and post-crisis periods. This finding indicates a greater level of risk sensitivity and a lower degree of risk tolerance (greater risk aversion) on the part of bond investors during the latter two phases of the cycle.[7] In other words, in the latter two periods, bond investors made a more accurate assessment of risks in the U.S. financial markets and/or they demanded a greater risk premium per unit of additional risk due to their elevated risk aversion, at least for some risk measures.

[7] Alternatively, this result could indicate that bondholders had a false sense of security during the pre-crisis period (mismeasurement error) rather than failing to react to risk.

Third, in terms of the magnitude of the effects (economic significance), the impact on yield spreads due to a one standard deviation increase in leverage, credit risk, profitability, and liquidity measures is the largest during the crisis period, reflecting greater risk premiums per unit of risk. This is likely due to investors' better risk assessment and/or greater risk aversion owing to fear and pessimism. Fourth, macroeconomic factors drive a smaller proportion of the explained yield variance during the crisis and post-crisis periods compared with the pre-crisis period. In fact, the percentage of variance in yield spreads explained by SIB-specific and bond-specific factors climbs from 23 percent in the pre-crisis period to 47 percent and 73 percent, respectively, across the crisis and post-crisis periods. This implies a considerable strengthening of market discipline with respect to idiosyncratic factors vis-à-vis macroeconomic factors, in particular in the post-crisis period.

Our finding that bond-specific and SIB-specific attributes are major drivers of yield spreads provides support for the proposal of mandatory issuance of bank debt and the use of yield spreads as early warning indicators in regulatory policies that leverage market discipline. This policy has received interest both in academic (Evanoff et al., 2007; Nguyen, 2013) and regulatory circles (Lang and Robertson, 2002). With our results, policymakers will be able to identify the risk factors to which bond investors are likely to respond and the extent of their sensitivity. They can then leverage this effect when formulating policies, procedures, and guidelines for bank regulation.

The rest of the paper proceeds as follows. In Section 2, we review the literature. In Section 3, we describe the econometric model and introduce the variables in the model. In Sections 4 and 5, we outline the hypotheses, describe the data sources, and discuss descriptive statistics. In Sections 6 and 7, we review the methodology and report results. Section 8

concludes.

2. Literature Review

The role of market participants in curbing risk-taking by firms is broadly referred to as market discipline. As Flannery (2001) explains, market discipline requires two "distinct components:" [1] market monitoring, which suggests that market participants obtain transparent and accurate data on the health of the monitored institution; and [2] market activism and influence, which suggests that, once investors become privy to a firm's financial health, they do act on the information, and, in turn, their actions do exert a significant impact on the behavior (i.e., risk-taking) of the monitored institutions. The U.S. banking industry provides an attractive setting for testing the impact of market discipline due to the extensive and standardized reporting requirements on this industry set forth by the Federal Financial Institutions Examination Council (FFIEC). Bank regulators, investors, researchers, and various other stakeholders can use the information available through these regulatory required reports to learn about the banks and react accordingly. Bond investors tend to use the financial statement information supplied by the banks, in conjunction with macroeconomic and bond-specific information, to determine the overall level of risk embodied in the bond; the riskier a bond is, the larger the risk premium demanded by bondholders is expected to be for a given level of risk aversion. Assuming transparency, reactions of market participants would serve to limit the riskiness of BHCs. However, government assurances such as "too big to fail" (TBTF) policy, bail outs, emergency lending facilities (e.g., the discount window, Term Auction Facility, Primary Dealer Credit Facility, Term Securities Lending Facility, Troubled Asset Relief Program (TARP)), and other explicit and implicit safety nets can weaken, if not eliminate, the impact of market discipline since market participants will be less vigilant when their investment is guaranteed, regardless of

bank solvency status (Flannery, 1998).

The stakeholders in market discipline include shareholders (in particular institutions), bondholders, depositors, counterparties in derivative positions, and bank auditors, among others. In this study, we focus on bank debtholders as enforcers of market discipline. Bank debtholders have been the focus of several prior studies.[8] For example, Flannery and Sorescu (1996) use data on SND spreads for BHCs from 1983 to 1991 and breakout the SND data into three separate sub-samples with different degrees of government protection. They find that the banks' accounting ratios have little to no effect on SND spreads during the earliest two sub-periods: [1] 1983 to 1985, when the "TBTF doctrine was most credible;" and [2] 1986 to 1988, when the regulators began to reduce implicit protection of SND holders. However, they find a change in investor behavior during the 1989 to 1991 sub-period, when conjectural government guarantees were no longer present and SND holders at failed financial institutions were realizing losses. Specifically, these authors find that bond investors do account for bank risk increases in the form of lower asset quality and greater leverage by demanding higher yield spreads during this last sub-period.

Morgan and Stiroh (1999) examine nearly 600 fixed-rate bond issuances by banks and BHCs from 1993 to 1998. They include bond ratings, time effects (to control for macroeconomic factors), and a litany of BHC-specific factors including asset and liability characteristics as explanatory variables in their model. They obtain several results. First, the banking industry prices debt similarly to non-bank industries in the sense that the impact of credit ratings on bond

[8] There have also been studies that empirically estimate the risk–spread relationship for non-U.S. banks, including Canadian (Caldwell, 2007), Japanese (Imai, 2007), Swiss (Birchler and Facchinetti, 2007), and European (Bruni and Paterno, 1995; Sironi, 2003) banks. Zhang et al. (2014) provide a good overview of the international evidence and perform a study of yield spreads of 631 sub-debt issuances in the UK's primary market between 1997 and 2009. These authors find that the yield spreads on this sub-debt do vary with the ratings assigned by traditional rating agencies. Despite this relationship, they find that some accounting measures, such as bank leverage, net loans to total assets, and liquidity ratio, among others, do not hold significant explanatory power for yield spreads.

spreads are virtually identical between the two industries, despite major dissimilarities in terms of regulation, leverage, and the uniqueness of bank assets and liabilities. Second, market participants do account for bank-specific risk factors when pricing debt. Third, larger banks experience market discipline to a lesser degree than smaller banks. The rationales offered for this finding is that large banks considered to be TBTF benefit from implicit deposit insurance, which counterbalances some of their risk, and/or market participants fail to properly gauge bank risk due to opacity of bond issuances.

Jagtiani et al. (1999) study the relationship between the risk levels and the return of bonds issued by some of the largest U.S. commercial banks. Their sample period runs from 1992 through 1997, where they study year-end secondary market observations of subordinated debt for 19 large commercial banks and 39 BHCs. They find that risk is similarly priced for BHCs and banks, in the sense that bondholders respond to risk characteristics of the issuers in an equally potent manner for the two groups.

Balasubramnian and Cyree (2011) use secondary market transactions of SNDs during the 1994 to 1999 period[9] and find two main results. First, there was a decrease in the sensitivity of SND yield spreads to bank risk factors (such as loans to assets, non-performing loans to total loans, net charge-offs, etc.) following the issuance of trust-preferred securities (TPSs)[10] in 1996.

[9] They end the sample in 1999 to remain consistent with some prior studies; to avoid possible data issues related to the enactment of the Financial Services Modernization Act (Gramm–Leach–Bliley Act) in 1999, the Regulation Fair Disclosure (Reg FD) in 2000, and the Sarbanes–Oxley Act in 2002; and to avoid the Internet bubble, Enron failure, and the 9/11 terrorist attacks.

[10] TPSs are securities issued from a trust set up by a BHC. The trust generally makes quarterly distributions to the TPS holders. TPSs are subordinated to other debt but are senior to preferred and common stocks. On October 21, 1996, the Board of Governors of the Federal Reserve System issued a press release approving the capital treatment of TPSs as tier 1 capital for BHCs, subject to a 25 percent limit (together with other cumulative preferred stock). Due to the capital treatment, dividend deferral rights (allows deferral for 20 quarters), and favorable tax treatment (dividends are tax deductible for the BHC), the issuance of TPSs was an attractive way for BHCs to raise capital without stock dilution. For a high-level overview of TPSs, see "A Guide to Trust Preferred Securities" by Alan Faircloth (Federal Reserve Bank of Atlanta) available at frbatlanta.org/banking-and-payments/publications/financial-update/2014/q1/viewpoint/spotlight-guide-trust-preferred-securities.aspx.

This result is partially due to the tax shield and flexibility in meeting capital regulatory requirements associated with TPS, which provide an additional buffer to SNDs from default risk. Second, a paradigm shift occurred after the bail out of Long-Term Capital Management in 1998 in the sense that off-balance sheet exposure became a determinant of SND yield spreads because bond market participants became more cognizant of banks' "hidden leverage."

Balasubramnian and Cyree (2014) use daily data for SND transactions in the secondary market and firm-specific, market-level, and bond-specific variables to examine the impact of the Dodd–Frank Wall Street Reform and Consumer Protection Act (Dodd–Frank Act) of 2010 on market discipline. They find that the passage of the act decreased the size-discount on yield spreads for the TBTF and systemically important financial institutions (SIFIs). The rationale is that the Dodd–Frank Act's intention to end TBTF policies (e.g., a living will) resulted in a decrease in the size-discount for the large BHCs for which the Federal Reserve Board conducts stress tests. In terms of magnitude, they find a 94 percent decrease in the size-discount associated with TBTF institutions along with a 47 percent discount in the size-discount across all banks. They attribute the increase in yield spreads after the passage of the Dodd–Frank Act (i.e., reduction in the size discount) to an improvement in market discipline due to the policy of reduced support for TBTF banks.

We follow Balasubramnian and Cyree's (2014) empirical methodology but introduce several important differences. First, our objective is to create an industry benchmark for SIB bond trades, while their focus is on the change in the size-discount associated with the passage of the Dodd–Frank Act. Second, our sample covers over 8 million bond trades, spanning from January 2003 through September 2014, while their work is based on a smaller sample of around 17,000 observations from June 2009 to December 2011. Third, we include all daily bond trades

as separate observations, indirectly weighting each firm's debt to the extent to which it is traded in the market. In contrast, they use an equal-weighting scheme of bond trades, regardless of intraday trade frequency, as they calculate the daily average yield spread when they have multiple transactions for the same bond. Fourth, keeping our goal of creating an industry benchmark model in mind, we include multiple bond types, including SND and non-SND, whereas Balasubramnian and Cyree focus solely on SNDs.

The area of market discipline that we focus on is the pricing of BHC debt in the secondary market. The notion of financial regulators using mandatory issuance of bank debt to mitigate risk-taking at these institutions has been investigated (e.g., by Jagtiani et al., 1999; Bliss and Flannery, 2002; and Lang and Robertson, 2002), although the findings remain in dispute. The mandatory issuance of BHC debt can mitigate risk-taking through two channels: [1] market cost on the debt-issuing institution through the primary issuance, and [2] greater debt yields in the secondary market in response to increased riskiness of the issuing bank and the use of it by regulators as a risk indicator for regulatory action, as detailed later. The focus of this paper is on the second channel. According to Lang and Robertson (2002), this channel can "become an extremely useful tool in the regulatory effort to increase market discipline in the banking industry." The rationale is that, as risk-taking at a BHC increases, bond traders will demand a greater risk premium when purchasing the debt in the secondary market. Since the bond yields are indicative of the overall risk levels of the issuing institution, regulators can flag elevated yields as early warning signs and subsequently take regulatory action.

Our research is timely because, given the recent financial crisis, innovative methods to regulate SIBs have garnered even greater attention. Also, the size and the trading volume of the overall bond market have increased tremendously. According to the Securities Industry and

Financial Markets Association, the amount of outstanding corporate debt and the average daily trading volume have grown from $4.3 trillion and $18 billion in 2003 to over $7.8 trillion and $26.7 billion, respectively, by 2014. The growth in size and liquidity of the corporate bond market is partly due to advancements in technology, such as the advent of high frequency trading, which has increased the transparency of the market. In fact, in 2014, bank debt reached an all-time high, and global banks more than doubled debt issuance from the prior year to nearly $275 billion, primarily due to the Basel III requirement of increased bank capital in the form of both debt and equity (Thompson, 2015). Changes in the regulatory landscape from Basel III, coupled with greater transparency in the market for corporate debt, make our study even timelier as bank regulators attempt to find the optimal shares of debt and equity capital to be held by large institutions.

The aforementioned studies have some common themes. In general, these studies use yield spreads of bonds to measure market discipline and include some combination of institution, security, and macroeconomic-specific risk factors as determinants of yield spreads. They also study the impact of bank risk measures on yield spreads within the context of the broader regulatory environment. For example, when the government safety net expands (as in the case of bail outs) or new hybrid securities are introduced (as in the case of TPSs), interpretation of bank risk measures can be impacted. Unusual volatility during and after the financial crisis in the macroeconomic realm, and the keen focus by regulators, investors, and other stakeholders on idiosyncratic risk makes it theoretically unclear which countervailing force is the primary driver of yield spreads in the secondary market. We develop our econometric model with these elements in mind.

3. Econometric Model and Variables

Following Balasubramnian and Cyree (2014) and Zhang et al. (2014), we model the yield spread (YS) on SIB bonds as a function of three sets of variables: SIB-specific, market-specific, and bond-specific factors, as described by equation 1.[11] The additive error term ε in the model accounts for idiosyncratic shocks to the yield spread and possible omitted variables. The reduced-form model, derived from equation 1, is described by equation 2:

$$YS = f(SIB - specific\ Risk\ , Market - specific\ Factors\ , Bond - specific\ Factors) + \varepsilon \quad (1).$$

$$YS_{i,b,t,q} = \beta_0 + \beta_1 * crisis + \beta_2 * postcrisis + \boldsymbol{\beta_D SIB_b} + \boldsymbol{\beta_F SIBF_{b,q-1}} + \boldsymbol{\beta_{MD} MacroD_t} + \boldsymbol{\beta_{MQ} MacroQ_{q-1}} + \boldsymbol{\beta_S BondS_i} + \boldsymbol{interactions} + \varepsilon_{i,b,t,q} \quad (2).$$

This specification allows one to determine how the secondary market yield spread ($YS_{i,b,t,q}$) for bond *i* of SIB *b* during day *t* in quarter *q* reacts to changes in the SIB-specific, market-specific, and bond-specific factors by using panel-data estimation techniques via inclusion of SIB dummy variables to account for bank heterogeneity. We define the regressors below. The data include the secondary market bond trades across the 26 designated SIBs. After merging databases from seven different sources[12] (see Section 5) and adjusting for outlier

[11] Theoretically, endogeneity could be a concern. However, our findings are robust to a number of alternative specifications such as omission or inclusion of various control variables and estimation techniques (such as random effects estimation).

[12] The seven database sources used in the analysis are: [1] Trade Reporting and Compliance Engine (TRACE), [2] Mergent Fixed Income Securities Database (FISD), [3] FR Y-9C reports, [4] the Bank Holding Company Performance Report (BHCPR), [5] Yahoo! Finance, [6] Treasury constant maturity rates provided by the Board of Governors of the Federal Reserve System, and [7] U.S. Bureau of Labor Statistics.

treatment, our sample includes over 8 million trades. The intercept β_0 in the model is allowed to shift over time across the three sub-periods and across the 26 SIBs by introducing the following dummy variables: [1] the crisis dummy ($crisis$), [2] the post-crisis dummy ($postcrisis$), and [3] the SIB dummies ($\boldsymbol{SIB}_b$). The crisis and post-crisis dummies serve as a catch-all for macroeconomic factors that are shared across all SIBs during the respective business cycle phases but are not explicitly included in the specification. The pre-crisis period serves as the base period. The SIB dummies capture all firm-specific factors not accounted for in the model, including unobserved heterogeneity such as firm culture, information technology infrastructure, management skills, cyber-security, etc.

The model variables are outlined in Table 2. Vector $\boldsymbol{SIBF}_{b,q-1}$ includes all SIB-specific risk factors lagged by one-quarter. These variables are stratified across the CAMELS stripes[13] and are lagged by one-quarter since consolidated financial statements for BHCs (FR Y-9C forms) are made public 45 days after the end of each quarter. The tier 1 leverage ratio at the BHC consolidated level represents **C**apital adequacy. Bank capital serves as a cushion that can be used to charge-off bad loans and other non-performing investments once the allowances for loan losses are depleted. However, one can also view excess bank capital as costly since these funds are not lent out or invested through other means. Net charge-offs to average loans serve as our **A**sset quality measure and can be viewed as a credit risk at an SIB. Bank inefficiency, calculated as non-interest expense (salaries and employee benefits, expenses of premises and fixed assets, etc.) less amortization of intangible assets divided by average assets, relates to **M**anagement

[13] Since CAMELS ratings are not publicly disclosed, bondholders are not privy to these ratings. Thus, we proxy for the categories. See Appendix A of the Comptroller's Handbook: Bank Supervision Process (accessed at www.occ.treas.gov/publications/publications-by-type/comptrollers-handbook/pub-ch-ep-bsp.pdf) for more information regarding the Uniform Financial Institutions Rating System (UFIRS) or CAMELS rating system. The CAMELS rating system has evolved over time, from the UFIRS, originally adopted by the FFIEC in 1979, which included five components, to the addition of a sixth component (sensitivity to market risks) in 1997.

inefficiency since it measures how much the management spent on overhead for every dollar of assets. Return on average assets (ROAA) is a standard measure for **E**arnings and is calculated as net income divided by average total assets. Our **L**iquidity measure is the liquidity ratio. It is calculated as short-term investments (the sum of interest-bearing bank balances, federal funds sold and securities purchased under agreements to resell, and debt securities with a remaining maturity of one year or less) divided by total assets. The last component, **S**ensitivity to interest rate risk, is measured by the funding gap defined as the difference between short-term assets and short-term liabilities (i.e., those that mature or reprice within one year) divided by total assets. In addition to these risk measures, we also include the lag of the gross positive fair value of derivative contracts (as a percentage of assets) and the lag of the natural log of BHC total assets (in real terms[14]). The former variable measures the off-balance sheet exposure to derivative contracts for interest rate, foreign exchange, equity derivative, and commodity contracts that are owed to the bank by its counterparties. The latter variable accounts for variation in institution size.

[Insert Table 2 Here]

We include both daily and quarterly[15] macroeconomic control variables in vectors $\boldsymbol{MacroD}_t$ and $\boldsymbol{MacroQ}_{q-1}$, respectively, to capture the daily trading environment within the context of the broader economy. The daily variables included are the percentage change in the S&P 500 index based on the daily closing value of the index, the change in the Chicago Board

[14] All variables reported in real terms reflect 2014:Q3 dollars based off the Consumer Price Index for all urban consumers (all items) from the U.S. Bureau of Labor Statistics.

[15] We do not see an issue including quarterly macroeconomic control variables to model daily yield spreads. Bond traders would account for the daily trading environment within the context of the broader economic trends. Econometrically, we are not concerned with multicollinearity between the daily and quarterly market variables due to the relatively low correlations shown in rows 12 and 13 of Appendix B and given the large number of observations.

Options Exchange Market Volatility Index (VIX), the slope of the yield curve, and the change in the federal funds rate.[16] The slope of the yield curve is calculated as the 20-year Treasury rate minus the 1-year Treasury rate. In "normal" times, one expects the yield curve to be upward sloping. However, prior to and during recessions, an inverted yield curve is not uncommon. The quarterly macroeconomic variables are quarterly lags of gross domestic product (GDP) and M2 growth, which capture the broader health of the economy (including the demand for money) and available liquidity, respectively.

The last vector $\boldsymbol{BondS}_i$ contains the bond-specific features. The variable time to maturity reflects the number of years until the bond matures. Log of the issue size relates to the log of the total dollar amount (in real terms) of the debt issuance in the primary market. The last variable is a dummy variable for SND; it takes the unit value for SND and zero for senior debt, rendering the latter the control group. One would expect a discount on senior debt when compared with SND since senior bondholders would be higher in the pecking order if the SIB were to liquidate its assets. Thus, the coefficient of the SND dummy is expected to be positive.

Lastly, the vector $\boldsymbol{interactions}$ includes the interaction terms between the crisis and post-crisis dummy variables and the SIB-specific, bond-specific, and macroeconomic risk factors. The coefficient estimates on the interaction terms (with continuous variables) are interpreted as changes in the slopes during the crisis and post-crisis periods, respectively. Economically, the interaction terms represent the possible change in bond investor behavior with respect to SIB-specific, bank-specific, and macroeconomic factors during the crisis and post-crisis phases of the business cycle.

[16] Our choice of daily macroeconomic variables is similar to those in Balasubramnian and Cyree (2014).

4. Hypotheses

As a risk factor increases in magnitude at a given bank, the bank's bond yield spreads are expected to increase (i.e., bond prices are expected to decrease). This increase in risk premium in the secondary market would be indicative of market discipline by bond traders. That is, the investor selling the bond will be disciplined by being forced to accept a lower price on the debt security as the risk level of the issuing SIB increases. As an analogy, one can think of bond yields as the barometer for market discipline and bank-specific risks as levers that raise or lower the barometer, depending on the level of risk. We propose four hypotheses concerning the association between SIB debt yield spread and various risk measures across the business cycle. The first hypothesis is standard in the market discipline literature on bond yields (Section 2). The question is if, how, and to what extent does each risk factor impact the yield spread? We formulate this hypothesis as:

H_1: An increase in SIB risk is associated with market discipline in the form of a higher yield spread.

Once the relationship between the yield spread and risk measures is established, we ask more penetrating questions that are not standard in the literature. These hypotheses examine how market discipline in bond yields could be used as a viable option for policymakers to leverage. For example, we trust that an increase in a risk metric will engender different responses depending on the phase of the business cycle. This differential is due to varying levels of sensitivity to risk and risk tolerance on the part of the bond market participants over the phases of the business cycle. We propose hypothesis H_2 as:

H_2: The sensitivity of the yield spread to an increase in SIB risk measures is business cycle phase dependent (i.e., the slope of a risk factor (its marginal impact) will change during the

crisis and post-crisis periods (slope shifts) compared with the pre-crisis period).

Including both crisis and post-crisis dummy variables and their interactions with other independent variables allows for changes in the slope across the pre-crisis, crisis, and post-crisis periods to be measured. As a separate issue, we are also interested in knowing how much of the variance in yield spreads is driven by macroeconomic factors versus SIB-specific and bond-specific factors during each business cycle phase. To investigate this issue, following Peria and Schmukler (2001) and Flannery and Sorescu (1996), we estimate the following analog of our main model across the pre-crisis (2003:Q1 to 2007:Q3), crisis (2007:Q4 to 2009:Q2), and post-crisis (2009:Q3 to 2014:Q3) periods (i.e., separately instead of pooling data from the three sub-periods)[17]:

$$YS_{i,b,t,q} = \beta_0 + d_q + \boldsymbol{\beta}_D \boldsymbol{SIB}_b + \boldsymbol{\beta}_F \boldsymbol{SIBF}_{b,q-1} + \boldsymbol{\beta}_{MD} \boldsymbol{MacroD}_t + \boldsymbol{\beta}_{MQ} \boldsymbol{MacroQ}_{q-1} + \boldsymbol{\beta}_S \boldsymbol{BondS}_i + \varepsilon_{i,b,t,q} \quad (3).$$

In equation 3, we add a quarter dummy d_q to the model (equation 2) to serve as a catch-all of macroeconomic factors *within* a business cycle phase and remove the crisis and post-crisis dummy variables and all associated interaction terms as the sample includes data on only one phase of the cycle. To elaborate, we include a dummy variable that corresponds to the quarter during which the daily bond trade is executed. This implies that the bond traders interpret each piece of information, such as information on idiosyncratic risks, in the context of the broader macroeconomic environment. The purpose of inclusion of this dummy variable is to capture all factors that are shared across SIBs within a given quarter. These factors include, for example,

[17] Peria and Schmukler (2001) used deposit growth rates and interest rates paid on deposits as measures of market discipline when performing the R-squared decomposition. We apply the same methodology to the bond market.

changes in fiscal and monetary policy, technological changes, and other systemic shocks. By comparing the R-squared values from the model specified in equation 3 to that of the same model that, alternatively, excludes firm dummy variables, SIB risk factors, or bond-specific variables, we can estimate the proportion of explained variation that is driven by macroeconomic factors vis-à-vis firm-specific and bond-specific factors. From a policy perspective, this is a crucial test because if macroeconomic conditions are the primary drivers of yield spreads, bond investors are demanding higher risk premia mostly due to systematic, rather than idiosyncratic, factors. Under these circumstances, bond investor behavior is largely a reflection of the macro environment, and a policy of mandatory debt issuance by the largest BHCs could not succeed because bond-specific and SIB-specific risk factors do not exert a significant influence on yields. To elaborate, if policymakers were to implement the mandatory issuance of subordinated debt and monitor yields on that debt in the secondary market as an early warning sign, they would do so with the assumption that bond investors are responding to bank risks through the price they are willing to pay on the debt. If instead, bond investors of SIB debt are simply reacting to the economy at large, then the bond yields will not be reflective of inherent risk at the issuing institution, market discipline will be greatly diminished since there is less sensitivity to the firm's idiosyncratic risks, and the responsibility of policymakers in curtailing SIB risk would become more challenging. Thus, we propose our third hypothesis as:

H_3: SIB-specific and bond-specific factors drive the majority (greater than 50 percent) of the explained variance in yield spreads (i.e., play a dominant role in market discipline) across all phases of the business cycle.

A pertinent question is how the proportions of variation in yield spread due to SIB-specific and bond-specific risk factors change across the phases of the business cycle. Two

scenarios are possible here. First, one might expect that bondholders become more attentive to idiosyncratic factors during the turbulent crisis times (more sensitive to SIB-specific and bond-specific risks), especially because the banking industry was experiencing arguably the most severe liquidity and solvency issues since the Great Depression. Under these conditions, the proportion of variance driven by macroeconomic factors could be smaller during the crisis compared with the pre and post-crisis periods. Second, it is possible that during the crisis period macroeconomic factors dominate all institution-specific risk measures because systemic shocks could dominate bond trader psychology and bond trader behavior, sidelining the idiosyncratic factors. Thus, determining which forces prevail is rendered an empirical exercise. This leads us to our fourth hypothesis:

H_4: The proportion of explained variation in market discipline driven by SIB-specific and bond-specific factors increases during the crisis period (2007:Q4 to 2009:Q2) compared with the pre-crisis (2003:Q1 to 2007:Q3) and post-crisis (2009:Q3 to 2014:Q3) periods.

5. Data Sources and Descriptive Statistics

5.1. Data Sources

Using the stock tickers of the 26 SIBs, we extract the yields and dates of all secondary market trades for these SIBs that are available in Trade Reporting and Compliance Engine (TRACE) from 2003:Q1 through 2014:Q3. Then, using the daily Treasury constant maturity rates provided by the Board of Governors of the Federal Reserve System[18] we interpolate (or extrapolate, where necessary) the risk-free rate associated with each trade based upon the number of days remaining until the debt matures. This procedure helps us to calculate the yield spread

[18] Daily Treasury rates are available for 1-, 3-, and 6-month periods and 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-year periods. Rates can be accessed through the Treasury Department's Resource Center.

for every trade.[19] Next, we merge in all bond-specific information from the Mergent Fixed Income Securities Database (FISD). Using the unique Committee on Uniform Securities Identification Procedures number for each bond, we match the bond-specific variables available in the Mergent FISD, such as callable, putable, time to maturity, issue size, and type (SND or non-SND), with the individual bond trades. We then drop the callable and putable bonds from our dataset because the option of the firm to buy the bond from the investor or the investor to demand principal repayment would complicate the market discipline mechanism.[20]

This process generates a dataset of daily yield spreads with bond-specific information. In the next step, we use the stock ticker and quarter identifiers to match the dataset with SIB-specific data from FR Y-9C reports and the Bank Holding Company Performance Report (BHCPR). Then, using the trade date, we merge in the macro variables for the specific day (or quarter) during which the trade took place.[21] Lastly, we winsorize by removing all observations with bond or daily macro variables that lie above the 99th or below the 1st percentile as outliers separately across the pre-crisis, crisis, and post-crisis periods. The process described provides observations for 8,045,221 trades of bank debt across all 26 SIBs from 2003:Q1 through 2014:Q3. The frequency of bond trades by SIBs across our pre-crisis, crisis, and post-crisis sub-samples are reported in Table 3. In this table, the top four firms in terms of trading volume are highlighted.

[Insert Table 3 Here]

[19] For example, suppose a trade takes place on January 5, 2004, with a yield of 5 percent; the bond has 1 ½ years to maturity, and the daily Treasury yields for the same day are 1.35 percent and 1.95 percent, respectively, for the 1-year and 2-year Treasury bonds. Linear interpolation would provide a risk-free rate of: $y = \frac{y_1 - y_0}{x_1 - x_0}(x - x_0) + y_0 = \frac{1.95 - 1.35}{2 - 1}(1.5 - 1) + 1.35 = 1.65\%$.

[20] Our main conclusions still hold with the inclusion of callable and putable bonds.

[21] For data sources of the macroeconomic variables, see the "Source" column of Table 3.

5.2. Descriptive Statistics

The summary statistics stratified across the pre-crisis, crisis, and post-crisis periods are shown in Table 4. Panels A, B, and C include SIB-specific, macroeconomic, and bond-specific variables, respectively. Note that the debt sample changes over the business cycle. For example, only during the crisis period are the bonds of all 26 SIBs traded, and liquidity is greatest during the post-crisis period. The daily mean yield spread for SIB debt traded across the pre-crisis, crisis, and post-crisis periods are 1.69 percent, 5.44 percent, and 3.30 percent, respectively, demonstrating a sharp contrast. The increases in yields during the crisis and post-crisis periods, relative to the pre-crisis period, are consistent with increased market volatility, greater risk aversion, and longer maturity of the bonds (4.77 years, 5.14 years, and 5.37 years, respectively) traded during these three periods (consistent with Guidolin and Tam, 2013).

[Insert Table 4 Here]

The average issue size in the primary market has also increased in real terms over the business cycle, peaking in the post-crisis era at around $1.6 billion, with a minimum value of $6.7 million and a maximum value of $4.6 billion during that same period. This could reflect the increase in bond liquidity due to advancement in electronic trading technology (e.g., trading algorithms) and declining transaction costs. Furthermore, there are new capital requirements in the pipeline surrounding SND with the implementation of Basel III reforms. According to the final rule,[22] the Basel III capital framework lists criteria that a financial instrument must meet in order to be considered as regulatory capital, which would presumably apply to all firms considered in this study. We include a number of firm-specific, bond-specific, and

[22] A description of the final rule can be accessed through the Office of the Comptroller of the Currency website at www.occ.gov/news-issuances/news-releases/2013/2013-110a.pdf.

macroeconomic-specific control variables, consistent with Balasubramnian and Cyree (2011, 2014). The correlation matrix of all continuous variables included in the model is shown in Appendix B.[23]

6. Empirical Results

6.1. Methodology

The model (equation 2) is estimated via the ordinary least squares (OLS) technique with heteroscedasticity-robust errors. Results are presented in Table 5. Columns 1, 2, and 3 of this table display the coefficient estimates for the risk measures during the pre-crisis period and their changes during the crisis and post-crisis periods, respectively. The coefficient changes refer to changes in slopes (intercepts) demonstrated by interactions of the crisis or post-crisis dummy variable with a continuous (dummy) variable. Column 1 also includes the intercept shifts due to the latter two phases of the business cycle (last two rows of panel B of Table 5). To calculate the overall effect, which we refer to as a marginal impact, of an increase in each risk measure on yields during the crisis or post-crisis periods, we add the coefficient estimate in column 2 (for the crisis) or column 3 (for the post-crisis) to the coefficient estimate in column 1. Panels A through C in this table contain the SIB-specific, macroeconomic, and bond-specific variables, respectively. The SIB fixed effects and the constant term, all significant at the1 percent level, are not reported to save space. The economic effects, reported in Table 6, measure the change in the yields in basis points (bps) attributable to a one standard deviation change in the pertinent independent variable (economic effect).

[23] The correlations between the liquidity ratio (variable #5) and the positive fair value of derivatives (variable #7) and between the daily change in S&P 500 index (variable #9) and the VIX (variable #10) stand at 0.69 and -0.73, respectively, raise concerns about collinearity. However, removal of these control variables from the model does not significantly influence the results or the conclusions.

[Insert Table 5 Here]

[Insert Table 6 Here]

A main question of interest is whether yields increase in the secondary market as SIB riskiness rises. From a policy standpoint, if regulators were to require regular issuance of debt, such as SNDs, by banks, it would be with the assumption that primary and secondary market participants would demand a higher rate for both new and outstanding debt (primary and secondary markets) in response to increased risk, thereby placing pressure on the BHC to mitigate it.

It is reasonable to presume that bond traders will react to an increase in SIB risk differently depending on the phase of the business cycle, reflected in the interaction terms for the crisis and post-crisis periods (Flannery and Sorescu, 1996). For example, secondary market participants may find an increase in credit risk for a SIB to be less problematic during the pre-crisis period when the economy is experiencing an upswing, because credit issues may be easier to remediate. However, during the crisis, when the flow of credit was tight and there were numerous bank solvency issues, additional credit risk could be seen as more destabilizing than in the pre-crisis period, further strengthening the impact on yields.

6.2. Results for SIB-Specific Variables

The coefficient estimates and the economic effects of the SIB-specific risk measures are shown in Table 5 (panel A) and Table 6, respectively, for the three sub-periods. We discuss these effects next.

Capital Adequacy (leverage): The marginal effect of the capital ratio on the yield spread is found to be negative and highly significant, with the magnitude of the effect varying across the three sub-periods. During the pre-crisis period, the marginal impact takes the value of -0.0570,

while, accounting for the interaction effects, it increases in magnitude to -0.1584 during the crisis and then increases further to -0.1794 during the post-crisis period (Table 6). These incremental effects are statistically different because the interaction terms between capital and the crisis and post-crisis dummy variables, respectively, are negative and statistically significant, as shown in Table 5. The negative capital ratio effects imply that bond traders view an increase in SIB capital as a force to reduce bank risk, and, thus, they lower their required yield on SIB debt. These results confirm that there exists a shift between business cycle phases regarding the extent to which market participants react to changes in risk measures. The economic effects show that a one standard deviation increase in tier 1 capital will decrease the yield on the SIB debt by 8 bps, 34 bps, and 24 bps, respectively, in the pre-crisis, crisis, and post-crisis eras. The greater sensitivity of bond buyers to changes in bank capital during the crisis could be related to the distribution of TARP capital infusions. In fact, the largest capital infusions under the Capital Purchase Program (CPP) were given to the SIBs, including Citigroup and Bank of America ($45 billion infusions each) and JPMorgan and Wells Fargo ($25 billion infusions each), who together comprise nearly 75 percent of the bond trades during the crisis period (Table 2). Since the CPP purchases injected additional capital into the firms during a time when their probability of failure was heightened, bond traders reacted more strongly to an additional buffer of capital support, which could be viewed as a mitigating factor. Moreover, the capital injections could have provided a signaling effect to the market that there were underlying issues that could potentially impact bank solvency at these large BHCs that the regulators were aware of via confidential information, which could partially explain the greater sensitivity of bond traders to bank capital. Put simply, if market participants believed that the SIBs required TARP funds to prevent insolvency, then this could explain the greater sensitivity of market participants to bank capital

levels. More generally, this market reaction by bond traders defends capital adequacy requirements set forth by the Basel Accord and supervisory stress testing exercises (DFAST and CCAR).

Asset Quality: Asset quality (credit risk) is measured by net charge-offs (loan and lease losses) to total loans ratio. The coefficient of this variable is positive and significant across the three sub-periods, indicating that bond traders raise their yield requirement when bank asset quality declines. The marginal and economic effects of asset quality are reported in Table 6. According to the figures in this table, the magnitude of the marginal impact of credit risk on SIB debt yields increases substantially, from 6.30 bps to 52.65 bps, and then declines back to 12.00 bps (Table 6) from the pre-crisis to the crisis and post-crisis periods. This indicates that bond investors did account for credit risk exposure of the SIB across all three phases of the business cycle but much more so during the crisis. It is also notable that increased sensitivity of the bond traders to credit risk during the crisis did not move back to the pre-crisis period level in the post-crisis period, demonstrating persistence of fear and risk aversion in the latter period.

According to the figures in Table 6, the magnitudes of economic effects of asset quality changes are 3 bps, 75 bps, and 20 bps, reflecting dramatically heightened sensitivity of the market participants in the crisis and post-crisis periods compared with the pre-crisis period when markets were calm. The crisis period, by far, displays the strongest effect. The greater impact of asset quality on risk premium during the crisis period implies that during times of economic expansion, as in the pre-crisis period, bond investors are less sensitive to changes in credit risk, likely a reflection of the robust economy and positive psychology. According to figures reported in Table 6, during the crisis, the bond traders reacted to changes in credit risk to a much greater

extent than to all other bank-specific risk measures included in our model, likely a symptom of the turbulent recession leading to investor fear and pessimism and overreaction due to deeper opacity and complexity of the banks during this period.

Management: The marginal impact for the inefficiency ratio, the proxy for the ability of bank management to control overhead, is negative and significant, and it increases in magnitude across the three sub-periods. This pattern of bond investor response to bank inefficiency could be an indication that BHCs spending more on non-interest expenses (such as hiring more skilled managers or investing in buildings that are more attractive to lure away customers from their competitors) is viewed favorably by investors and that the BHCs indeed benefit from these expenses. Moreover, greater non-interest expenses could imply that SIBs that had the ability to invest in their employees and infrastructure, especially during and after the crisis, were perceived to be safer and more stable. For example, during the crisis, when the solvency of SIBs was in doubt and policy authorities were implementing TBTF policies, SIB's ability to pay expenses such as salaries, employee benefits, and operating expenses would send a message to investors that these SIBs are strong enough to continue business as usual. During the pre-crisis period, the magnitude of the effect was small; a one standard deviation increase in the inefficiency ratio decreased the yield by only 3 bps in this period. However, during the crisis and post-crisis periods, the economic effects stood at -19 bps and -41 bps, respectively, suggesting that during the latter two phases of the business cycle bond traders viewed SIB expenses on areas such as salaries, employee benefits, and premises as a much stronger risk-mitigating factor.

Earnings (ROAA): For the profitability measure, ROAA, the effects are negative and

significant at the 1 percent level for all three sub-periods, as expected. This indicates that an increase in SIB profitability is perceived by bond traders as decreasing the chances of default on SIB bonds. The marginal impacts of profitability take values of -0.2807, -0.6045, and -0.4714, respectively, during the pre-crisis, crisis, and post-crisis periods, indicating a decrease of 13 bps, 50 bps, and 37 bps in the yield for a one standard deviation positive profitability shock during each respective business cycle phase. As was the case with the credit risk measure, there is more sensitivity to changes in bank profitability during the crisis compared with the pre-crisis period, suggesting that, during periods of greater macroeconomic uncertainty, each unit of profitability translates into a greater risk premium reduction by bond traders than in calmer sub-periods. The stronger effect observed during the crisis seems to have sustained itself even in the post-crisis period as the shift in psychology of the traders in more highly valuing bank profitability was persistent rather than short-lived.

Liquidity: The effect of the liquidity ratio (short-term (<1 year) assets divided by consolidated assets) is positive and significant across the three sub-periods but weaker during the post-crisis phase. As Berrospide (2012) explains, during the summer of 2007 at the onset of the mortgage crisis, short-term funding had dried up, and securitization markets were headed for collapse. As a result, SIBs became concerned about counterparty, liquidity, and portfolio risks, in particular regarding the size of their exposures related to sub-prime assets. Consequently, the interbank market froze and banks began to "hoard liquid buffers." Figures in panel A of Table 4 reflect this hoarding of liquidity at the SIBs, as we see the liquidity ratio increase from 12.49 percent to 16.10 percent and then to 25.76 percent, respectively, across the pre-crisis, crisis, and post-crisis periods. The marginal impacts in Table 6 suggest that holding excess liquidity was seen as costly

to the SIB and, thus, increased the SIB yields. In other words, traders viewed excessive cash holding as a suboptimal and costly allocation of resources. In terms of magnitude, a one standard deviation increase in the liquidity ratio translated into a yield spread increase of 55 bps, 69 bps, and 56 bps, respectively, across the three sub-periods. The interpretation of these findings is that SIBs holding high levels of liquid assets, relative to total assets, in order to prepare for negative shocks in the near term, were perceived as distressed and at risk because it was assumed that such banks were unable to rely on liability management sources of liquidity to raise funds when needed and were holding excessive liquidity to counter that problem.

Sensitivity to Interest Rate Risk: Interest rate risk is measured by the funding gap ratio (short-term (<1 year) assets less short-term (<1 year) liabilities to total assets). Since SIBs included in our sample held, on average, more short-term assets than liabilities (they have positive funding gaps), during the sample period, they were protected from the anticipated rise in interest rates, especially during the post-crisis period. Thus, wider positive gaps corresponded to greater profits and lower yield on SIB debt as interest rates were expected to rise.[24] Specifically, the funding gap marginal impacts on SIB yields are all negative and highly significant (-0.0250, -0.0215, and -0.0377, respectively, for the three sub-periods) (Table 6). Figures reported in Table 4 show that the average SIB increased its funding gap ratio from 18.24 percent to 19.11 percent to 31.86 percent, respectively, of total assets across the pre-crisis, crisis, and post-crisis quarters, in anticipation of rising rates. In terms of economic effects, the gap coefficients translate to a decrease in the SIB yields of 22 bps, 26 bps, and 47 bps for each respective phase of the business

[24] The Fed was expected to raise rates in 2015. (See the Federal Reserve Bank of San Francisco Economic Letter "Expectations for Monetary Policy Liftoff," November 18, 2013, available at www.frbsf.org/economic-research/publications/economic-letter/2013/november/federal-funds-rate-liftoff-increase-monetary-policy.)

cycle, when SIBs benefit from a one standard deviation increase in the positive funding gap.

6.3. Pertinent Hypotheses

The results displayed in column 1 in Table 5, Panel A, resolutely fail to reject hypothesis H_1, purporting that an increase in SIB risk measures results in market discipline in the form of higher yields for SIB bonds traded in the secondary market. Results displayed in columns 2 and 3 also fail to reject hypothesis H_2, proposing that secondary bond market participants' sensitivity to an increase in risk is dependent upon the phase of the business cycle. Two main implications can be drawn here. First, researchers and policymakers should both account for the phase of the business cycle and sensitivities of the market players when studying market discipline. Specifically, policymakers need to stay cognizant of how the behavior of market participants can change within the context of the business cycle. If regulators were to use SIB yields as early warning indicators, they would need to adjust the thresholds for policy shifts based on the state of the macroeconomic environment. Second, our results support the mandatory issuance of SIB debt as a method of market discipline, since we find that bond traders do respond to increased bank risk by demanding higher yields on SIB debt in every phase of the business cycle. Thus, fluctuations in yield spreads for SIB debt can serve as a barometer to gauge overall risk levels, and regulators could utilize this mechanism to curtail risk. U.S. banking regulators had monitored the yield spreads of large banking institutions in the past, but, in the post-crisis period, the focus has shifted away from market discipline and toward the regulatory components of the Dodd–Frank Act, such as the DFAST and CCAR exercises. With that said, the difficulty with monitoring yield spreads in the past was the thinness of the market, which is why required issuance of debt would be a necessary component if the monitoring of yield spreads were to be implemented within the current regulatory framework.

In general, regulators and policymakers should account for the effect of market discipline on formulation and implementation of their monetary and fiscal policies designed to achieve specific risk targets because, otherwise, they may miss the targets. Put simply, market discipline via the monitoring of yield spreads provides an avenue for regulators to curtail SIB risk to desired levels. Moreover, yield spread thresholds should be business cycle phase dependent since their sensitivity to SIB risks changes within the context of the macroeconomic cycle. Besides policymakers, managers of bank risk and investors should also account for the sensitivity of bond yields to the phases of the business cycle, including the stance of monetary and fiscal policies in issuing or purchasing bonds, because bond yields contain current information on the health of the banking institutions.

6.4. Results for Macroeconomic and Bond-Specific Variables

We report the results associated with macroeconomic and bond-specific variables in panels B and C of Table 5, respectively. The daily macroeconomic variables and their interaction terms, which include the change in the S&P 500 index, the change in the VIX, slope of the yield curve, and the change in the federal funds rate, are found to be significant at the 1 percent level. The sole exception is the VIX interaction term during the post-crisis period. Similarly, the quarterly measures used, including the GDP and M2 growth rates, are significant at the 1 percent level. The former results confirm that bond traders do account for the daily trading environment within the context of the economy at large.

An interesting finding is how the effect of a given macro variable changes across the phases of the business cycle. For example, the daily change in the S&P 500 index has a negative coefficient estimate of -0.0591 during the pre-crisis period, indicating that S&P 500 index returns and SIB debt yields move in opposite directions (or the daily change in the S&P 500

index and SIB debt returns move in the same direction) during this period. The finding supports the generally positive correlation between daily stock and bond price movements during the pre-crisis quarters, reflecting investor confidence and an increasing demand for both debt and equity securities in the secondary market during this time span. However, during the crisis phase of the business cycle, the effect for the broad market index switches to a positive sign, indicative of a negative correlation between SIB debt prices and the broad equity market.[25]

We report the coefficient estimates for the bond-specific variables in panel C of Table 5. The reference group for the bond type is non-SND. The positive and significant coefficients for the SND dummy variables suggest that, as expected, these junior riskier bonds trade at a higher yield than the benchmark non-SND. The estimates for time to maturity marginal impacts are all positive and significant at the 1 percent level across all three sub-periods, as implied by the liquidity premium hypothesis of term structure. The marginal impacts of years to maturity are 0.0991, 0.0959 (0.0991 - 0.0032), and 0.2043 (0.0991 + 0.1052), respectively, implying that for each additional year of remaining term to maturity the yield will increase by approximately 9.9 bps, 9.6 bps, and 20.4 bps, respectively, during the three sub-periods. The greater premium observed for the pre- and post-crisis periods may be reflective of stronger expectations of rate increases during these two periods than during the crisis. Lastly, during all three sub-periods, an increase in the size of the bond issuance in the primary market positively impacts yield spreads.

[25] These results reflect the mechanism studied by Baele et al. (2010). They examine stock and bond return comovements with a focus on their time variation. They find that fundamental factors play a relatively large role for bond returns, while liquidity factors and variance premium matter to a greater extent for stocks. Some studies (e.g., Connolly et al., 2005) attribute the negative correlation of the stock-bond returns to "flight-to-safety" in response to large negative shocks such as those of 1997 and 1998. They find that the negative comovement between stock and bond returns is related to investor uncertatinty. Specificially, they find that the lagged and contemporaneous VIX have a negative relation with the stock-bond return. However, Campbell et al. (2009) create a pricing model for stock and bond returns where the real economy "enables the model to fit the changing covariance of bond and stock returns," which opens the door for additional drivers.

In other words, the issuing banks will have to pay a higher yield to be able to sell a bigger volume.

7. The Relative Share of Macroeconomic and Bank-Specific Factors in Driving Yields

In this section, we investigate the relative power of bank-specific and bond-specific factors versus macroeconomic variables in driving the changes in SIB bond yields. This issue is critical from a policy perspective because market discipline relies on the premise that market participants do react to all publicly available information, which in turn keeps a check on the SIB risk levels. If bond market participants are reacting mostly to the overall economic environment, in lieu of SIB-specific risks, this will pose an impediment for relying on market discipline because the magnitude of its effect will be slight.

To test the proportion of explained variation in yield spreads driven by SIB-specific factors versus the macroeconomic environment, we re-run the model (equation 3) including only the macroeconomic factors and quarter time dummies for each of the three sub-periods. Then, we obtain the R-squared from each of the three separate regressions following the method used by Peria and Schmukler (2001). Theoretically, the "macro-only" specification would capture all explained variation that arises from macroeconomic factors because the quarter time dummies would serve as a catch-all for factors that are shared across all SIBs during the pertinent phase of the business cycle. We then determine the percent of the R-squared from the fully specified regression that is comprised by the R-squared from the specification that includes only macroeconomic factors. The incremental R-squared reveals the extent to which market participants are reacting to the overall economic environment versus the SIB-specific and bond-specific risk factors. Results are shown in Table 7.

[Insert Table 7 here]

Hypothesis H_3 states that SIB-specific and bond-specific factors drive the majority of variation seen in yield spreads. Per Table 7, the percentage of variance in yield spreads attributable to macroeconomic factors is 77 percent, 53 percent, and 27 percent, respectively, across the pre-crisis, crisis, and post-crisis periods. Given these percentages, we reject hypothesis H_3 during the pre-crisis and crisis periods since only 23 percent and 47 percent, respectively, of the variation in yield spreads is attributable to SIB-specific and bond-specific risks. Notably, the latter figure (47 percent), although it falls short of constituting the majority share of the yield spread variance, is still very considerable and may offer a tool to the policymakers to rely on. The more interesting result, however, is that we cannot reject the hypothesis for the post-crisis period considering that 73 percent of the R-squared is attributable to institution-specific and security-specific risk. This indicates that in the post-crisis period market discipline has considerably strengthened in controlling bond yield variations and can be effectively used by policymakers to achieve their targets in terms of bank risk levels. Furthermore, we reject hypothesis H_4, postulating that the proportion of variance in yields comprised of SIB-specific and bond-specific factors peaks during the crisis period since the aforementioned results show that such factors dominate in the post-crisis period.

These findings beg the fundamental question: Why do bond traders react *much* less to macroeconomic factors during and since the financial crisis? We believe a major contributing factor is the implementation of the unconventional fiscal and monetary policies during and after the crisis. These include the introduction of TARP, establishment of emergency lending facilities (e.g., Term Auction Facility, Primary Dealer Credit Facility, Term Securities Lending Facility, etc.), bail outs of AIG and Bear Stearns, and macroeconomic interventions by the Federal Reserve that remained in effect through the specified post-crisis period, most notably QE

programs. These heavy and unusual regulatory interventions in the markets likely broadened the explicit and implicit safety nets and consequently drove the market participants to treat such changes as expected. This environment dampened the proportion of variation in yields attributable to macroeconomic shocks, rendering these forces secondary factors.[26] Other possible reasons that could have contributed to the bond investor shift from macroeconomic to bank-specific factors include the calm environment prevailing during the pre-crisis phase, the (intended) end of TBTF policies with the passage of the Dodd–Frank Act in July 2010, and changes in bond-trading technology, especially during the post-crisis phase, such as more accurate and timely bond pricing software.[27]

8. Conclusion

We pursue three objectives. First, we investigate whether market participants in the secondary bond market for SIB debt react to SIB-specific, macroeconomic, and bond-specific features via movements in yield spreads. Second, we study how the behavior of bond traders changed in terms of reaction to variation in risk factors across various phases of the recent business cycle. Third, we investigate the relative force of SIB-specific and bond-specific versus the macroeconomic factors in driving SIB bond yields. Market discipline on SIBs in the market for debt is important to study because there has been renewed interest in unorthodox regulation

[26] The mechanism at work is the financial accelerator, which characterizes how business cycles can impact financial factors. Gertler and Lown (1999) show that the high-yield bond spread reflects information about aggregate economic activity. However, the authors note that "the informativeness of any financial indicator is sensitive to the nature of the business cycle and, relatedly, to the conduct of monetary policy." This finding relates to the analysis at hand because monetary and fiscal policy attempts to dampen the financial accelerator mechanism with respect to negative shocks during the crisis and post-crisis periods. Thus, bond investors become less concerned with the macroeconomic factors and focus more on the institution specific risks.

[27] Although there are outside factors that we do not explicitly control for, such as foreign competition (e.g., foreign interest rates) for large institutional investors and foreign exchange rates, these factors would theoretically be captured by our quarter dummy variable. Furthermore, residual diagnostics (available upon request) confirm that our error term does not contain any systemic bias and has a mean of zero across the pre-crisis, crisis, and post-crisis periods, which mitigates our concern that these results could be a reflection of omitted variable bias.

as policymakers have been attempting to identify the gaps in the existing laws[28] and to implement new regulations to prevent similar crises in the future. One such regulation would be the mandatory issuance of SIB subordinated debt according to which regulators would monitor yield spreads on SIB debt as early warning indicators for regulatory actions. If regulators plan on implementing compulsory SIB debt issuance with the expectation that bond investors would keep risk in check, it is imperative to study the behavior of these stakeholders to examine if they indeed respond to changes in bank-specific factors with significant strength.

Several interesting results are obtained. First, bond traders do account for firm, macroeconomic, and bond-specific features as evidenced by the significant SIB bond yield sensitivity to changes in the risk measures. Second, sensitivity of yields to changes in risk factors is dependent upon the concurrent phase of the business cycle. For example, coefficient estimates for the credit risk (net charge-offs to total loans) show that a one standard deviation increase in this ratio will increase the yield spread for the SIB debt by 3 bps in the pre-crisis era but increase it by 75 bps during the crisis period, reflecting heightened fear and greater risk aversion on the part of market investors. Third, when we test the proportion of explained variance in yields that is driven by firm-specific and bond-specific features vis-à-vis macroeconomic elements, we find that 77 percent of movements in yield spreads are the result of macroeconomic components in the pre-crisis era, but this proportion drops dramatically to 53 percent and 27 percent, respectively, during the crisis and post-crisis periods. We attribute the drop during the crisis to the broadened implicit and explicit government safety nets shifting bond investors' focus from the macroeconomic to the regulatory actions and their impacts on SIB risk factors. The even more dramatic shift from macroeconomic to SIB risk factors in the post-crisis period is likely

[28] Some would go as far as to say there were "gaping holes" in the financial architecture (e.g., Richardson, 2012).

due to the anticipated end of the TBTF policy as communicated in the Dodd–Frank Act during this last phase of the business cycle and the awakening of the market participants to the possibility that crises of colossal magnitude can possibly occur and that the rating agencies and other watchdogs cannot be seriously trusted.[29]

In general, these findings provide evidence that bondholders do react to changes in SIB-specific risk in a rational manner within the context of the business cycle. Moreover, market discipline through SIB-specific and bond-specific risk measures has increased dramatically in the post-crisis era, as measured by the relative strength of the forces driving the yields on secondary market debt for these institutions. This trend, if sustained, provides an opportunity for increased reliance on market discipline via mandatory debt issuance and the monitoring of these debt yields as a complement to prevailing regulations. Specifics on how mandatory debt issuance could be implemented are beyond the scope of this paper, but this issue needs to be critically examined by both regulators and researchers. Given that bond investors drove a significant proportion of the explained variation in yields during a time of unprecedented market intervention by fiscal and monetary authorities, it is clear that market discipline is a complement to regulation and supervision that can be leveraged to the benefit of the banking sector, investors, and ultimately the health of the overall economy.

[29] Note that technological advancement, such as improvements in bond pricing and increases in liquidity, might have also contributed to the shift of investor attention to bond-specific risks during the crisis and post-crisis periods from macroeconomic risks during the pre-crisis era. Additionally, the calm conditions of the pre-crisis period of the business cycle phase could have contributed to the focus of bond investors to the macroeconomy during this time when compared with the latter two phases of the business cycle.

References

Baele, Lieven, Geert Bekaert, and Koen Inghelbrecht. “The determinants of stock and bond return comovements.” *Review of Financial Studies* 23.6 (2010): 2374–2428.

Balasubramnian, Bhanu, and Ken B. Cyree. “Market discipline of banks: why are yield spreads on bank-issued subordinated notes and debentures not sensitive to bank risks?” *Journal of Banking and Finance* 35.1 (2011): 21–35.

—. “Has market discipline on banks improved after the Dodd–Frank Act?” *Journal of Banking and Finance* 41 (2014): 155–166.

Berrospide, Jose M. “Bank liquidity hoarding and the financial crisis: an empirical evaluation.” Finance and Economics Discussion Series, Division of Research and Statistics and Monetary Affairs, Federal Reserve Board, Washington, D.C. (2012).

Birchler, Urs W., and Matteo Facchinetti. “Can bank supervisors rely on market data? A critical assessment from a Swiss perspective.” *Swiss Journal of Economics and Statistics* 143.2 (2007): 95–132.

Bliss, Robert R., and Mark J. Flannery. “Market discipline in the governance of U.S. bank holding companies: monitoring vs. influencing.” *European Finance Review* 6.3 (2002): 361–396.

Board of Governors of the Federal Reserve System and United States Department of the Treasury. “The feasibility and desirability of mandatory subordinated debt.” Report by the Board of Governors of the Federal Reserve System and the Secretary of the U.S. Department of the Treasury (2000).

Bruni, Franco, and Francesco Paterno. “Market discipline of banks’ riskiness: a study of selected issues.” *Journal of Financial Services Research* 9.3 (1995): 303–325.

Caldwell, Greg. “Best instruments for market discipline in banking.” Bank of Canada Working Paper 2007-9 (2007).

Campbell, John Y., Adi Sunderam, and Luis M. Viceira. “Inflation bets or deflation hedges? The changing risks of nominal bonds.” National Bureau of Economic Research Working Paper 14701 (2009).

Connolly, Robert, Chris Stivers, and Licheng Sun. “Stock market uncertainty and the stock-bond return relation.” *Journal of Financial and Quantitative Analysis* 40.1 (2005): 161–194.

DeYoung, Robert, Mark J. Flannery, William W. Lang, and Sorin M. Sorescu. “The information content of bank exam ratings and subordinated debt prices.” *Journal of Money, Credit and Banking* 33.4 (2001): 900–925.

Evanoff, Douglas D., and Larry D. Wall. “A subordinated debt as bank capital: a proposal for regulatory reform.” Federal Reserve Bank of Chicago *Economic Perspectives* 24.2 (2000): 40–53.

Evanoff, Douglas D., Julapa Jagtiani, and Taisuke Nakata. “The potential role of subordinated debt programs in enhancing market discipline in banking.” Federal Reserve Bank of Kansas City Working Paper 07-07 (2007).

Flannery, Mark J. “Using market information in prudential bank supervision: a review of the U.S. empirical evidence.” *Journal of Money, Credit and Banking* 30.3 (1998): 273–305.

—. “The faces of ‘market discipline’.” *Journal of Financial Services Research* 20.2–3 (2001): 107–119.

Flannery, Mark J., and Sorin M. Sorescu. “Evidence of bank market discipline in subordinated debenture yields: 1983–1991.” *Jounral of Financ*e 51.4 (1996): 1347–1377.

Gertler, Mark, and Cara S. Lown. “The information in the high-yield bond spread for the business cycle: evidence and some implications.” *Oxford Review of Economic Policy* 15.3 (1999): 132–150.

Guidolin, Massimo, and Yu Man Tam. “A yield spread perspective on the great financial crisis: break-point test evidence.” *International Review of Financial Analysis* 26 (2013): 18–39.

Imai, Masami. “The emergence of market monitoring in Japanese banks: evidence from the subordinated debt market.” *Journal of Banking and Finance* 31.5 (2007): 1441–1460.

Jagtiani, Julapa, George Kaufman, and Catharine Lemieux. “Do markets discipline banks and bank holding companies? Evidence from debt pricing.” Federal Reserve Bank of Chicago *Emerging Issues* (1999).

Lang, William W., and Douglas D. Robertson. “Analysis of proposals for a minimum subordinated debt requirement.” *Journal of Economics and Business* 54.1 (2002): 115–136.

Morgan, Donald P., and Kevin J. Stiroh. “Bond market discipline of banks: is the market tough enough?” Federal Reserve Bank of New York Staff Report 95 (1999).

Nguyen, Tu. “The disciplinary effect of subordinated debt on bank risk taking.” *Journal of Empirical Finance* 23 (2013): 117–141.

Peria, Maria Soledad Martinez, and Sergio L. Schmukler. “Do depositors punish banks for bad behavior? Market discipline, deposit insurance, and banking crises.” *Journal of Finance* 56.3 (2001): 1029–1051.

Richardson, Matthew. “Regulating Wall Street: The Dodd–Frank Act.” Federal Reserve Bank of Chicago *Economic Perspectives* 36.3 (2012): 85–97.

Sironi, Andrea. “Testing for market discipline in the European banking industry: evidence from subordinated debt issues.” *Journal of Money, Credit, and Banking* 35.3 (2003): 443–472.

Thompson, Christopher. “Bank debt issuance doubles to record levels.” *Financial Times* January 19, 2015.

Zhang, Zhichao, Wei Song, Xin Sun, and Nan Shi. “Subordinated debt as instrument of market discipline: risk sensitivity of sub-debt yield spreads in UK banking.” *Journal of Economics and Business* 73 (2014): 1–21.

Table 1. SIB Debt Trades in the Secondary Market by Bond Type

Bond Type	Period			Total
	Pre-Crisis (2003:Q1 to 2007:Q3)	Crisis (2007:Q4 to 2009:Q2)	Post-Crisis (2009:Q3 to 2014:Q3)	
	#Trades	#Trades	#Trades	#Trades
Non-SND	724,953	699,049	4,270,108	5,694,110
SND	495,706	405,581	1,449,824	2,351,111
Total	**1,220,659**	**1,104,630**	**5,719,932**	**8,045,221**

Notes: This table reports the stratification of trades by bond type (SND versus non-SND) within the final sample (after merging all databases, interpolating Treasury rates, adjusting for outliers, etc.). Senior debt is higher in the pecking order vis-à-vis subordinated debt if the SIB was to become insolvent and liquidated. See Section 5 for a description of the process used to arrive at the final sample of bond trades.

Table 2. Variables Included in the Analysis

Panel A: SIB-specific variables	**Source**	**Units**	**Frequency**	**Definition**
lag(Tier 1 Capital Ratio)	FR Y-9C	%	Quarterly	Tier 1 capital ratio (BHC Consolidated) calculated as the: **sum of:** total BHC equity capital, qualifying Class A non-controlling (minority) interest in consolidated subsidiaries, qualifying restricted core capital elements, qualifying mandatory convertible preferred securities of internationally active BHCs, and other additions to (deductions from) tier 1 capital **less:** net unrealized gains (losses) on available-for-sale securities, accumulated net gains (losses) on cash flow hedges and amounts recorded in accumulated other comprehensive incomes resulting from the initial and subsequent application of FASB ASC 715-20 to defined benefit post-retirement plans, non-qualifying perpetual preferred stock, disallowed goodwill and other disallowed intangible assets, cumulative change in fair value of all financial liabilities accounted for under a fair value option that is included in retained earnings and is attributable to changes in the BHC's own creditworthiness, disallowed servicing assets and purchased credit card relationships, and disallowed deferred tax assets **divided by:** average total assets for leverage capital purposes
lag(Net Charge-offs (NCOs)/Loans)	BHCPR	%	Quarterly	Loan and lease losses/average loans and leases
lag(Inefficiency Ratio)	BHCPR	%	Quarterly	The sum of salaries and employee benefits, expense on premises and fixed assets (net of rental income), amortization expense of intangible assets, and other non-interest expenses (i.e., total noninterest expense) divided by average assets*
lag(ROAA)	BHCPR	%	Quarterly	Net income/average assets
lag(Liquidity Ratio)	BHCPR	%	Quarterly	Short-term investments (the sum of interest-bearing bank balances, federal funds sold and securities purchased under agreements to resell, and debt securities with a remaining maturity of one year or less)/consolidated assets*
lag(Net Short-term (ST) Assets/Assets)	BHCPR	%	Quarterly	The difference between earning assets that are repriceable (or that mature within one year) and the sum of interest-bearing deposit liabilities that reprice or mature within one year and long-term debt that reprices within one year divided by total assets*
lag(Positive Fair Value (FV) of Derivatives/Assets)	FR Y-9C	%	Quarterly	The sum of the gross positive fair values of derivative contracts (held for trading and for purposes other than trading) for interest rate, foreign exchange, equity derivative, and commodity/other contracts divided by consolidated assets
lag(Assets)	FR Y-9C	real $ ($000)	Quarterly	BHC consolidated assets

Table 2, continued

Panel B: Macroeconomic variables	**Source**	**Units**	**Frequency**	**Definition**
Change in S&P 500 Index	Yahoo! Finance	%	Daily	The percent change in the S&P 500 index from the previous trading day
Change in VIX	Yahoo! Finance	%	Daily	The percent change in the VIX from the previous trading day
Slope of Yield Curve	Board of Governors	%	Daily	20-year minus the 1-year Treasury rate
Change in Federal Funds Rate	Board of Governors	%	Daily	The percent change in the effective federal funds rate
lag(GDP Growth)	U.S. Bureau of Labor Statistics	%	Quarterly	"Real GDP, billions of chained 2009 dollars, seasonally adjusted annual rate"**; percent growth over the prior quarter
lag(M2 Growth)	U.S. Bureau of Labor Statistics	%	Quarterly	"M2 money stock, billions of dollars, seasonally adjusted"**; percent growth over the prior quarter
Panel C: Bond-specific variables	**Source**	**Units**	**Frequency**	**Definition**
Yield Spread	TRACE	%	Daily	All bond trades for SIBs pulled from TRACE based off stock ticker; then, based on days to maturity, a yield is calculated for an equivalent Treasury security via interpolation; the difference between the actual bond yield and the interpolated Treasury yield provides the yield spread
Time to Maturity	Mergent FISD	Years	Static	Maturity date minus the issuance date (if primary market) or trade date (if secondary market)
Issue Size	Mergent FISD	Real ($000)	Static	The par amount of the bond issuance
SND	Mergent FISD	Binary	Static	A dummy variable indicating if the bond is subordinated debt

* Definition provided by "A User's Guide for the Bank Holding Company Performance Report," available at www.federalreserve.gov/boarddocs/supmanual/bhcpr/usersguide13/0313.pdf.
** Definition provided by Federal Reserve Economic Data (FRED) repository from the Federal Reserve Bank of St. Louis.
Notes: Total SIB assets (panel A) and issue size (panel C) are transformed to real 2014:Q3 dollars using the Consumer Price Index for all urban consumers (all items) from the U.S. Bureau of Labor Statistics.

Table 3. Frequency of Bond Trades by Individual SIBs

	Pre-Crisis (2003:Q1 to 2007:Q3)		Crisis (2007:Q4 to 2009:Q2)		Post-Crisis (2009:Q3 to 2014:Q3)	
Ticker	Freq.	Percent	Freq.	Percent	Freq.	Percent
ALLY	0	0.0%	0	0.0%	25,039	0.4%
AXP	0	0.0%	40,281	3.6%	277,364	4.8%
BAC	284,406	23.3%	253,328	22.9%	1,084,305	19.0%
BBT	7,803	0.6%	11,477	1.0%	50,683	0.9%
BK	0	0.0%	8,638	0.8%	46,248	0.8%
BMO	1,133	0.1%	0	0.0%	2,036	0.0%
C	351,621	28.8%	214,139	19.4%	686,247	12.0%
CMA	3,130	0.3%	2,061	0.2%	9,194	0.2%
COF	21,773	1.8%	29,680	2.7%	69,436	1.2%
DFS	0	0.0%	0	0.0%	3,295	0.1%
FITB	6,001	0.5%	12,511	1.1%	31,517	0.6%
GS	0	0.0%	87,750	7.9%	1,206,499	21.1%
HBAN	2,363	0.2%	2,491	0.2%	1,299	0.0%
JPM	261,462	21.4%	206,457	18.7%	839,306	14.7%
KEY	11,217	0.9%	12,942	1.2%	32,459	0.6%
MS	0	0.0%	25,902	2.3%	483,242	8.4%
MTB	477	0.0%	827	0.1%	2,241	0.0%
NTRS	3,113	0.3%	2,948	0.3%	12,189	0.2%
PNC	8,785	0.7%	7,862	0.7%	67,323	1.2%
RBS	0	0.0%	0	0.0%	83,056	1.5%
RF	1,120	0.1%	8,170	0.7%	74,994	1.3%
STI	14,994	1.2%	13,013	1.2%	28,351	0.5%
STT	1,570	0.1%	2,203	0.2%	19,972	0.3%
USB	54,463	4.5%	10,696	1.0%	46,410	0.8%
WFC	183,850	15.1%	148,498	13.4%	484,267	8.5%
ZION	1,378	0.1%	2,756	0.2%	52,960	0.9%
Total	**1,220,659**	**100%**	**1,104,630**	**100%**	**5,719,932**	**100%**

Notes: This table shows the frequency of bond trades by individual SIBs in the secondary market sample during the pre-crisis, crisis, and post-crisis periods. The top four firms in terms of trading volume (liquidity) are highlighted in yellow during each business cycle period. Appendix A includes the SIB name associated with each ticker.

Table 4. Summary Statistics

	Pre-Crisis (2003:Q1 to 2007:Q3) Trades = 1,220,659 Bonds = 547 SIBs = 19				Crisis (2007:Q4 to 2009:Q2) Trades = 1,104,630 Bonds = 473 SIBs = 22				Post-Crisis (2009:Q3 to 2014:Q3) Trades = 5,719,932 Bonds = 1,269 SIBs = 26			
	mean	sd	min	max	mean	sd	min	max	Mean	sd	min	max
Panel A: SIB-specific variables												
lag(Tier 1 Ratio) (%)	6.24	1.39	4.37	17.89	7.05	2.13	4.03	17.51	7.83	1.36	5.13	19.26
lag(NCOs/Loans) (%)	0.98	0.51	-0.11	3.56	1.88	1.42	-0.01	7.38	1.69	1.63	-0.17	8.33
lag(Inefficiency Ratio) (%)	0.47	0.52	-2.93	1.84	0.53	1.23	-2.76	20.25	0.32	1.13	-5.66	10.66
lag(ROAA) (%)	1.36	0.45	0.18	3.97	0.43	0.83	-17.97	2.26	0.75	0.79	-9.69	3.90
lag(Liquidity Ratio) (%)	12.49	7.47	0.11	61.34	16.10	12.80	0.14	59.18	25.76	13.93	0.41	60.86
lag(Net ST Assets/Assets) (%)	18.24	8.72	-16.41	63.35	19.11	12.16	-5.37	44.37	31.86	12.39	-5.21	63.10
lag(Pos. FV Deriv./Assets) (%)	24.93	23.87	0.05	93.95	49.58	42.12	0.17	173.32	53.75	35.47	0.00	141.55
lag(Assets) ($ millions)	827,995	435,832	21,280	1,944,932	1,321,632	669,198	44,365	2,090,597	1,319,578	742,779	40,049	2,521,099
Panel B: Macroeconomic variables												
Change in S&P 500 Index (%)	0.06	0.69	-1.82	2.17	0.10	1.94	-5.28	6.47	0.08	0.89	-2.91	2.95
Change in VIX (%)	-0.09	4.77	-13.10	17.53	-0.46	5.82	-15.69	23.84	-0.04	5.97	-14.09	24.85
Slope of Yield Curve (%)	1.71	1.54	-0.23	4.11	3.05	0.72	0.74	4.11	3.22	0.62	2.03	4.19
Change in Federal Funds Rate (%)	0.17	2.33	-9.01	9.52	0.13	10.01	-40.00	39.24	0.12	6.73	-23.08	37.50
lag(GDP Growth) (%)	0.75	0.40	0.10	1.70	-0.95	0.91	-2.10	0.70	0.48	0.43	-0.40	1.10
lag(M2 Growth) (%)	1.31	0.57	-0.10	2.20	2.52	0.88	1.20	3.30	1.47	0.93	0.00	4.60
Panel C: Bond-specific variables												
Yield Spread (%)	1.69	1.13	-0.45	4.90	5.44	2.48	0.88	15.20	3.30	1.63	0.29	7.80
Time to Maturity (Years)	4.77	3.80	0.15	28.74	5.14	5.02	0.18	29.77	5.37	4.83	0.19	28.57
Issue Size ($ thousands)	843,737	597,012	9,519	3,462,629	1,418,690	952,760	14,306	4,496,020	1,591,388	1,020,052	6,700	4,626,411
SND (Y/N)	0.41	0.49	0.00	1.00	0.37	0.48	0.00	1.00	0.25	0.43	0.00	1.00

Notes: Summary statistics for all secondary transactions for SIBs are from 2003:Q1 through 2014:Q3 in the Mergent FISD database, for which there is complete data. The data is broken into three sub-samples across the pre-crisis, crisis, and post-crisis periods. Total assets and size of the issuance are reported in real 2014:Q3 dollars and are reported prior to log transformation.

Table 5. Determinants of SIB Debt Yield (Equation 2): The OLS Estimates

	(1)	(2)	(3)
	Variable w/out Interaction	**Interaction w/ Crisis Dummy**	**Interaction w/ Post-crisis Dummy**
	(2003:Q1 to 2007:Q3	(2007:Q4 to 2009:Q2)	(2009:Q3 to 2014:Q3)
Panel A: D-SIB Specific variables			
lag(Tier 1 Ratio)	-0.0570***	-0.1014***	-0.1224***
	(0.0015)	(0.0019)	(0.0018)
lag(NCOs/Loans)	0.0630***	0.4635***	0.0570***
	(0.0033)	(0.0046)	(0.0033)
lag(Efficiency Ratio)	-0.0593***	-0.0969***	-0.3010***
	(0.0033)	(0.0061)	(0.0034)
lag(ROAA)	-0.2807***	-0.3238***	-0.1907***
	(0.0056)	(0.0089)	(0.0057)
lag(Liquidity Ratio)	0.0736***	-0.0199***	-0.0334***
	(0.0003)	(0.0003)	(0.0003)
lag(Net ST Assets/Assets)	-0.0250***	0.0035***	-0.0127***
	(0.0002)	(0.0004)	(0.0002)
lag(Pos. FV Deriv./Assets)	0.0098***	-0.0035***	0.0066***
	(0.0001)	(0.0001)	(0.0001)
lag(log of Assets)	-0.3552***	-0.0034	-0.2870***
	(0.0056)	(0.0037)	(0.0028)
Panel B: Macroeconomic variables			
Change in S&P 500 Return	-0.0591***	0.1752***	0.0472***
	(0.0014)	(0.0022)	(0.0017)
Change in VIX	-0.0050***	0.0266***	-0.0003
	(0.0002)	(0.0005)	(0.0002)
Slope of Yield	0.4461***	-0.1331***	-0.0799***
	(0.0011)	(0.0039)	(0.0013)
Change in Federal Funds Rate	0.0079***	-0.0163***	-0.0083***
	(0.0003)	(0.0004)	(0.0003)
lag(GDP Growth)	0.1647***	-1.8062***	-0.1141***
	(0.0018)	(0.0061)	(0.0021)
lag(M2 Growth)	-0.0696***	-0.8345***	0.3865***
	(0.0013)	(0.0053)	(0.0015)
Crisis Dummy Variable	3.3618***	n/a	n/a
	(0.0882)	n/a	n/a

Post-crisis Dummy Variable	7.4846***	n/a	n/a
	(0.0648)	n/a	n/a
Panel C: Bond-specific variables			
Time to Maturity	0.0991***	-0.0032***	0.1052***
	(0.0003)	(0.0005)	(0.0003)
log of Issue Size	0.0851***	0.0390***	-0.0072***
	(0.0010)	(0.0032)	(0.0011)
SND (Y/N)	0.2313***	0.9810***	0.3359***
	(0.0016)	(0.0045)	(0.0019)
Trades	8,045,221		
Bonds	1,624		
BHCs	26		
R-squared	0.6858		
BHC Effects	Yes		

Notes: The model is a regression of yield spreads of over 8 million SIB debt trades in the secondary market against bond, bank, and (daily and quarterly) macroeconomic-specific variables (equation 2). The dependent variable is the spread between the yield on the bond trade and a constant maturity Treasury with an equivalent term structure (calculated via interpolation; see Section 5). The sample includes bond trades in the secondary market from 2003:Q1 through 2014:Q3, and the specification includes dummy variables for the crisis (2007:Q4 to 2009:Q2) and post-crisis (2009:Q3 to 2014:Q3) periods with interactions for all covariates. Columns 2 and 3 report the coefficient estimates for the interaction terms of each independent variable with a crisis dummy variable and post-crisis dummy variable, respectively. Thus, to calculate the marginal effect of an increase in each risk measure on the average yield spread during the crisis or the post-crisis periods, one simply adds the coefficient estimate in column 2 (for the crisis) or column 3 (for the post-crisis) to the coefficient estimate in column 1. We use heteroscedasticity-robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. SIB fixed effects and a constant are included in each regression, but the output is omitted to save space.

Table 6. Economic Effects of a One Standard Deviation Shock to SIB-Specific Risk Factors Across the Three Sub-Periods

Risk Measures (CAMELS)	***Marginal Impacts***			***Standard Deviations***			***Economic Effect (in bps)***		
	Pre-Crisis (2003:Q1 to 2007:Q3)	Crisis (2007:Q4 to 2009:Q2)	Post-Crisis (2009:Q3 to 2014:Q3)	Pre-Crisis (2003:Q1 to- 2007:Q3)	Crisis (2007:Q4 to 2009:Q2)	Post-Crisis (2009:Q3 to 2014:Q3)	Pre-Crisis (2003:Q1 to 2007:Q3)	Crisis (2007:Q4 to 2009:Q2)	Post-Crisis (2009:Q3 to 2014:Q3)
lag(Tier 1 Ratio)	-0.0570	-0.1584	-0.1794	1.39	2.13	1.36	-8	-34	-24
lag(NCOs/Loans)	0.0630	0.5265	0.1200	0.51	1.42	1.63	3	75	20
lag(Efficiency Ratio)	-0.0593	-0.1562	-0.3603	0.52	1.23	1.13	-3	-19	-41
lag(ROAA)	-0.2807	-0.6045	-0.4714	0.45	0.83	0.79	-13	-50	-37
lag(Liquidity Ratio)	0.0736	0.0537	0.0402	7.47	12.80	13.93	55	69	56
lag(Net ST Assets /Assets)	-0.0250	-0.0215	-0.0377	8.72	12.16	12.39	-22	-26	-47

Notes: This table shows the economic effect of a one standard deviation shock to each risk measure in bps on the yield spread. To calculate the economic effects, we take the product of the coefficient and the reported standard deviation (multiplied by 100 to convert to bps). Economic effects are calculated across the pre-crisis, crisis, and post-crisis periods for all bank-specific risk measures. To calculate the marginal effects during the crisis and post-crisis periods, we add the coefficient estimate of the risk measure from the pre-crisis period to the coefficient estimate of the interaction term between the risk measure with the crisis or post-crisis period dummy variable, respectively.

Table 7. Variance Decomposition Between Macroeconomic and SIB- and Bond-Specific Factors

	Pre-Crisis (2003:Q1 to 2007:Q3)	Crisis (2007:Q4 to 2009:Q2)	Post-Crisis (2009:Q3 to 2014:Q3)
A: R-squared (Full Specification)	0.7217	0.5538	0.7246
B: R-squared (Macro Factors Only)	0.5526	0.2924	0.1959
% Explained by Macro Factors = B/A	77%	53%	27%
% Explained by D-SIB and Bond Factors	23%	47%	73%

Notes: To calculate the proportions of variance explained by macroeconomic and SIB- and bond-specific factors, we take the following steps. First, we run the fully specified model across the pre-crisis, crisis, and post-crisis periods separately and report the R-squared values. Second, we run the model without the SIB- and bond-specific variables (i.e., only include the change in the S&P 500 index, change in the VIX, the slope of the yield curve, change in the federal funds rate, GDP growth, M2 growth, and quarter time dummies) and report the R-squared values. The latter model captures all macroeconomic effects. The difference between the R-squared values between the two models for each sub-sample period describes the proportion of variance explained by the SIB- and bond-specific variables. The test is adopted from Peria and Schmukler (2001).

Appendix A. List of U.S. SIBs

#	Ticker	SIB Name	Designation
1	ALLY	Ally Financial	D-SIB
2	AXP	American Express Company	D-SIB
3	BAC	Bank of America	G-SIB
5	BBT	BB&T	D-SIB
4	BK	Bank of New York Mellon	G-SIB
6	BMO	BMO Financial	D-SIB
7	C	Citigroup	G-SIB
8	CMA	Comerica	D-SIB
9	COF	Capital One Financial	D-SIB
10	DFS	Discover Financial Services	D-SIB
11	FITB	Fifth Third Bancorp	D-SIB
12	GS	Goldman Sachs	G-SIB
13	HBAN	Huntington Bancshares	D-SIB
14	JPM	JPMorgan Chase	G-SIB
15	KEY	KeyCorp	D-SIB
16	MS	Morgan Stanley	G-SIB
17	MTB	M&T Bank	D-SIB
18	NTRS	Northern Trust	D-SIB
19	PNC	PNC Financial Services Group	D-SIB
20	RBS	Royal Bank of Scotland Group	D-SIB
21	RF	Regions Financial	D-SIB
23	STI	SunTrust Banks	D-SIB
22	STT	State Street	G-SIB
24	USB	U.S. Bancorp	D-SIB
25	WFC	Wells Fargo	G-SIB
26	ZION	Zions Bancorporation	D-SIB

Appendix B. Correlation Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	lag(Tier 1 Ratio)	1.00																
2	lag(NCOs/Loans)	0.10	1.00															
3	lag(Inefficiency Ratio)	-0.02	0.07	1.00														
4	lag(ROAA)	0.13	-0.05	-0.62	1.00													
5	lag(Liquidity Ratio)	-0.27	-0.40	-0.43	-0.06	1.00												
6	lag(Net ST Assets/Assets)	0.32	-0.52	-0.30	0.11	0.44	1.00											
7	lag(Pos. FV Deriv./Assets)	-0.38	-0.24	-0.22	-0.31	0.69	0.30	1.00										
8	lag(log of Assets)	-0.54	0.06	0.15	-0.25	0.22	-0.17	0.45	1.00									
9	Change in S&P 500 Return	0.00	0.02	-0.01	-0.01	0.00	0.00	0.01	0.00	1.00								
10	Change in VIX	0.01	-0.01	0.00	0.01	0.01	0.01	-0.01	0.00	-0.73	1.00							
11	Slope of Yield Curve	0.18	0.33	-0.07	-0.18	0.14	0.15	0.17	0.02	0.02	-0.01	1.00						
12	Change in Federal Funds Rate	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	-0.07	0.07	0.00	1.00					
13	lag(GDP Growth)	-0.06	-0.10	0.00	0.18	0.06	0.10	-0.11	-0.05	0.00	0.02	-0.16	0.00	1.00				
14	lag(M2 Growth)	0.02	-0.12	0.12	-0.12	0.03	0.07	0.21	0.06	0.00	-0.02	-0.12	0.03	-0.48	1.00			
15	Yield Spread	0.02	0.26	0.06	-0.36	0.03	-0.08	0.21	0.05	0.03	-0.03	0.37	-0.01	-0.41	0.24	1.00		
16	Time to Maturity	-0.03	0.02	0.01	-0.03	0.07	-0.02	0.01	0.07	0.00	0.01	0.02	0.00	0.03	-0.03	0.41	1.00	
17	log(Issue Size)	-0.08	0.06	-0.06	0.01	0.14	-0.06	0.12	0.18	0.00	0.00	0.08	0.00	-0.06	0.03	0.01	-0.11	1.00

Notes: Correlation matrix for the secondary market sample (i.e., all bond trades of SIBs for debt from 2003:Q1 through 2014:Q3). Includes all continuous variables included in the analysis, excluding interaction terms.