Internal Models, Make Believe Prices, and Bond Market Cornering*

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Abstract

We show that U.S. life insurers used internal models to over-report the value of a large fraction of corporate bonds during the financial crisis. Reported credit spreads of bonds valued using internal models were lower by 220 bps, relative to similar bonds valued using traded prices or quotes. Misreporting is higher for bonds that are likely to be impaired and negatively affect regulatory ratios, for insurers that have low regulatory capital, for bonds that are opaque, and for bonds held by few insurers. Using novel data on state regulators, we document a negative correlation between supervision and misreporting within a state, for bonds held by multiple insurers. In contrast, supervision appears ineffective for bonds with single owners, which have no close pricing benchmarks. Consistent with these incentives, we find an increase in asset selection toward opaque bonds and bonds held by few insurers, which help bypass regulatory scrutiny and maximize the value of the option to use reporting discretion. Our findings have implications for the micro-structure of a segment of the corporate bond market and for properly assessing the fragility of financial institutions in bad times.

Keywords: Internal Models, Corporate Bonds, Capital Regulation, Bond Market Cornering, Life Insurers.

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1. Introduction

A wide class of financial assets, including corporate bonds, over-the-counter derivatives, and private equity, trade infrequently and have opaque prices. A common feature of such assets is that they inherently embed an *option* that provides holders discretion over reported values. When traded prices are unavailable, institutions have the flexibility to mark their asset positions using internal "models". This provides an option to report inflated asset values, which could be valuable when prices decline, balance sheets get constrained, and the marginal value of an extra unit of capital is high. Despite the large literature on agency frictions, it is not immediately obvious to what extent institutions can overcome costly internal and external scrutiny and exploit reporting discretion.[1] However, to the extent that the option remains valuable, it creates distorted incentives for portfolio selection and trading beyond what might be implied by standard risk-return characteristics of assets.[2] In particular, one way to maximize the use of discretion is to tilt selection toward opaque assets and to acquire large positions in assets (corner markets), which make reporting less verifiable because of lack of close pricing benchmarks.

We study these incentives for U.S. life insurers and their corporate bond investments. A vast majority of corporate bonds have just a handful of owners. Life insurers are also one of the largest holders of opaque bonds, e.g. privately placed debt. We examine to what extent the option to use reporting discretion matters for this behavior. We first tackle this question in an ex-post sense, i.e. conditional on selection of assets, we ask to what extent and in which bonds the use of reporting discretion is higher? Second, we evaluate to what extent this shifts ex-ante behavior and distorts portfolio selection. We uncover evidence that U.S. life insurers used internal models to over-report the value of a large fraction of bonds during the financial crisis. In aggregate, we estimate an additional decline in regulatory capital between \$9-\$18 billion, which is 30% higher than what was reported in 2008. We show shift in asset selection, towards bonds that are opaque and bonds that are held by fewer insurers, which help bypass regulatory scrutiny and maximize the value of the option to use reporting discretion.[3]

In general, it is difficult to empirically verify whether financial institutions indeed misre-

[1] See, Jensen and Meckling (1976). Various stakeholders, both within the firm (corporate governance) and outside the firm (auditors, regulators) help to rein in these frictions (see, e.g. Shleifer and Vishny (1986) and Edmans, Gabaix, and Landier (2008)).

[2] The cornerstone of the intermediary asset pricing literature, e.g., He and Krishnamurthy (2013), is the existence of agency frictions within financial institutions.

[3] A close literature shows that avoiding loss recognition creates distorted trading incentives, see, e.g. Milbradt (2012) and Ellul et. al. (2015).

port the value of assets that trade less frequently because it is hard to find reliable pricing benchmarks. For example, assets that otherwise have comparable features also trade less frequently, by definition, and do not have observable prices. In addition, to observe any misreporting, we need the option to use reporting discretion to be in-the-money (net of any costs of scrutiny), at least at certain times, for certain institutions, or for certain assets. Finally, we require exogenous shifts in the ability to use reporting discretion to evaluate its impact on portfolio selection.

To study the ex-post behavior and the extent of misreporting, we exploit a unique regulatory set-up that provides heterogeneity in the incentives to use reporting discretion for the *same* bond at the *same* point in time but *across* insurers, depending on the cost at which insurers purchased a bond.[4] U.S. life insurers hold corporate bonds at book value (historical cost) for regulatory reporting. Assets are marked down when a bond is deemed "permanently impaired", which is likely to occur when fair value starts to fall below book value due to perceived permanent changes in credit risk of a bond.[5] A permanent impairment therefore implies a decline in the total value of assets and therefore the amount of regulatory capital. Thus, the incentive to report a higher fair value depends on the book value, which in turn depends on the cost at which the bond was originally purchased. Insurers that acquired the bond at a higher cost (higher book value), would like to report a price above this high threshold in order to avoid permanent impairment. In contrast, insurers who acquired the same bond when the market value of the bond was lower, have the incentive to report a lower price or a price that is likely to be closer to the true value. This incentive structure allows us to examine whether the reported prices of the *same* bond held by different insurers line up according to the variation in the bond's acquisition cost.

Our setting also allows us to make progress for a number of additional reasons. First, corporate bonds account for over 50% of insurers' assets. Thus, negative shocks to these assets matter in a large way. Second, we observe the *reported* fair values for all bond positions held by insurance companies. Corporate bonds trade in over-the-counter markets and often a continuously observable price does not exist because many bonds trade infrequently.[6] This implies that often corporate bonds are valued using models developed by the insurance com-

[4] Regulation is not the only reason to misreport. Institutions may also over-report values for other reasons, e.g. GAAP reporting, performance driven compensation, or to avoid headline risk.

[5] See National Association of Insurance Commissioners' (NAIC) Statements of Statutory Accounting Principles (SSAP) number 26 and the discussion in Section 2.

[6] Corporate bonds have a wide spectrum of price discovery and liquidity, ranging from very liquid corporate bonds issued by large and publicly listed firms to very illiquid bonds, including privately placed debt issued by private corporations. See, for example, Collin-Dufresne, Goldstein, and Martin (2001) and Dick-Nielsen, Feldhutter, and Lando (2012) among others.

panies holding these bonds. We observe not just the reported fair values, but also whether they are computed using internal models. This allows us to compare the evolution of prices of bonds valued using internal models and bonds valued using non-internal sources (e.g. brokers) without relying on the unobserved true prices. Third, we observe the valuations during the financial crisis when balance sheets were constrained and the incentive to use reporting discretion was high. Moreover, we observe the actual extent of regulatory constraints at the firm level, which provides further cross-sectional variation in the incentives to use reporting discretion. Finally, we exploit the heterogeneity in regulatory strictness across state regulators in the U.S. to understand whether the extent of misreporting lines up with the costs of regulatory scrutiny.

Consistent with these ideas, using holdings data from 2004 to 2016, we first document significant dispersion in reported prices (and implied credit spreads) for the same bond and at the same point in time *across* insurers. Moreover, we show that this is not a general phenomena; it is concentrated in bonds that are valued using internal models and it increases sharply during the financial crisis when insurance balance sheets were constrained and the incentive to use reporting discretion was higher.[7]

Second, we show that reported prices are systematically higher (and credit spreads are lower) for bonds valued using internal models in 2008, as compared to bonds that are otherwise similar but for which external quotes are available. The economic magnitude of the difference is large and equals about 220 bps for the average bond, and increases substantially for high yield bonds for which the likelihood of impairment due to permanent change in credit risk is higher. We show these findings are not driven by model uncertainty (Hansen and Sargent (2008)), error, disagreement about fundamentals (Lintner (1969)), or insurers simply reporting stale prices and extrapolating from past prices in the absence of traded prices and broker quotes.

Third, we compare the reported credit spreads of the *same* bond, but across insurers. Consistent with the regulatory incentives described above, we find a positive and statistically significant relationship between credit spread at acquisition and the credit spread reported by insurers. Thus, when insurers acquire a bond at a higher price, they are more likely to over-report prices, which helps to reduce the likelihood of permanent impairment. However, this is not true for all bonds. It *only* holds for bonds that are valued using internal models, but not for bonds valued using traded prices or quotes, where there is no reporting discretion.

[7]These findings are consistent with alternative accounts of the health of the insurance sector during the financial crisis. See, for example, McDonald and Paulson (2014), Koijen and Yogo (2015a), which in extreme cases resulted in bail outs under TARP.

Moreover, placebo tests show that the positive relationship between between credit spread at acquisition and the credit spread reported by insurers only exists during the financial crisis and not in other years.

Fourth, the positive relationship between reported spreads and acquisition spreads is significantly higher for insurers that are relatively more constrained by regulatory capital, as measured by the ratio of available to required capital. Moreover, misreporting is higher for more constrained insurers, even when we compare the reported spreads of insurers that use internal models to those that use traded prices or quotes for the same bond.

Insurers may have limited capacity to exploit reporting discretion if close pricing benchmarks exist, e.g. another bond of the same issuer, or if the same bond is held by several insurers providing regulators with multiple reference points and making prices more verifiable. Misreporting in both such cases might have higher expected regulatory costs. Consistent with this, fifth, we find that misreporting is higher (and statistically significant) in bonds that are more opaque, e.g. privately placed bonds (390 bps), bonds of private companies (320 bps), orphan bonds, i.e. single issuance of a company (250 bps), and foreign bonds (230 bps). Misreporting is also higher in bonds that are held by fewer number of insurers. Within bonds that are valued by internal models, those that have more concentrated holding structure have an even lower increase in reported credit spreads during the crisis, as compared to internal model bonds with a less concentrated holding structure.

The absence of transaction prices that justify the use of internal models (extensive margin) and the ability to bypass regulatory scrutiny (intensive margin) help enable the use of reporting discretion. These conditions are more easily met when insurers hold larger quantities in bonds that are more opaque or when they are the dominant holder of a bond. By exercising market power and cornering the market[8] in certain bonds, insurers can reduce the number of available reference prices, which increases the search costs for regulators and makes it harder for them to verify the true value of a bond. Moreover, these bonds have lower number of participants in the secondary market, which helps to decrease transactions and quotes from broker-dealers.

Using the fragmented regulatory structure in the U.S., where insurers are regulated at the state level, and novel data on the resources available with state regulators, we confirm these hypotheses. We show that misreporting is negatively correlated with the degree of supervision in a state. The higher the supervision, the lower is the extent of misreporting.

[8] Typically, the term "market cornering" is associated with investors misusing market power and acquiring large positions to manipulate markets and generate trading profits (Allen, Litov, and Mei (2006)).

We proxy for the extent of supervision in a number of ways, including the total number of financial analysts and examiners, number of discretionary exams conducted, and the total budget per insurer within a state. Crucially, the negative relationship exists only for bonds for which regulators have multiple reference prices and breaks down for bonds that have no reference prices, implying that insurers have a greater ability to bypass regulatory scrutiny when they hold bonds for which prices are less verifiable. Moreover, we find that bonds that have a more concentrated holding structure, defined as bonds held by up to two insurers, trade less than bonds that have a less concentrated holding structure, consistent with the idea that insurers may have a greater control over the amount of trading and availability of reference prices, if it holds a substantial share of the bond's total issue.

Our findings imply that the option to use reporting discretion creates incentives to hold bonds that are more opaque and positions that are more concentrated, distorting portfolio selection ex-ante. We document a number of facts consistent with this idea. First, insurers that were in top quantile of internal models usage in 2008, high discretion insurers (HDI), hold a significantly higher share in opaque bonds and bonds that have a more concentrated holding structure, compared to insurers that used internal models, but were in the bottom quantile of usage in 2008 low discretion insurers (LDI). Second, we exploit a shift in the regulation that made it easier for insurers to use internal models and allowed greater discretion over reported values to show that HDI increased the quantity held in opaque and concentrated bonds, relative to LDI. This helps address two identification challenges, first, reverse causality, and second, that HDI hold more opaque and concentrated positions because they have have a better technology to hold bonds to maturity.

Third, to illustrate these incentives further and delve deeper into the exact mechanism, we test whether insurers increase the share of the total issuance amount held within a bond. For each bond, we quantify the dominant share, i.e. the share of the total issuance held by the largest holder of that bond. We find that dominant share increased significantly for new purchases after the regulatory shift for bonds with *small* issuance amounts. In the cross-section of insurers, the increase in dominant share is concentrated within HDI much more than LDI. Taken together, these results imply that the option to use reporting discretion likely distorts the ex-ante portfolio selection in small bonds. Intuitively, holding a large share in a bond, on one hand, allows more reporting discretion, but on the other hand, may have detrimental impact on portfolio diversification and capital requirements that are due to concentration limits. Holding a large share in bonds with *smaller* issuance size helps alleviate this trade-off problem. Our findings therefore have implications for the micro-structure of a segment of the corporate bond market.

Related Literature: Our paper contributes to broad strands of the literature on agency problems in financial institutions, heterogeneity in regulatory oversight, and micro-structure of corporate bond markets. First, our findings on reporting discretion relate to the literature on avoiding loss recognition and the misuse of models in regulatory reporting by financial institutions. Milbradt (2012) develops a theory of why constrained banks may have the incentives to suspend trading in opaque over-the-counter securities in order to avoid marking-to-market losses. Ellul, Jotikasthira, Lundblad, and Wang (2015) show that insurers facing historical cost accounting are more likely to participate in gains trading and not sell assets that have large unrecognized losses. Behn, Haselmann, and Vig (2014) show that model-based capital regulation allow banks to under-report probabilities of default and risk-weights.[9] We add to this theme by establishing a direct channel of avoiding loss recognition and regulatory misreporting in the context of corporate bond investments of life insurers during the financial crisis.[10] Our findings point to the need to design systems that are able to better assess the fragility of financial institutions in bad times.

Second, our paper relates to the upcoming literature that documents heterogeneity in regulatory oversight across different regulators and its implications for regulated entities. Agarwal, Lucca, Seru, and Trebbi (2014) show that federal regulators are systematically tougher than state regulators and document considerable heterogeneity in the strictness of bank regulators across states. Kisin and Manela (2019) show that banks that pay higher fees face more lenient regulation. In the same vein, we document heterogeneity in oversight across state regulators and show how the lack of oversight manifests itself in the actions of insurance companies.

Our paper also helps to understand concentration in ownership patterns in the corporate bond market. Prominent explanations for concentrated holding structure go back to Bolton and Scharfstein (1996), who show that lower number of creditors increase coordination and bargaining power during renegotiation. Similarly, Bris and Welch (2005) show that dispersed creditors face more difficulty and higher cost when collecting claims than concentrated creditors. We provide an alternative account of why insurance companies might have a preference for concentrated holdings. As our results show, financial assets can have additional characteristics that are of interest to financial institutions beyond the standard risk-return characteristics. Thus, our findings also help to better understand the objective

[9] Also, see Begley, Purnanandam, and Zheng (2017), and Plosser and Santos (2018).

[10] Anecdotal evidence points towards the pervasiveness of this issue beyond insurers. See for example, "Private equity's mark-to-make-believe problem" by Matthew Klein, "The Big Short: Inside the Doomsday Machine" by Michael Lewis, and "The Greatest Trade Ever: The Behind-the-scenes Story of How John Paulson Defied Wall Street and Made Financial History" by Gregory Zuckerman.

function and preferences of financial institutions, which are the key building blocks for the literature on intermediary asset pricing (He and Krishnamurthy (2013)) and characteristics based asset pricing (Koijen and Yogo (2018)).

The paper is organized as follows. Section 2 provides the institutional set-up and an overview of the regulatory structure of the U.S. insurance sector. Section 3 describes the data sources. Section 4 presents the main empirical findings on the use of internal models to misreport asset values. Section 5 documents linkages between misreporting and regulatory scrutiny, and documents the findings on ex-ante portfolio selection. Section 6 concludes.

2. Institutional Details

A large portion of U.S. life insurers' assets are invested in corporate bonds, for example, about 46% of total assets in 2013.[11] Moreover, as credit risk (unlike interest rate risk) is largely mismatch risk because of lack of matched exposures on the liability side, shocks to credit risk are an important source of variation of capital for insurance companies. The ability to use internal models allows insurance companies discretion over reported values. This could be valuable for a number of reasons, including smoothing fluctuations in regulatory or GAAP reporting, relaxing balance sheet constraints, avoiding headline risk, or smoothing performance driven compensation, features that are particularly valuable in bad times when the marginal value of an extra unit of capital is high.

We focus on the incentives arising from the regulatory framework for two reasons. First, prior literature has shown that life insurers operate subject to statutory regulation.[12] Moreover, the regulatory framework provides heterogeneity in the incentives to use reporting discretion for the same bond, at the same point in time, but across insurers, allowing us to pin-down the use of discretion cleanly. The regulatory framework also shifts over time, impacting the ability of insurers to use internal models. We describe the key features of the regulatory setting below.

2.1. Reporting Requirements

The statutory (regulatory) reporting for corporate bond assets is largely at book value (historical cost), unless a bond is deemed permanently impaired in which case insurers have

[11] See, McMenamin, Paulson, Plestis, and Rosen (2013).

[12] See, Koijen and Yogo (2015-2019), Sen and Humphry (2016), and Ge (2017) for liability side, Becker and Ivashina (2014), Ellul et. al. (2011) and Ellul et. al. (2015) for asset allocation, and Sen (2018) for risk management decisions.

to recognize "other-than-temporary-impairment" (OTTI) and mark down the value of the bond to its market value.[13] Permanent impairment is likely to occur when a bond's fair value starts to fall below book value due to perceived permanent changes in credit risk of the bond (NAIC SSAP No. 26).[14] Thus, in general mark-to-market changes in the credit risk of a bond do not impact the regulatory value of total assets. However, when a bond is permanently impaired due to changes in credit risk, insurers are forced to recognize losses, which negatively affect the total value of regulatory assets.

A key metric for state regulators to determine capital adequacy and for rating agencies to determine credit ratings is the risk based capital ratio (RBC) of insurance companies, which is defined as the ratio of total available regulatory capital (assets minus liabilities) to total required capital:

$$\text{RBC Ratio} = \frac{\text{Assets - Liabilities}}{\text{Required Capital}}$$

The National Association of Insurance Commissioners (NAIC) prescribes that insurers compute required capital at the bond level by multiplying the appropriate risk weights with the book value of a bond, where risk weights depend on the bond's credit rating. Corporate bonds are sorted into "NAIC risk categories" from 1 to 6 based on a bond's credit rating and each category is then assigned a risk weight. Category 1 (6) are the safest (riskiest) bonds and attract the lowest (highest) risk weights.[15]

Thus, permanent impairment introduces variability in RBC ratios because, first, there is a negative impact on regulatory capital (numerator of the ratio) as bond assets are marked down. Second, if accompanied with a rating downgrade, there is a simultaneous increase in required capital (denominator of the ratio). Both forces become stronger during a downturn, such as the 2008 financial crisis.

This gives *some* insures the incentive to use discretion and report higher fair values for certain bond positions and in certain times. The incentive to report a higher fair value depends on the book value at which a bond is being held, which in turn depends on the cost

[13]See NAIC Valuation Manual (2016) and Ellul, Jotikasthira, Lundblad, and Wang (2015) for a description of the statutory accounting framework for insurance companies.

[14]NAIC Statements of Statutory Accounting Principles (SSAP) number 26 states that "An OTTI shall be considered to have occurred if it is probable that the reporting entity will be unable to collect all amounts due according to the contractual terms of a debt security in effect at the date of acquisition. A decline in fair value that is an OTTI *includes* situations when a reporting entity has made a decision to sell a security prior to its maturity at an amount below its carrying value."

[15]See NAIC Risk Based Capital Guidelines (2013).

at which the bond was originally purchased.[16] Thus, we can use the variation in the initial cost of purchase, which determines the current book value of a bond, across insurers to get useful heterogeneity in the incentive to use reporting discretion for the same bond and at the same time, but across different insurers.

2.2. How are Prices Sourced and Verified?

To keep track of potential cases of permanent impairment, regulators require insurance companies to report the fair value of each position, along with the book value. The reporting guidelines, suggest that wherever possible, insurers first report traded prices or prices taken from external sources, which include quotes from broker-dealers and pricing services (e.g. IDC, Reuters, Bloomberg). In the event that it is not possible to obtain prices from external sources, insurers are allowed to compute the fair value of securities "analytically" using "internal models".[17] As a large fraction of corporate bonds trade infrequently and in over-the-counter markets, often prices are not observed continuously. Thus, the fair values for a large fraction of bonds are obtained using models developed by insurers holding the bonds.

The Role of SVO: Prior to 2008, NAIC's Securities Valuation Office (SVO) acted as an aggregator of bond valuations, which the SVO sourced from public transactions, brokers-dealers, pricing services, and from insurers' analytical models. Along with providing bond valuations, the SVO also assigned credit ratings to bonds. In 2008, a NAIC task force amended the rules and allowed insurers to obtain valuations directly from public transactions, third-party sources, and internal models, bypassing the need to go to the SVO. While, SVO could still be used to source bond valuations, going to the SVO was no longer mandatory. Thus, the role of SVO, as a provider of bond valuations, declined and insurers' discretion over reported values increased after 2008.

State Regulators: U.S. insurers are regulated at their state of domicile and not federally. State regulators conduct financial examinations and audits to ensure the solvency of insurance companies operating in their states. In particular, the responsibility to determine the veracity of regulatory reporting lies with state regulators, who employ a large number of financial examiners and analysts for this purpose. Financial examinations investigate a company's accounting methods and modeling procedures, verify and validate what is pre-

[16] For further details see, NAIC's Report on U.S. Insurer Invested Asset Other-Than-Temporary Impairments as of Year-End 2015.

[17] NAIC SSAP no. 26 states that "Whenever possible, fair value should represent the price at which the security could be sold, based on market information. Fair value should only be determined analytically when the market-based value cannot be obtained."

sented in the annual statements, and test whether the company has complied with reporting guidelines and state regulations.[18] Financial examiners specialize in these activities and are trained in the use of specialized computer audit software.[19] Any reporting discrepancy results in disciplinary "actions" such as delinquency orders, suspensions, and revocation of licenses. Financial exams are of two types, regular and discretionary. Regular exams typically occur every 3 to 5 years. However, discretionary exams occur on an ad hoc basis, at the discretion of state regulators and if special circumstances warrant more frequent examinations.

However, monitoring is highly resource intensive due to the sheer number of bonds held by insurers, decentralized reporting at the state level, and the lack of active trading and price benchmarks in the corporate bond market. Crucially, as we will also discuss in depth in the next section, a key implication of the regulatory incentive structure is for insurers to exercise market power and hold a large share of the bond's issue, which further impedes price verification for some bonds. We exploit heterogeneity in regulatory strictness across states to understand to what extent the extent of misreporting lines up with strictness and whether insurers are able to bypass regulatory scrutiny for certain positions.

3. Data

3.1. Corporate Bond Holdings

Insurance companies report fixed income holdings at the position level to state regulators at an annual frequency, which we collect from the NAIC's Schedule D database.[20] We restrict attention to corporate bond positions. For each position, we observe the bond characteristics, inclding CUSIP, the NAIC credit rating category, coupon, maturity, and special features e.g. callable, putable, convertible, and sinking fund. NAIC rating categories range from NAIC 1 to NAIC 6, where NAIC 1 are AAA, AA, and A, NAIC 2 are BBB, NAIC 3 are BB, NAIC 4 are B, NAIC 5 are CCC, and NAIC 6 are CC or below rated bonds.[21] For each position, we also observe the holding characteristics, including the par value held, the date of purchase, price paid at acquisition, the book value at the time of acquisition, and the book value at which the bond is being held currently. The sample spans from 2004 to 2016.

Although bonds are held at book value, insurers also report the "fair value" of each position, in order for regulators to determine potential cases of permanent impairment.

[18] As stated in the Insurance Department Resources Reports.

[19] States employ a number of staff for other supervisory activities, e.g. supervisors, actuaries, captive specialists, market conduct supervisors, market conduct examiners, and anti-fraud staff etc..

[20] These include treasuries, municipal bonds, asset and mortgage backed, and corporate bonds.

[21] See, NAIC Risk Based Capital Guidelines (2013).

Various valuation methods are used to compute fair values, ranging from actual transaction prices, broker quotes, pricing services (Bloomberg, IDC, Reuters), and insurers' internal models. The unique aspect of these data is that we observe insurers' own valuations for each position. We also observe whether the position is valued using internal models or other external sources. Table 1 reports the share of the corporate bond portfolio that is valued using internal models for the largest insurers by total assets. Among the top 5, Metlife and Prudential value more than 40% of corporate bonds using internal models. Table 2 reports the shares at the bond level. 45% of the bonds as a share of total par value and 38% as a share of total number of bonds are valued using internal models.

As permanent impairment occurs due to a decline in the *credit risk* of a bond and not due to shifts in bond values due to changes in interest rates, we compute the implied credit spread for each position from reported prices. We proceed as follows. First, we compute the reported price by dividing the total reported fair value of the position by the total par value of the position and then multiplying the ratio by 100, so that the computed price corresponds to a par value of $100. Second, using the computed price, a bond's remaining maturity at each year end date, coupon rate, and assuming a semi-annual payment schedule, we compute the *implied* yield-to-maturity (YTM) of the bond position.[22,23] In doing so, we exclude positions where par value, fair value, maturity date, or coupon rate are not populated. Finally, to compute the credit spread, we subtract from the implied YTM of the bond, the YTM of a comparable maturity treasury, where the YTM of treasuries are from Datastream.[24]

Table 2 reports the key summary statistics. The sample contains all bonds that were held by insurers in 2008, which amount to a total of 19,259 unique bonds from 9,615 issuers, approximately 40% of which are valued by internal models. The distribution of credit ratings is highly similar across both internal and non-internal model bonds. The median rating for both categories is 2, which corresponds to a rating of BBB. The average remaining maturity is around 8 years for internal model and 9 years for non-internal model bonds. A slightly higher fraction of internal model bonds are callable, as compared to non-internal model bonds.[25] The fraction of bonds with other specials features, e.g. putable, convertible, and sinking fund, are trivial, which we therefore do not report. We track the reported prices and credit

[22] In doing so, we also assume that the bond is a straight bond. A very tiny proportion of our sample of bonds are putable, convertible, or have sinking fund features. However, roughly about 20% of the bonds are callable. We provide robustness of our main results in the next Section, by excluding callable bonds.

[23] In effect, we have assumed that the term structure of interest rates is flat.

[24] We match the maturity of the corporate bond with the maturity of treasuries to the closest month. Datastream provides the YTM of treasuries for the following maturities: 1 month, 3 months, 6 months, 1 year, 2 years, 3 years, 5 years, 7 years, 10 years, 20 years, and 30 years. We linearly interpolate for remaining maturities starting from 1 month to 360 months (30 years).

[25] Our results are not sensitive to having callable bonds in our sample.

spreads of our sample of bonds. Consistent with the similarities in bond characteristics, internal model and non-internal model bonds have highly similar reported prices and credit spreads on average in all periods excluding 2008. The acquisition prices and costs are also roughly similar.

Table 2 also reports the holdings characteristics. The holdings data are reported at the state-subsidiary level, which is the unit of operation for U.S. life insurers. Each operating company completes regulatory filings at their state of domicile. [26] We aggregate all the bond positions at the insurance *group* level, by using NAIC operating company code to group code mappings. Our final sample contains holdings of 350 insurance groups in the U.S.. To study how holding patterns vary across the two types of bonds, for each bond, we compute the cross-insurer average of the holding amount and the duration for which a bond has been held. The table reports the distribution of these two variables. Both the holding amount and the duration held are larger for internal model bonds ($12 million and 4.3 years) than non-internal model bonds ($7 million and 3.0 years) on average, suggesting that insurers hold larger amounts of internal model bonds and that they hold these bonds for a longer period of time. We return to these differences in holding patterns in Section 5.

3.2. U.S. State Regulators' Characteristics

We collect novel data on state regulators from the NAIC's annual "Insurance Department Resources Reports" from 2005, which provide key statistics on the resources and regulatory activities of individual state insurance departments, including number and types of staff, annual budget, revenue collected, number of examinations conducted, and number of actions taken at the state level. We construct three proxies to measure the extent of supervision at the state level: total number of financial examiners and analysts (hereafter examiners) employed in a state, total number of financial exams (regular and discretionary) conducted in a state, and total budget available at the state level. We scale each variable by the number of insurers domiciled in a state. For each state, we compute the time series average of each variable from 2005 to 2008 as we want an ex ante measure of supervision, to examine its relationship with misreporting in 2008, and to capture a full cycle of exams, which occur every 3 to 5 years.

Table 3 documents the summary statistics for the 43 states in the U.S., where life insurers are domiciled. On average, there are 0.27 examiners per insurer in a state, i.e. one examiner is assigned to roughly four insurers. However, there is considerable variation across states,

[26] For example, an insurer's subsidiary in Connecticut reports holdings to state regulators at Connecticut. The same insurer's subsidiary in California reports to the California state regulator.

with some states employing only 0.07 examiners (10th percentile) and other states employing as many as 0.56 examiners (90th percentile) per insurer. We see similar heterogeneity in the total budget per insurer. The average state has about \$0.2 million per insurer, however, the standard deviation is roughly the same in magnitude. There is considerably less variation across states in the number of regular exams, as they are statutorily determined. In contrast, there is significant variation in the frequency of discretionary exams across states, with about half the states conducting no discretionary exams.

4. Internal Models and the Use of Reporting Discretion

4.1. Comparing Reported Credit Spreads Across Bonds

We start by documenting stylized facts on the reporting patterns of corporate bonds across insurers. First, reported values vary significantly across insurers for the same bond. For each bond at every valuation date, we compute the cross-insurer dispersion (standard deviation and range) in reported prices and implied credit spreads. Figure 1 shows the average dispersion from 2004 to 2016 for credit spreads and Figure A.1 shows the same for prices. There is significant dispersion in reported prices and implied credit spreads across insurers.[27] Second, the dispersion is concentrated within bonds that are valued using internal models and increases sharply during the financial crisis. For example, the average cross-insurer standard deviation in reported spreads is 160 bps, and the average difference between the highest and the lowest reported spreads is 330 bps, for bonds valued using internal models during the crisis. Reported prices show the same trend. The average cross-sectional standard deviation in reported prices is \$5 for a par value of \$100 and the average difference between the highest and the lowest reported price is \$11.

Several factors may give rise to dispersion in reported prices, e.g. disagreement about fundamentals (Lintner (1969)), model uncertainty (Hansen and Sargent (2008)), or model error, all of which can be more pronounced in a crisis. However, consistent with misreporting, the reported spreads are systematically lower (and prices are higher) during the crisis for bonds valued by internal models. Figure 2 shows the evolution of average credit spreads over time and Figure A.2 shows the same for prices. In general, the average reported spreads (and prices) of bonds valued using internal models and non-internal models are similar throughout time, except during the crisis, when the spreads (and prices) sharply diverge. Even though,

[27] In line with this, Cici, Gibson, and Merrick (2011) show dispersion in month-end valuations of identical corporate bonds held by different mutual funds. They show cross-fund pricing dispersion is higher for lower credit quality bonds, longer maturity bonds, and smaller-size issues. Price dispersion for individual bonds also increases during periods when bond market return volatility is high.

both types of bonds exhibit a significant increase in credit spreads, the reported spreads are lower for bonds valued using internal models. The same pattern is also seen for reported prices.[28] The difference in average reported values, between internal model and non-internal model bonds, is as high as 220 bps for spreads (and $8 for prices) during the crisis.

To formally illustrate that the difference in reported credit spreads between internal model and non-internal model bonds during the crisis is not due to differences in bond characteristics, we estimate the following regression:

$$\overline{CS}_{it} = \gamma(IM_i \times Crisis_t) + \beta X_{it} + \alpha_i + \alpha_t + \epsilon_{it}, \tag{1}$$

where $\overline{CS}_{it}$ is the cross insurer average of the reported credit spreads for bond i at time t, IM_i is a dummy variable that takes a value of 1 if a bond is valued using internal models by at least one insurer in 2008, $Crisis_t$ is a dummy variable that takes a value of 1 if the year is 2008 and 0 for all other years, X_{it} are bond level controls, and α_i and α_t are bond and time fixed effects. Bond level controls include credit ratings and maturity. The regression includes all bonds that were part of insurance holdings in 2008 and tracks them over time from 2004 to 2016. The main coefficient of interest is γ, which measures the increase in credit spreads in 2008 compared to all other years for internal model bonds, relative to the same change for non-internal model bonds.

Table 4 documents the main findings. In our baseline specification (column I), where we control for credit ratings and maturity, we estimate a negative and statistically significant γ at the 1% level, which implies that the increase in credit spreads for internal model bonds is significantly lower than the increase for non-internal model bonds. The economic magnitude of the difference is large and equal to 220 bps, as also seen in Figure 2. The coefficient on $Crisis_t$ is 730 bps, which captures the average increase in credit spreads for all bonds during the crisis. In column II, we add bond fixed effects and time fixed effects. Bond fixed effects control for the impact of time invariant bond characteristics, e.g. seniority, callable, coupon rate, covenants etc, on credit spreads to the extent these characteristics do not impact spreads in a different way during the crisis, an issue we return to later. Column II shows that the estimate does not change meaningfully.

In column III, we add issuer cross time fixed effects.[29] The coefficient is identified by comparing internal and non-internal bonds issued by the *same* issuer. Comparing reported

[28]Before the crisis, both types of bonds are valued slightly above par at around $104 and after the crisis at around $110. This rise is largely explained by the decrease in interest rates during this time.

[29]We identify the issuer by the first six digits of a CUSIP, which are unique to a bond issuer.

spreads within the same issuer helps in two ways. First, it controls for time varying issuer characteristics, e.g., impact of the crisis on credit quality of the issuer which may not be fully captured by credit ratings. Second, it allows us to account for model uncertainty, error, and disagreement about fundamentals to the extent they arise at the issuer level. The estimate is negative, statistically significant, and the magnitude is about 40 bps, i.e. even when we compare bonds of the same issuer, those that are valued using internal models have a significantly lower increase in spreads in 2008, controlling for several bond characteristics. The lower estimate in column III suggests that when there are other bonds issued by the same issuer, which have traded prices or external quotes, an insurer may have limited capacity to exploit reporting discretion.

One concern could be that absent traded prices, some insurers simply report stale prices, i.e. they just report 2007 prices in 2008. If some insurers report stale prices and other report true prices, then on average we may uncover a lower decline (increase) in prices (spreads) for internal model bonds. To test whether stale prices drive our results, we plot a distribution of the difference in reported spreads between 2008 and 2007 at insurer-bond level for bonds valued using internal models. If insurers report stale prices, then we expect to see a large mass at zero. Figure A.3 shows that the distribution is not concentrated at zero. On similar lines, another concern could be that insurers extrapolate using past changes in spreads. We plot a distribution of the difference in change in reported spreads between 2008 vs. 2007 and 2007 vs. 2006. If insurers extrapolate using past growth rates, then we expect to see a large mass at zero. Figure A.4 shows that the distribution is not concentrated at zero.

4.1.1. Bond Characteristics and Reporting Discretion

To understand in which types of bonds the use of reporting discretion is higher, we examine misreporting by several bond characteristics.

Investment grade vs. high yield: We first examine whether we see higher misreporting for bonds that have a higher expected default and likelihood of impairment, e.g. high yield bonds.[30] Figure A.5 plots the average credit spreads in 2008 for each rating separately. Credits spreads are consistently lower for internal model bonds within each rating category. To test whether misreporting varies by credit ratings, we quantify the difference in the reported spreads of internal model bonds and non-internal model bonds within each rating category. To do so, we re-estimate equation (1) for each NAIC rating category. Table 5

[30] The credit spread consists of expected default (cash flow component) and risk premium (e.g., compensation for default and liquidity risk). The fraction of credit spread that is due to expected default is higher for low grade and higher maturity bonds (Almeida and Philippon (2007), Huang and Huang (2012)).

shows that there is no misreporting for highly safe bonds (AAA, AA, A). The difference in spreads is 100 bps for BBB bonds, 290 bps for BB bonds, and 850 bps for bonds rated B and below, after accounting for all other bond characteristics.

Opaque bonds: Insurers may have limited capacity to exploit reporting discretion if a bond is traded frequently or if close pricing benchmarks exist, e.g. another bond of the same issuer. Misreporting in such cases might have higher expected regulatory costs. Thus, misreporting is expected to be higher in more opaque, relative to less opaque bonds. To test this idea, we use several proxies the extent of trading and whether close benchmarks are available. We compare (i) privately placed bonds vs. bonds that trade publicly; (ii) bonds of private companies vs. bonds belonging to public companies; (iii) orphan bonds, i.e. single issuance of a company, vs. non-orphan bonds, i.e. bonds for which another bond of the same issuer is available; (iv) domestic vs. foreign bonds. Table 5 shows that higher than average and statistically significant misreporting exists for privately placed bonds (390 bps), bonds of private companies (320 bps), orphan bonds (250 bps), and foreign bonds (230 bps).

4.1.2. Holding Characteristics and Reporting Discretion

Positions that are held by fewer insurers could provide greater discretion as regulators may find it harder to verify reported prices in the absence of reference prices. To test the idea that misreporting is higher in bonds that are held by few insurers, we estimate the regression below that quantifies the additional misreporting for positions with fewer insurers:

$$\begin{aligned}\overline{CS}_{it} = \lambda(CO_i \times IM_i \times Crisis_t) + \gamma(IM_i \times Crisis_t) + \delta(CO_i \times Crisis_t) + \\ + \beta X_{it} + \alpha_i + \alpha_t + \epsilon_{it},\end{aligned} \tag{2}$$

where CO_i is a dummy variable that takes a value of 1 if a bond is held by up to two insurers in 2008, which is the median number of insurers holding a bond. The rest of the variables are exactly as defined in equation (1). The coefficient λ measures whether there is a differential increase in the credit spreads in 2008 for internal model bonds that also have a more concentrated holding structure, relative to internal model bonds that have a less concentrated holding structure.

Table 6 shows that λ is negative and significant (at the 5% level). Thus, among bonds that are valued by internal models, those that have a more concentrated holding structure, have a lower increase in reported credit spreads, as compared to internal model bonds with less concentrated holding structure. In other words, the the increase in reported spreads in 2008 is the highest for non-internal model bonds, followed by internal model bonds with more than 2 holders, and finally followed by internal model bonds with less than 2 holders. The difference in spreads between more and less concentrated bonds is close to 60 bps on average, which is more than 25% of the average difference between internal and non-internal model spreads during the crisis.

4.2. Comparing Reported Credit Spreads Across Insurers

A concern about comparing internal model and non-internal model bonds is that bond characteristics could be different and that these differences impact valuations in a different way during the crisis. Even though, Table 2 shows that internal and non-internal model bonds match well across various characteristics, there could be unobserved bond characteristics, e.g. covenants, that impact valuations differently. Our setting allows us to make progress because we can compare valuations of the same bond at the same time but across insurers. We proceed in two steps. We first compare how reported credit spreads line up with acquisition credit spreads, and in particular for more constrained insurers. Second, we compare the levels of reported spreads when the same bond is held by more than one insurer and some of them use internal model and the others use traded prices or quotes.

Correlation between reported and acquisition spreads: Life insurers hold corporate bonds at book value. Regulation requires insurers to mark down assets if a bond's market value falls sufficiently below book value due to perceived permanent changes in credit risk. This negatively impacts regulatory capital and the RBC ratio, giving some insurers the incentive to report a higher fair value for certain positions. The incentive to misreport depends on the book value at which a bond is being held, which in turn depends on the cost at which the bond was originally purchased. An insurer that acquired the bond at a higher cost (higher book value), has the incentive to report a price that is close to this high threshold to avoid permanent impairment. In contrast, insurers who acquired the same bond likely at a different point in time when the market value of the bond was lower, has the incentive to report a price closer to the true value.

We illustrate the regulatory incentives with a hypothetical example. Suppose, two insurers hold a bond and both use internal models for valuation. Insurer A acquired the bond at a price of $70 and insurer B acquired the same bond at a price of $80. The book value for insurer A is $70 and for insurer B is $80.[31] Suppose, the bond was trading at $90 in 2007, but falls to $60 in 2008. Then, insurer A and B have heterogeneous reporting incentives given the regulatory framework. Insurer A would like to report a price that is close to $70 to

[31] To simplify, we ignore amortization over the life of the bond.

avoid impairment, while insurer B would like to report a price that is close to \$80. Illustration 1 depicts the idea graphically. Insurer A reports prices close to \$70 and exercises lower discretion than insurer B, who reports prices close to \$80 and exercises greater discretion. Another way to think about these incentives is in terms of the amount of mark down. If insurer B reports the true price, then it has to mark down its position by a larger amount than insurer A. Thus, insurer B has a higher incentive to misreport, all else equal.

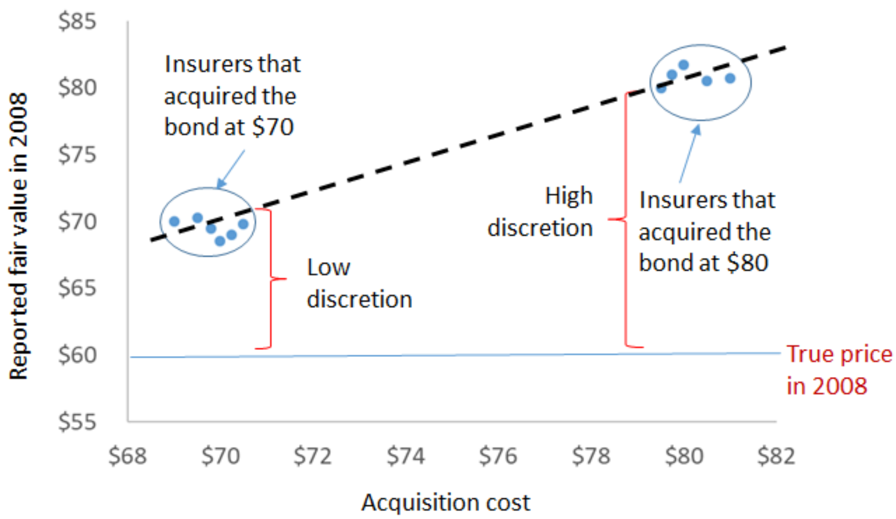

Illustration 1: Identification Strategy

This implies that we expect a positive relationship between acquisition cost (acquisition credit spreads) and reported price (reported credit spreads) for bonds valued using internal models. If insurers report truthfully and do not exercise discretion, then we would expect no relationship between reported and acquisition spreads. Similarly, if a bond is valued using traded prices or external quotes, then there is no flexibility, and we should find no relationship between reported and acquisition spreads.

To test the relationship between reported credit spreads and acquisition credit spreads in 2008, we estimate the following regression:

$$CS_{ij} = \gamma IM_{ij} + \delta CS_{ij}^{Acq} + \lambda(CS_{ij}^{Acq} \times IM_{ij}) + \alpha_i + \alpha_j + \epsilon_{ij}, \tag{3}$$

where CS_{ij} is the reported spread of bond i held by insurer j, CS_{ij}^{Acq} is the spread of bond i at the time of acquisition by insurer j, IM_{ij} is a dummy variable that takes a value of 1 if insurer j valued bond i using internal models, and α_i and α_j are bond and insurer fixed effects. Because some insurers use internal models for valuation, even though a quote or traded price might be available, thus IM_{ij} varies across insurers for the same bond and does not get absorbed by bond fixed effects. The sample includes all bonds held in 2008.

Bond fixed effects allow us to measure the correlation between reported spreads and acquisition spread by comparing the spreads of the *same* bond, but across insurers. Insurer fixed effects control for insurer characteristics that do not vary from bond to bond, e.g. RBC ratio, leverage, risk aversion, etc. Moreover, this helps control for any insurer specific model error that does not vary at the bond level, e.g. modeling of the macro-economic variables. δ measures the baseline correlation for all bonds and λ measures whether the correlation increases for positions valued using internal models.

Table 7 documents the main findings. In column I, we restrict the sample to all bonds that are valued using internal models. There is a positive and statistically significant (at the 1% level) relationship between reported credit spreads and acquisition credit spreads.[32] The magnitude is large: a 100 bps difference in credit spreads at acquisition results in a 30 bps higher reported credit spreads.[33] In contrast, there is no relationship between reported credit spreads and acquisition credit spreads for bonds that are valued using non-internal models (column II). In column III, we test for the difference in the two coefficients formally. We estimate a positive and statistically significant λ (at the 1% level), implying that when insurers acquire a bond at a higher credit spread, they are more willing to report a credit spread that is high, relative to insurers that acquired the bond at a lower credit spread. Thus, misreporting is higher in positions where the likelihood of impairment (and the impact of a potential mark-down) are higher. An insignificant δ implies that this relationship exists only for positions valued by internal models.

One concern could be that the positive correlation between reported spreads and acquisition spreads arises because of model uncertainty (Hansen and Sargent (2008)) or disagreement about fundamentals (Lintner (1969)). More optimistic insurers would place a higher value on a bond both at acquisition and at all subsequent points. Similarly, uncertainty about model parameters could lead to higher valuations both at acquisition and at all subsequent points. To alleviate this concern, we conduct placebo tests by re-estimating equation (3) in alternative years for internal model bonds. Table A.1 shows that the positive relationship only exists in 2008 and 2009, when balance sheets were constrained, but not in other years, implying that model uncertainty or disagreement about fundamentals are less likely

[32] As the estimation happens within the same bond by comparing across two different insurers, only bonds that are held by more than one insurer identify the coefficient and bonds held by just one insurer get dropped from the sample.

[33] The magnitude of the coefficient depends on the exact rule for impairment, which is discretionary, thus it is hard to form an expectation about the size of the coefficient. We, therefore, just focus on its sign.

to drive our results.

Constrained Insurers and Reporting Discretion: The incentive to use reporting discretion varies depending on insurers' extent of regulatory constraints. Insurers that are highly constrained for regulatory capital are more likely than others to report higher bond values, in order to avoid impairment and a reduction in capital. We test to what extent the relationship between reported credit spreads and the acquisition credit spreads varies in the cross-section of insurers depending on regulatory ratios. To test this, we merge the holdings data with insurers' regulatory reports to get RBC ratios in 2007 for each insurer. We split our sample in three groups: low, medium, and high RBC ratio. The "low" ("high") group are insurers in the bottom quantile of RBC ratio and thus have the highest (lowest) incentive to avoid permanent impairment. Table 8 reports the findings from estimating equation (3) on the three sub-samples. The positive relationship between reported credit spreads and the credit spread at acquisition is mainly concentrated and highest in magnitude for low RBC group, i.e. among insurers that are potentially most constrained by regulatory capital. Thus, misreporting is higher for insurers for whom the marginal value of an extra unit of regulatory capital is highest.

Differences in level of reported spreads: We next compare the levels of reported spreads when the same bond is held by more than one insurer and some of them use internal model and the others use traded prices or quotes. Table 8 shows that the coefficient on IM_{ij} is negative and statistically significant for low RBC insurers. This means that even *within the same bond*, the reported spreads of insurers that use internal models are lower compared to those that used traded prices or quotes, and by as much as 120 bps.

The magnitude of the difference is lower than what is documented in Section 4.1. This is due to two reasons. First, these estimations ignore positions where all insurers value a bond using internal models. Second, when we compare the reported spreads across different insurers for the same bond, we ignore all bonds that are held by a single insurer. As shown in Table 5, misreporting is the highest among bonds that are valued using internal models and held by few insurers. Table A.2 illustrates this point further. When a bond is held by two insurers, and one of them uses internal model and the other uses traded prices or quotes, the insurer that uses internal models reports a spread that is about 150 bps lower. As number of holders increases, misreporting declines substantially for bonds that are valued using internal models even though traded prices and quoted exist.

4.3. Forecasting Revisions in Regulatory Capital

What would the true decline in regulatory capital be if insurers reported bond valuations truthfully in 2008? To answer this question, we forecast revisions in regulatory capital for each insurer. The revised capital in 2008 is equal to the reported capital in 2008 minus the asset reduction in 2008 the insurer should have taken, had it reported correctly.

$$C^{Revised} = C^{Reported} - \sum_i \text{Asset Reduction}_i. \tag{4}$$

Insurers write down a bond position if the fair value of the bond falls below the reported book value due to perceived permanent changes in credit risk. We compute the amount of asset reduction using position level data as follows:

$$\text{Asset Reduction}_i = (BV_i^R - P_i^*)\ [\mathbb{1}_{i,IM}]\ [\mathbb{1}_{P_i^* < P_i^R}]\ [\mathbb{1}_{BV_i^R > P_i^*}]\ [\mathbb{1}_{i,Impaired}]. \tag{5}$$

Equation (5) says that the reduction for bond i is the difference between reported book value, BV_i^R, and its true fair value, P_i^*, for positions which meet the following criteria. First, the position is valued using internal models. $\mathbb{1}_{i,IM}$ is an indicator variable that takes a value of 1, if the insurer used internal models to value bond i and 0 otherwise.[34] Second, the reported price, P_i^R, is greater than the true fair value, i.e. the insurer misreported. $\mathbb{1}_{P_i^* < P_i^R}$ is an indicator variable that takes a value of 1 when this condition is met and 0 otherwise. Third, the reported book value is above the true fair value, as asset reductions happen only when the book value is higher. $\mathbb{1}_{BV_i^R > P_i^*}$ is an indicator variable that takes a value of 1 when this condition is met and 0 otherwise. Fourth, the fair value is sufficiently below the book value so that impairment is necessary. $\mathbb{1}_{i,Impaired}$ is an indicator variable that takes a value of 1 when this condition is met and 0 otherwise.

To compute P_i^* for bonds that are valued using internal models, we sort bonds into two groups. Bonds in group I are valued by some insurers using internal models and others using traded prices or broker quotes. For bonds in this group, we take the lowest price reported by a non-internal model valuer as the true fair value.[35] Bonds in group II are valued by all insurers using internal models, thus we do not have a pricing benchmark. To get the true fair value for this case, we create a pricing matrix using bonds for which traded prices or quotes existed in both 2008 and 2007. We sort bonds into rating and maturity buckets and compute the average percentage change in price between 2008 and 2007 for each bucket,

[34] We compute revisions only for positions valued using internal models and ignore cases where insurers searched for the lowest quote from a broker.

[35] We take the lowest value due to the tendency of insurers to search for the highest quote.

which we apply to all the bonds in group II by matching rating and maturity.

To identify if an impairment would have been taken place, we rely on historical cases of impairment. We compute on average how much was the fair value below the book value (in percentage terms) when an impairment took place, separately for each NAIC rating category. For example, on average the fair value of a BB bond is 15% below the book value when impairment happens. Thus, when prices decline by more than 15%, we write down assets. However, if the decline is below 15%, we do not write down assets.[36]

Table 9 shows that life insurers in aggregate should have revised down regulatory capital by an additional $9 billion (considering group I bonds only) and $18 billion (considering both group I and II bonds), which amounts to 3-5% of the reported capital in 2008. The significance of the revisions is evident when we compare with the reported decline in capital between 2008 and 2007. At the aggregate level, the reported decline in 2008 was 11%. However, it should have been between 14-16%, i.e. more than 30% higher than what was reported in 2008. A vast majority of the revisions are concentrated within the largest 20 insurers. Our estimates suggest a revision in the decline in regulatory capital from 15% to 18-20%. Overall, these facts square well with insurers' significant attempts to recapitalise during the financial crisis by using government bailouts, raising common equity, redacting dividends, and selling policies at a discount (Koijen and Yogo (2015a)).

5. Regulatory Costs and Implications for Portfolio Selection

The extent to which an insurance company can misreport bond valuations depends on two underlying conditions. First, the ability of insurers to bypass regulatory scrutiny. An insurer would like to hold bonds where there are fewer reference points available to the regulator, which would make it difficult for the regulator to pin down the true value of a bond. Second, the lack of trading in a bond significantly increases the likelihood that internal models are used for bond valuation. Thus, an insurer will be unwilling to trade itself and crucially also avoid positions where the propensity that other insurers might trade is high.

We argue that these two conditions create incentives to hold bonds that are opaque and are that are held by fewer insurers and therefore distort ex-ante selection of corporate bonds. Opaque bonds and bonds owned by fewer insurers provide regulators fewer reference price points for comparison. In addition, insurers have greater control on the amount of secondary market trading, if it owns a large market share in a bond. Indeed, insurers are some of the

[36] We use the entire sample 2004-2016 to uncover the historical impairment rule. The thresholds are NAIC 1 (10%), NAIC 2 (13%), NAIC 3 (15%), NAIC 4 (18%), NAIC 5 (32%) and NAIC 6 (45%).

largest holders of opaque bonds, e.g. privately placed debt. Moreover, the holding patterns are highly concentrated. Figure 4 shows that over 46% of bonds are held by just one insurer and over 60% of the bonds are held by up to three insurers only. To illustrate the implications for ex-ante selection, we proceed in two steps. First, we show that that bonds with fewer reference points help to bypass regulatory scrutiny and that they trade less. Second, using a regulatory change that made it easier to use internal models, we examine the impact on insurers' portfolio compositions.

5.1. Regulatory Costs

5.1.1. Bypassing Regulatory Supervision

We first investigate the extent to which regulatory strictness impacts reporting behavior. Insurance companies are regulated and supervised at their state of domicile and not at the federal level. We show that the cross-sectional dispersion in reported fair values and credit spreads is mainly concentrated within a state and not across states, i.e. insurers report different bond valuations for the same bond to the same state regulator. To quantify the proportion of within state dispersion, we compute the cross-sectional (across insurers) standard deviation of the reported fair values and credit spreads for internal model bonds within a state, i.e. for each state, we only consider reported bond prices from insurers that are domiciled in a state and ignore bond prices from insurers that are domiciled outside. The overall U.S. level dispersion is computed by combining all U.S. states as described in Section 4.1. Table A.3 shows that the bulk of misreporting is concentrated within states. The average within state standard deviation (1.1%) is 70% of the overall standard deviation (1.55%) in credit spreads of internal model bonds. In contrast, bulk of the variation for non-internal model bonds are due to across state variation.

We next document significant heterogeneity in misreporting across states. We measure the extent of misreporting within a state by the change in credit spreads for internal model bonds in 2008 compared to all other years, relative to the same change for non-internal model bonds after controlling of various bond characteristics. To do so, we re-estimate the specification in equation (1) with bond and year fixed effects (see Table 4, column II) and compute the main coefficient of interest γ_k for each state k separately.[37] For ease of

[37]The regression conditions on the bonds that existed in a state in 2008. A bond is classified as internal model within a state if at least one insurer domiciled in that state valued the bond using an internal model.

interpretation we define misreporting for state k as:

$$(6) \qquad Misreporting_k = -(\gamma_k).$$

Thus, higher values of $Misreporting_k$ indicate higher misreporting. Figure 3 documents the heterogeneity across states, where we group states by the estimated coefficient $Misreporting_k$. Misreporting is economically large (over 100 basis points) in a substantial fraction of states. At the same time, many states have almost negligible misreporting. To understand how various measures of regulatory supervision impact misreporting we estimate:

$$Missreporting_k = \alpha + \gamma(Supervision_k) + \beta X_k + \epsilon_k,$$

where $Missreporting_k$ denotes the extent of misreporting in state k as described in equation (6), $Supervision_k$ denotes the degree and quality of supervision in state k, which we proxy by number of financial analysts and examiners, number of discretionary exams, and budget per domestic insurer in a state as described in Section 3.2, X_k are controls, which include mean RBC ratio and mean log assets of all insurers domiciled in each state. We split our analysis at two levels: (i) bonds valued by internal models and owned by multiple insurers within a state which implies that a regulator has multiple reference prices for comparing reported values; (ii) bonds valued by internal models and owned by a single insurer within a state which implies that regulators have no reference price for comparison.

Table 10 documents the key findings. First, there exists a negative relationship between misreporting and the degree of supervision across all three measures for the bonds with reference prices (columns I, II, and III). Thus, the extent to which an insurance company can misreport bond valuations depends on the extent of regulatory supervision. However, this negative relationship only exists for bonds that have multiple owners within a state and therefore multiple reference prices. The relationship breaks down for bonds that have single owners and therefore no reference price. We find no relationship between misreporting and the degree of regulatory supervision in such cases (columns IV, V, VI), implying that insurers have a greater ability to bypass regulatory scrutiny when they hold more concentrated positions.

5.1.2. Creating Price Opaqueness

NAIC guidelines specify that insurers should only use internal models to value an asset when the prices are not available from an external source. In this section we analyze how concentrated ownership structure correlates with trading and availability of reference prices in the secondary market. To identify bond transactions, we merge our sample of bonds with the TRACE database. Figure 5 documents the main findings on transactions patterns. Bonds that have a more concentrated holding structure, defined as bonds that are held by up to two insurers, trade less than bonds that have a less concentrated holding structure, defined as bonds that are held by more than two insurers. Bonds that have more concentrated holding structures had on average 7 transactions in TRACE per month, in comparison to 64 transactions for bonds that have less concentrated holding structures. We formally test whether the difference is statistically significant after accounting for differences in bond and issuer specific characteristics. Table A.4 documents the findings and confirms that bonds that have a more concentrated holding structure are likely to trade less by 50 percentage points, which implies that they have lower price discovery.

5.2. Implications for Portfolio Selection

Conditional on selection of assets, we document that certain insurers find the option to use reporting discretion valuable. However, what we do not know is to what extent portfolio selection is distorted to maximize the option value of discretion? In other words, whether the option to use reporting discretion matter for ex-ante portfolio selection. Certain bond and holding characteristics - opaque bonds and bonds that are held by few insurers - allow for more misreporting. These bonds help create two conditions that facilitate misreporting. First, they minimize the costs of regulatory scrutiny by reducing the number of available reference prices. Second, they reduce the total number of participants in the secondary market, which helps to decrease transactions and quotes from broker-dealers. Thus, to the extent selection is impacted at all, insurers may prefer to hold opaque bonds and the entire (or a large enough share) of a bond's total issue.

We start by documenting stylized facts on the composition of insurers' bond portfolios. We split insurers into two groups: insurers that were in top quantile of internal models usage in 2008, high discretion insurers (HDI), and insurers that used internal model, but were in the bottom quantile of usage in 2008, low discretion insurers (LDI). To compute usage, for each insurer, we compute the share of total par value of the corporate bond portfolio that is valued using internal models. For both groups, Table 11 shows the distribution of share of total par value of the corporate bond portfolio that are opaque or have a concentrated holding structure.[38] The median LDI holds 18% of their portfolio in opaque and 7% in concentrated bonds. In contrast the median HDI holds 40% of their portfolio in opaque and 25% in concentrated bonds. Within opaque bonds, the median HDI hold substantially higher

[38]Because fair values are misreported, we show the share of total par value held.

shares across all sub-categories than the median LDI, e.g. privately placed (34% vs. 0.7%), bonds of private companies (25% vs. 0.7%), orphan bonds (16% vs. 12%), and foreign bonds (8% vs. 0.2%).

However, the differences in portfolio composition cannot be taken to conclude that ex-ante selection is distorted. First, because the reverse explanation, that insurers that have high share of opaque and concentrated bonds simply misreport more, is equally probable. Second, it can be argued that HDI have a better technology to hold bonds to maturity. As a result, they tilt selection to opaque assets like private debt and hold more concentrated positions in certain bonds, given that insurers with inferior technology do not prefer such bonds.

To get past this identification problem, we exploit a shift in the regulation that made it easier for insurers to use internal models after 2008, providing us time series variation in the use of reporting discretion. This allows us to study the shift in portfolio shares over time and across high and low discretion insurers, instead of focusing on the difference in levels. Prior to 2008, NAIC's SVO acted as the main provider of bond valuations to insurers, which the SVO sourced from public transactions, brokers-dealers, and from insurers' analytical models. In 2008, a NAIC task force amended the rules and allowed insurers to obtain valuations directly from public transactions, third-party sources, and internal models. While, SVO could still be used to source bond valuations, going to the SVO was no longer mandatory for insurers. Thus, the role of SVO as a provider of bond valuations declined and insurers' discretion over reported values increased after 2008. Moreover, the large decline in insurers' regulatory capital and the uncertainty about the future recovery of bond spreads during the financial crisis, also created significant incentives for an increased use of internal models.

To explore whether reporting discretion matters for ex-ante portfolio selection, we start by looking at the relationship between changes in opaque and concentrated bond holdings and internal models share. Figure 6 shows that there is a positive relationship between internal models share and growth in holdings of opaque and concentrated bonds after 2008 for the largest 20 insurers. Thus, even within the largest insurers that have similar total assets, shift in holdings line up with internal models share. To evaluate the shift in the quantity of opaque and concentrated bonds formally, we estimate:

$$\textit{(Opaque or Concentrated)}_{jt} = \gamma(HDI_j \times Post_t) + \beta X_{jt} + \alpha_j + \alpha_t + \epsilon_{jt}, \tag{7}$$

where $\textit{(Opaque or Concentrated)}_{jt}$ includes: (i) log of total par value; (ii) par value scaled by total assets; and (iii) par value scaled by total capital. HDI_j is a dummy variable that takes the value of 1 for insurers that are in top quantile of internal models usage in 2008 (HDI) and 0 for insurers that are in bottom quantile (LDI). We expect to see greater portfolio shifts for insurers that used more internal models. $Post_t$ is a dummy variable that takes a value of 1 from 2008, when the role of SVO declined. The main identifying assumption in using the decline in SVO's role as a shock to the use of internal models is that it is uncorrelated with shift in technology to hold bonds to maturity. X_{jt} are controls, including log(assets) and RBC ratio. α_j are insurer fixed effects and α_t are time fixed effects.

The main coefficient of interest is γ, which measures the change in holdings for HDI relative to LDI after the shock. Table 12 documents the main findings. γ is positive, statistically significant, and economically large in magnitude. As a share of total assets, opaque bonds have increased by close to 2% and concentrated bonds by 1.9% for HDI relative to LDI after 2008. The increase appears substantially high when we scale by total regulatory capital (numerator of the RBC ratio), given that insurers are highly levered.

5.2.1. Cornering the market

To illustrate these incentives further, we delve deeper into the exact mechanism by which insurers increase the quantity of opaque and concentrated bonds. The idea is not just to increase quantities, but to hold a large enough share of a bond's total issue, as by exercising market power and "cornering the market", insurers can minimize scrutiny and limit secondary market trading. However, at the same time, holding a large share in a bond could be detrimental as it implies lower diversification and more capital requirements arising due to concentration limits.[39] Holding higher amounts in bonds with *small issuance size* helps solve this trade-off problem.[40]

However, it is natural to expect that insurers will hold higher share of a bond's total issue within small bonds. For example, bonds that have a smaller issuance size may suffer from lower liquidity or higher information asymmetry, if small issuance size is correlated with firm size. If insurers prefer illiquid bonds because they are typically buy and hold investors and have long-dated liabilities, then we expect insurers to hold a higher share in bonds with smaller issuance size. Moreover, portfolio constraints that impose minimum dollar investment thresholds, because of search and monitoring costs, also imply a higher share of total issue in small bonds. To get past this, we use variation along two dimensions:

[39] NAIC deals with concentration risk by applying an asset concentration factor. The purpose of the concentration factor is to reflect the additional risk of high concentrations in single exposures (represented by an individual issuer of a security or a holder of a mortgage, etc.)

[40] This also helps to satisfy the budget constraint more easily, compared to holding a large proportion in a bond which has a large issuance amount.

across insurers and over time. To the extent that reporting discretion matters, and both HDI and LDI are equally patient and have similar minimum investment thresholds, we expect that cornering would arise more from insurers that had high internal models share. Second, the variation over time allows us to study the shift in portfolio shares over time, instead of focusing on the difference in levels.

We test these ideas using the following triple differences specification, where we compare the relative shift in the share held of a bond's total issue (issuance share) for HDI and LDI, after the shift in the regulation in 2008 for small bonds relative to large bonds. We estimate:

$$\begin{aligned} \textit{Issuance Share}_{ijt} = \gamma(HDI_j \times \textit{Small Bond}_i \times Post_t) + \delta(HDI_j \\ \times SmallBond_i) + \alpha_{it} + \alpha_{jt} + \epsilon_{ijt}, \end{aligned} \tag{8}$$

where HDI_j is a dummy variable that takes the value of 1 for insurers that are in the top quantile of internal models usage in 2008 and 0 for insurers that are in bottom quantile. $\textit{Small Bond}_i$ is a dummy variable that takes the value of 1 for bonds that are in bottom quartile in term of issuance size and 0 for bonds in the top quartile. $Post_t$ is a dummy variable that takes a value of 1 from 2008. We expect to see a greater shift in issuance share of small bonds for HDI relative to LDI, thus we expect γ to be positive.

Table 13 presents the results. We first estimate equation (8) on all bond holdings of insurers (column I). We add $Insurer \times Year$ and $Bond \times Year$ fixed effects to control for any time varying insurer or bond characteristics that impact holding patterns.γ is positive and statistically significant. As insurers typically hold bonds to maturity, we expect our results to be stronger for new purchases. To formally check this, we split holdings into existing (column II) and new purchases (column III). Column III only conditions on bonds that were added in an insurer's portfolio in any given year. $Insurer \times Year$ fixed effects allows us to control for any time varying insurer characteristics. We find stronger effects for new purchases relative to existing holdings. Thus, issuance share has increased for HDI, after the shift in the regulation, both for existing positions and for new purchases, in comparison to LDI. Taken together, these results imply that the option to use internal models likely distorts the ex-ante portfolio selection within small bonds.

6. Conclusion

In this paper, we document that U.S. life insurers used internal models to over-report the value of a large fraction of corporate bonds during the financial crisis to improve their regulatory capital positions. In aggregate, we estimate an additional decline in regulatory capital between \$9-\$18 billion, which is 30% higher than what was reported in 2008. We find greater misreporting for bonds that are likely to be impaired and negatively affect regulatory ratios, for insurers that have low regulatory capital, for bonds that are opaque, and for bonds held by few insurers. Using novel data on state regulators, we show that supervision helps to rein in this behavior, but becomes ineffective for bonds which have no close pricing benchmarks. These incentives imply distortions in asset selection towards opaque and concentrated positions that provide insurers greater discretion over reported values. We find evidence consistent with these asset selection incentives.

Our findings have implications for the micro-structure of a segment of the corporate bond market and could be helpful to design regulatory initiatives that are aimed to increase transparency and price discovery in financial markets such as MiFID and TRACE. Moreover, this channel may also hold for other financial institutions and other asset classes that share similar characteristics. For example, pension funds and endowments hold a large portfolios of private equity and real estate assets, which also suffer from a high degree of price opacity. Understanding the way financial institutions employ reporting discretion across asset classes will be helpful in properly assessing the fragility of financial institutions in bad times.

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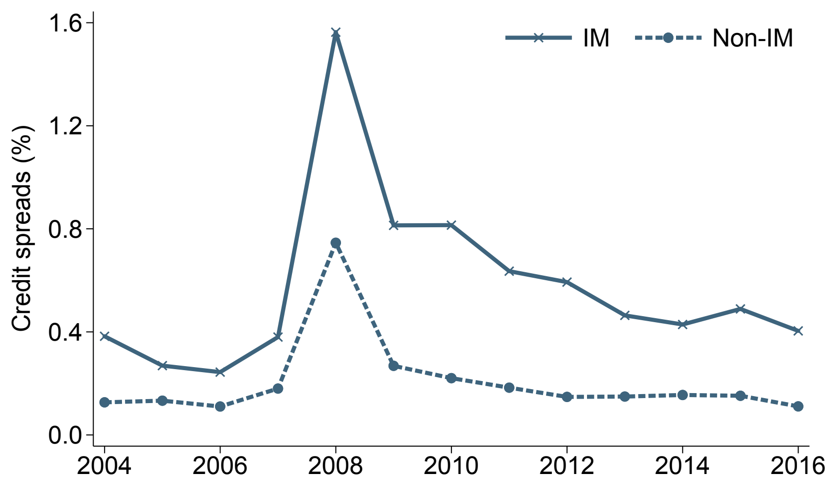
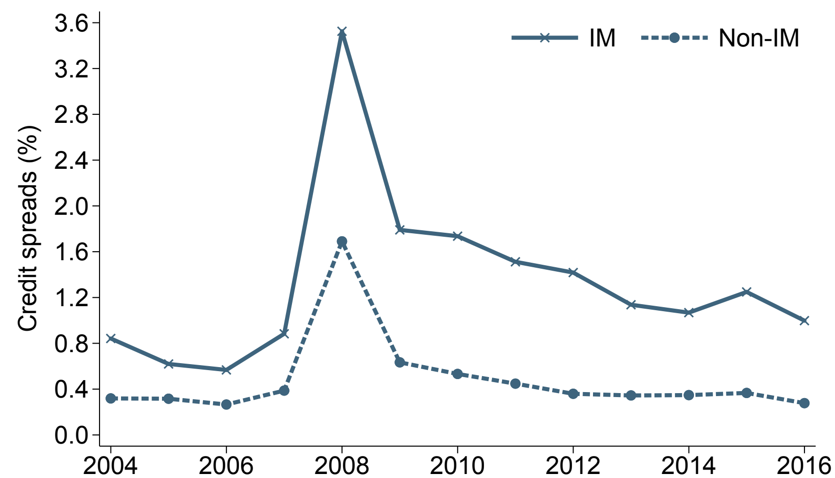
I. Figures

Figure 1: Cross Insurer Dispersion in Reported Credit Spreads

This figure shows that reported values vary significantly across insurers for the same bond. We compute cross-sectional standard deviation and range for each bond at each point in time across insurers and then compute the average standard deviation and average range for internal model (IM) and non-internal model (non-IM) valued bonds separately. A bond is classified as internal model if at least one insurer valued it using an internal model in 2008. The sample includes bonds held in 2008.



(a) Standard Deviation



(b) Range

Figure 2: Evolution of Reported Credit Spreads

The figure shows how credit spreads have changed during the financial crisis for bonds that were valued using internal models, as compared to bonds that were not valued by internal models. We compute the cross-sectional average of reported credit spreads for each bond at each point in time across insurers and then compute the mean for internal model (IM) and non-internal model (non-IM) valued bonds. A bond is classified as internal model if at least one insurer valued it using an internal model in 2008. The sample includes bonds held in 2008.

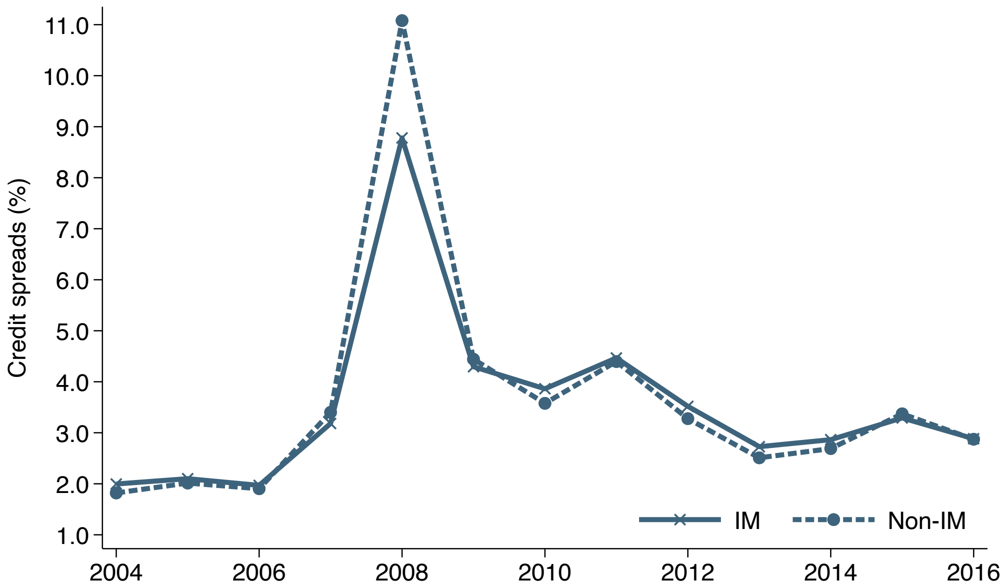


Figure 3: Misreporting Across U.S. States

The figure shows the extent of misreporting within each state. To quantify misreporting, we re-estimate the specification in equation (1) with bond and year fixed effects and compute the main coefficient of interest γ for each state separately. We split states into four groups by the estimated coefficient, e.g. 1%-2% means an estimated misreporting between 100 to 200 bps.

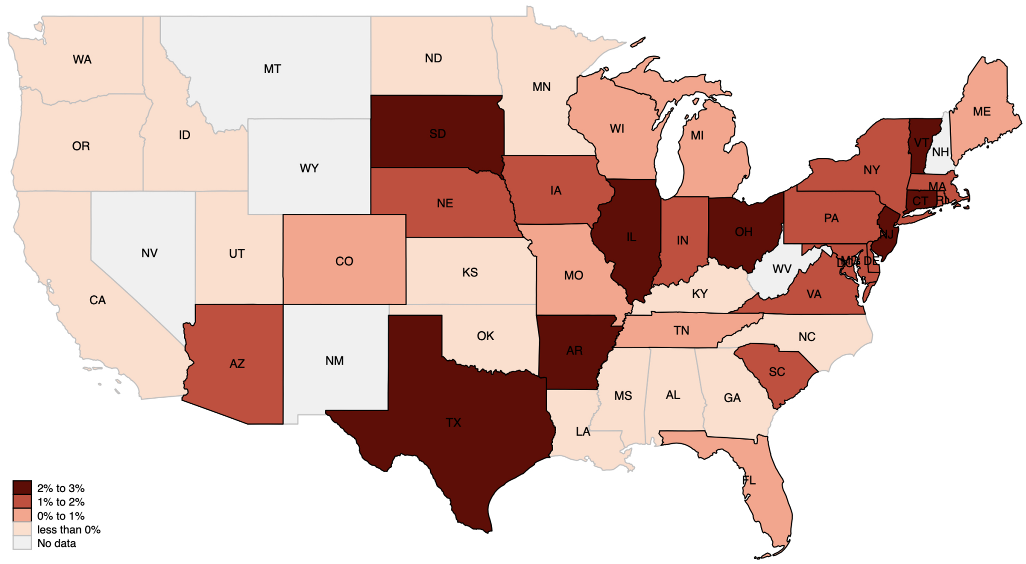


Figure 4: Concentration in Holding Structure of Corporate Bonds

The figure shows a distribution of number of insurers holding a particular bond in 2008.

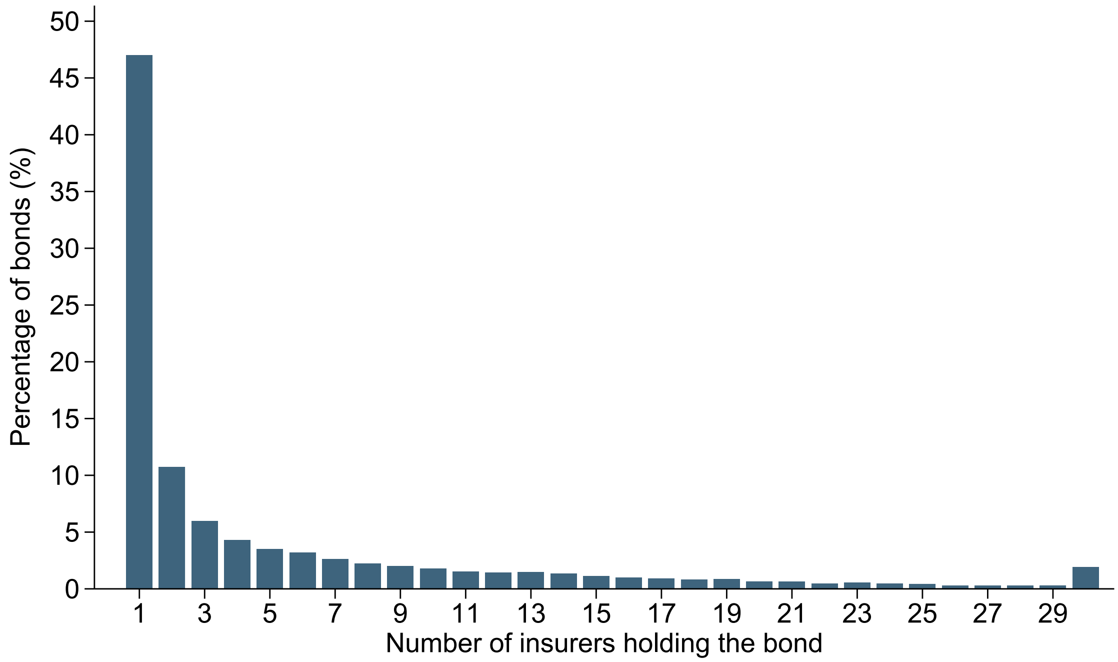


Figure 5: Number of Transactions in TRACE

The figure shows the number of TRACE transactions during the crisis for bonds with more concentrated holding structure (held by up to two insures), as compared to bonds with less concentrated holding structure (held by more than two insures).

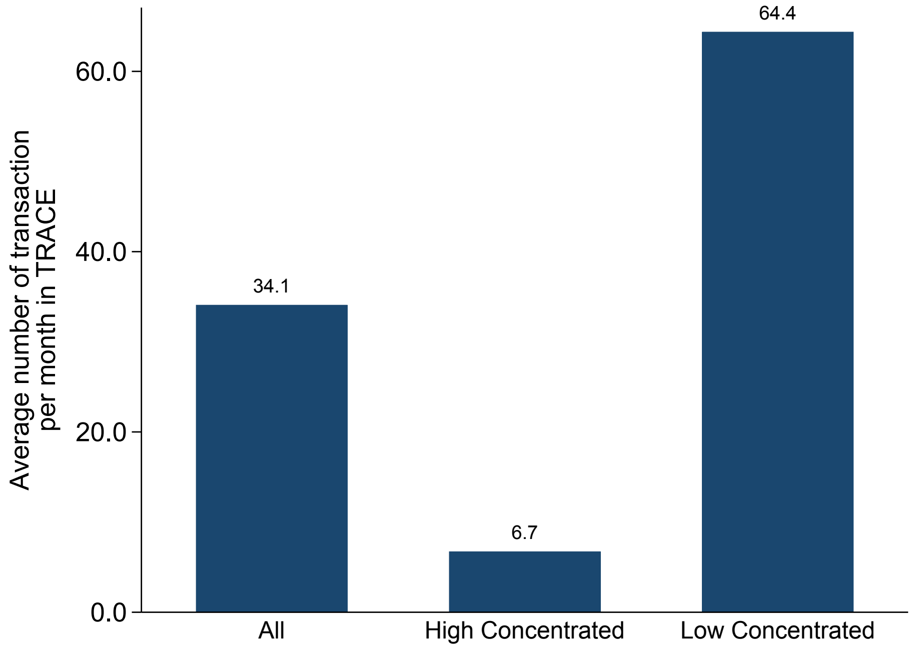
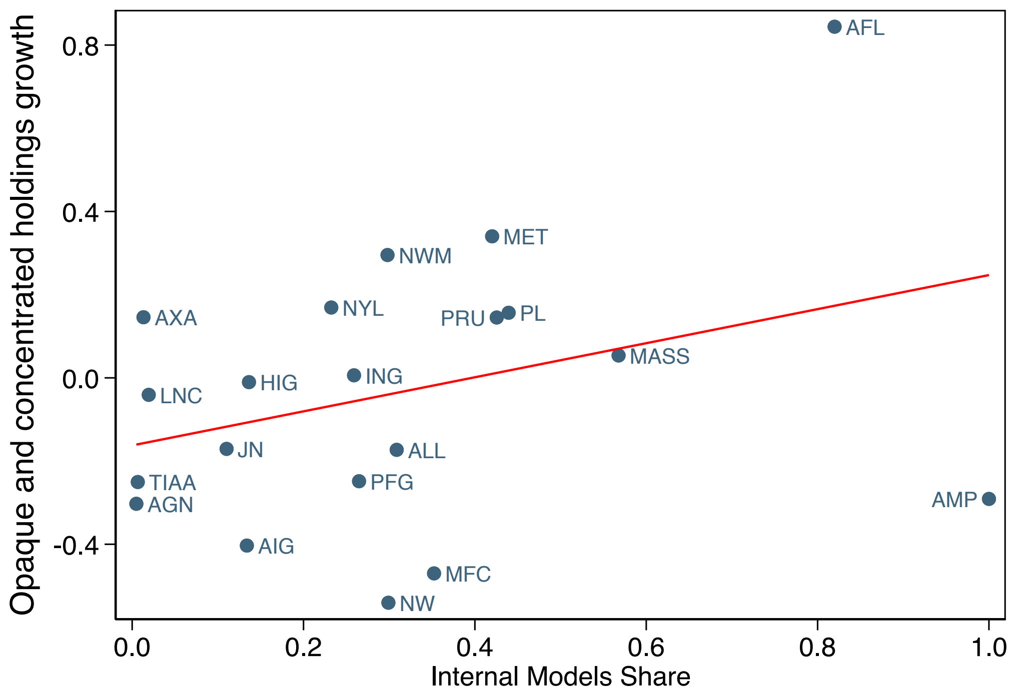


Figure 6: Shift in Asset Selection

The figure shows the shift in asset selection towards bonds that are opaque and are held by fewer insurers for the largest insurance companies sorted by total assets. We plot the log change in total par value held for concentrated and opaque bonds between 2006 and 2010 on the Y axis. Concentrated bonds are bonds held by up to two insures and opaque bonds include, private placements, bonds of private companies, orphan bonds, and foreign bonds. The X axis is the internal model share in 2008.



II. Tables

Table 1: Share of Bonds Valued by Internal Models - Largest 20 Insurers

The table shows the share of the total corporate bond portfolio that is valued using internal models in 2008 for the largest 20 insurers. Internal models share is computed by dividing the par value of bonds valued using internal models by the total par value of the entire bond portfolio.

Insurer	Total assets (2007; $ Billion)	Internal models share (2008; %)
Metlife	471	42.2
Prudential Financial	389	42.9
AIG	380	13.1
Hartford	271	14.2
Manulife Financial	219	35.6
TIAA	200	0.7
Aegon	199	0.4
New York Life	196	23.3
ING	191	26.3
AXA	160	1.3
Northwestern Mutual	157	29.6
Lincoln National	156	2.0
Principal Financial	136	26.5
Massachusetts Mutual	132	56.9
Nationwide	111	29.9
Pacific Life	99	44.8
Allstate	90	31.0
Ameriprise Financial	85	100.0
Jackson National	81	11.1
Genworth Financial	71	19.9

Table 2: Bond and Holdings Characteristics

Table shows descriptive statistics for internal model (Panel A) and non-internal model bonds (Panel B) for the year 2008. A bond is defined as "internal model" if at least one insurance company valued the bond using an internal model in 2008.

	Mean	StDev	P10	P25	Median	P75	P90
Panel a: Internal model							
Number of bonds	7340						
Proportion by par value	45.3%						
Number of issuers	3830						
NAIC rating	2.09	1.18	1.00	1.00	2.00	2.00	4.00
Remaining maturity	7.74	5.90	2.17	3.75	6.00	9.58	16.08
Callable share (%)	26						
Credit spread (2008)(%)	8.78	8.58	3.55	4.85	6.41	9.37	15.00
Reported price (2008)	90.34	18.12	67.81	84.74	95.01	101.07	106.22
Credit spread (excl 2008)(%)	3.57	3.92	1.33	1.82	2.56	3.83	6.12
Reported price (excl 2008)	104.24	11.93	95.78	100.71	105.02	110.08	115.11
Credit spread (acquisition)(%)	3.08	3.24	0.95	1.47	2.23	3.64	5.64
Reported price (acquisition)	98.23	12.00	95.54	99.44	100.00	100.00	103.51
Holding Size (million)	12.03	22.76	1.00	3.17	7.33	13.50	24.00
Duration held (years)	4.31	3.77	0.53	1.44	3.46	5.79	9.59
Panel b: Non-internal model							
Number of bonds	11919						
Proportion by par value	54.7%						
Number of issuers	5785						
NAIC rating	2.13	1.32	1.00	1.00	2.00	3.00	4.00
Remaining maturity	8.95	7.39	2.25	3.83	6.17	11.00	21.58
Callable share (%)	17						
Credit spread (2008)(%)	11.08	11.73	3.31	4.53	6.93	13.02	22.94
Reported price (2008)	84.19	22.42	51.35	70.59	89.47	100.40	106.13
Credit spread (excl 2008)(%)	3.64	4.05	1.16	1.67	2.54	4.22	6.75
Reported price (excl 2008)	103.56	12.83	92.35	98.44	103.61	109.88	117.15
Credit spread (acquisition)(%)	3.58	3.95	1.04	1.68	2.58	4.26	6.94
Reported price (acquisition)	98.28	11.91	91.60	97.68	99.99	100.74	106.48
Holding Size (million)	7.06	10.57	0.28	1.53	4.82	9.01	14.38
Duration held (years)	3.04	2.99	0.38	0.88	2.05	4.42	6.75

Table 3: State Regulators' Characteristics

Table shows the descriptive statistics for the resources available with and the measures of supervision taken by state insurance regulators from 2005 to 2008.

	Mean	StDev	P10	P25	Median	P75	P90
Domiciled insurers	170	154	45	66	110	208	382
Examiners per insurer	0.27	0.19	0.07	0.13	0.22	0.34	0.56
Budget per insurer ($ million)	0.20	0.19	0.05	0.08	0.15	0.32	0.38
Discretionary exams per insurer	0.02	0.03	0.00	0.00	0.00	0.02	0.05
Regular exams per insurer	0.23	0.08	0.13	0.17	0.22	0.29	0.32
Observations	43						

Table 4: Internal Models and Reporting Discretion

The table shows the difference in credit spreads between internal model bonds and non-internal model bonds during the financial crisis relative to other periods. We estimate:

$$\overline{CS}_{it} = \gamma(IM_i \times Crisis_t) + \beta X_{it} + \alpha_i + \alpha_t + \epsilon_{it},$$

where $\overline{CS}_{it}$ is the cross insurer average of the reported credit spreads for bond i at time t, IM_i is a dummy variable for bond i that takes a value of 1 if it is valued by internal models by at least one insurer in 2008, $Crisis_t$ is a dummy variable that takes a value of 1 if the year is 2008 and 0 in all other years, X_{it} are bond level controls, which include credit ratings and maturity, and α_i and α_t are bond and time fixed effects. The regression includes all bonds that were part of insurance holdings in 2008 and tracks them over time from 2004 to 2016. For column I, a constant is estimated but not reported. Table shows standard errors in parentheses, which are clustered at the bond level. Significance: * 10%; ** 5%; *** 1%.

	I	II	III
$IM_i \times Crisis_t$	-0.022***	-0.022***	-0.004***
	(0.001)	(0.001)	(0.001)
$Crisis_t$	0.073***		
	(0.001)		
IM_i	0.000		
	(0.000)		
R^2	0.439	0.661	0.923
Observations	124163	122974	89043
Controls	Yes	Yes	Yes
Bond Fixed Effects	No	Yes	Yes
Year Fixed Effects	No	Yes	NA
Year × Issuer Fixed Effects	No	No	Yes

Table 5: Bond Characteristics and and Reporting Discretion

The table shows the difference in credit spreads between internal model bonds and non-internal model bonds during the financial crisis relative to other periods for various segments of the data by estimating equation (1) for separate sub-samples. Panel A breaks down various NAIC rating categories, which range from NAIC 1 to NAIC 6, where NAIC 1 are AAA, AA, and A, NAIC 2 are BBB, NAIC 3 are BB, NAIC 4 are B, NAIC 5 are CCC, and NAIC 6 are CC or below rated bonds. Panel B documents results for various proxies for a bon'd price opacity: (i) privately placed bonds (PP) vs. bonds that trade publicly (non-PP); (ii) bonds of private companies (Private) vs. bonds belonging to public companies (Public); (iii) orphan bonds, i.e. single issuance of a company, vs. non-orphan bonds, i.e. bonds for which another bond of the same issuer is available; (iv) domestic vs. foreign bonds. The regression conditions on bonds that existed in 2008 and the sample starts in 2004 and ends in 2016. Table shows standard errors in parentheses, which are clustered at the bond level. Significance: * 10%; ** 5%; *** 1%.

	NAIC Ratings				Private Placements		Private Firms		Orphan		Foreign	
	NAIC 1	NAIC 2	NAIC 3	NAIC 4+	Non-PP	PP	Public	Private	Non-Orphan	Orphan	Domestic	Foreign
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
$IM_i \times Crisis_t$	-0.001	-0.010***	-0.029***	-0.085***	-0.008***	-0.039***	-0.013***	-0.032***	-0.020***	-0.025***	-0.022***	-0.023***
	(0.001)	(0.001)	(0.003)	(0.006)	(0.002)	(0.003)	(0.002)	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)
R-squared	0.657	0.707	0.723	0.661	0.642	0.709	0.647	0.706	0.656	0.666	0.657	0.702
Observations	51444	45158	10219	12848	82506	40468	89486	33488	95511	27463	110225	12749
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6: Concentrated Positions and Reporting Discretion

The table shows whether misreporting is greater for positions that have fewer insurers. We estimate:

$$\overline{CS}_{it} = \gamma(IM_i \times Crisis_t) + \delta(CO_i \times Crisis_t) + \lambda(CO_i \times IM_i \times Crisis_t) + \beta X_{it} + \alpha_i + \alpha_t + \epsilon_{it},$$

where $\overline{CS}_{it}$ is the cross insurer average of the reported credit spreads for bond i at time t, CO_i is a dummy for bond i and takes a value of 1 if the bond is held by less than or equal to two insurers in 2008 (which is the median number of insurers holding a bond), IM_i is a dummy variable for bond i that takes a value of 1 if it is valued by internal models by at least one insurer in 2008, $Crisis_t$ is a dummy variable that takes a value of 1 if the year is 2008 and 0 in all other years, X_{it} are bond level controls, which include credit ratings and maturity, and α_i and α_t are bond and time fixed effects. Table shows standard errors in parentheses, which are clustered at the bond level. Significance: * 10%; ** 5%; *** 1%.

	I
$CO_i \times IM_i \times Crisis_t$	-0.006**
	(0.002)
$IM_i \times Crisis_t$	-0.019***
	(0.001)
$CO_i \times Crisis_t$	0.003
	(0.002)
R^2	0.661
Observations	122974
Controls	Yes
Bond Fixed Effects	Yes
Year Fixed Effects	Yes

Table 7: The Role of Regulatory Incentives

The table shows the relationship between reported credit spreads and acquisition credit spreads during the crisis. We estimate:

$$CS_{ij} = \gamma IM_{ij} + \delta CS_{ij}^{Acq} + \lambda(CS_{ij}^{Acq} \times IM_{ij}) + \alpha_i + \alpha_j + \epsilon_{ij},$$

where CS_{ij} is the reported credit spread of bond i held by insurer j, CS_{ij}^{Acq} is the acquisition credit spread of bond i by insurer j, IM_{ij} is a dummy variable for bond i that takes a value of 1 if insurer j valued the bond using an internal model, and α_i and α_j are bond and insurer fixed effects. The sample includes all bonds held in 2008. We first estimate the model separately for IM bonds (Column I) and non-IM bonds (Column II) and subsequently estimate the model on full sample (Column III). Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	IM	Non-IM	All
	I	II	III
CS_{ij}^{Acq}	0.305***	0.005	0.013
	(0.056)	(0.010)	(0.010)
IM_{ij}			-0.003
			(0.002)
$CS_{ij}^{Acq} \times IM_{ij}$			0.121***
			(0.042)
R^2	0.752	0.969	0.953
Observations	8257	83165	94424
Bond Fixed Effects	Yes	Yes	Yes
Insurer Fixed Effects	Yes	Yes	Yes

Table 8: Regulatory Incentives - Cross-Sectional Split by Regulatory Constraints

The table shows the relationship between reported credit spreads and acquisition credit spreads during the crisis for insurers with low, medium, and high RBC Ratio in 2007. We estimate:

$$CS_{ij} = \gamma IM_{ij} + \delta CS_{ij}^{Acq} + \lambda(CS_{ij}^{Acq} \times IM_{ij}) + \alpha_i + \alpha_j + \epsilon_{ij},$$

where CS_{ij} is the reported credit spread of bond i held by insurer j, CS_{ij}^{Acq} is the acquisition credit spread of bond i by insurer j, IM_{ij} is a dummy variable for bond i that takes a value of 1 if insurer j valued the bond using an internal model, and α_i and α_j are bond and insurer fixed effects. The sample includes all bonds held in 2008. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	Low RBC	Medium RBC	High RBC
	I	II	III
CS_{ij}^{Acq}	0.006	0.001	0.058
	(0.016)	(0.011)	(0.035)
IM_{ij}	-0.012**	0.001	-0.004
	(0.005)	(0.002)	(0.003)
$CS_{ij}^{Acq} \times IM_{ij}$	0.354**	0.036	0.079*
	(0.165)	(0.029)	(0.046)
R^2	0.972	0.961	0.958
Observations	15323	54697	15791
Bond Fixed Effects	Yes	Yes	Yes
Insurer Fixed Effects	Yes	Yes	Yes

Table 9: Forecasting Revisions in Regulatory Capital

The table shows revisions in regulatory capital if insurers reported bond valuations truthfully in 2008. The decline in 2008 is relative to capital on Q4 2007. Asset reductions are computed by splitting bonds into two groups. Group I are bonds for which quotes or traded prices are available from another insurer holding the same bond. Group II are bonds for which quotes or traded prices are not available. For Group II bonds, we compute true bond values by using rating and maturity matched price changes from traded bonds as a benchmark. Top 20 insurers are the largest 20 insurers by total assets in 2007.

	Reported capital ($ billion)		Asset reduction ($ billion)		% Decline in capital	
	Capital (2008)	Decline	I	I & II	Reported	Revised
All insurers	331	41.7	9.3	18.3	11%	14%-16%
Top 20 insurers	209	36.7	7.2	11.4	15%	18%-20%

Table 10: Regulatory Supervision and Misreporting

The table shows the relationship between misreporting and regulator's level of strictness in 2008 across U.S. states. We estimate:

$$Misreporting_k = \alpha + \gamma(Supervision_k) + \beta X_k + \epsilon_j,$$

where $Misreporting_k$ denotes the level of misreporting by insurers in state k and $Supervision_k$ denotes the level of supervision by regulator in state k. Supervision is measured in three different ways: (i) total number of financial examiners and analysts employed in a state; (ii) total number of discretionary exams conducted in a state, and (iii) total budget available at the state level. We scale each variable by the number of insurers domiciled in a state. X_k represents the controls, which include mean RBC ratio and mean log assets of all insurers in a state. $Misreporting_k$ and $Supervision_k$ are standardised by scaling them with their standard deviations. Significance: * 10%; ** 5%; *** 1%.

	With Reference Prices			No Reference Prices		
	I	II	III	IV	V	VI
Examiners per insurer	-0.266***			-0.015		
	(0.096)			(0.138)		
Discretionary exams per insurer		-0.151*			0.036	
		(0.086)			(0.094)	
Budget per insurer			-0.179*			-0.059
			(0.091)			(0.088)
R^2	0.219	0.184	0.192	0.0553	0.0564	0.0585
Observations	43	43	43	43	43	43
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Table 11: Composition of Bond Portfolios

The table shows the distribution of share of total par value of the corporate bond portfolio that are opaque or have a concentrated holding structure in 2008. Panel (a) provides descriptive statistics for insures that were in bottom quantile of internal model usage (LDI) and panel (b) provides the same for insures that were in top quantile (HDI). Opaque bonds are broken into four subcategories: (i) private placements; (ii) bonds issued by private firms; (iii) orphan bonds; and (iv) foreign bonds. Concentrated bonds are defined as bonds held by up to two insurers.

	Mean	StDev	P10	P25	Median	P75	P90
Panel A: Low Discretion Insurers (LDI)							
A1. Opaque	17.90	8.61	10.21	11.12	16.29	23.07	30.36
Private Placements	4.79	8.33	0.00	0.00	0.67	5.26	18.14
Foreign	1.81	3.18	0.00	0.00	0.20	1.48	8.36
Private Firms	3.89	6.69	0.00	0.00	0.67	4.06	14.64
Orphan	13.79	5.63	8.03	10.33	12.48	17.87	21.16
A2. Concentrated Holdings	7.45	9.24	0.82	2.17	4.06	9.29	16.37
Panel B: High Discretion Insurers (HDI)							
B1. Opaque	40.41	21.84	7.96	19.86	47.75	51.28	59.83
Private Placements	27.16	20.84	0.00	0.23	33.79	42.49	47.36
Foreign	10.28	13.17	0.00	0.00	7.73	15.43	20.20
Private Firms	19.62	16.19	0.00	0.00	24.90	34.77	35.97
Orphan	18.28	12.04	1.38	12.23	16.37	23.00	41.25
B2. Concentrated Holdings	25.25	22.46	2.37	7.88	20.51	36.64	52.67

Table 12: Shift in Opaque and Concentrated Bonds

The table shows the shift in quantity of opaque and concentrated bonds for HDI and LDI in 2008. We estimate:

$$\mathit{(Opaque\ or\ Concentrated)}_{jt} = \gamma(HDI_j \times Post_t) + \beta X_{jt} + \alpha_j + \alpha_t + \epsilon_{jt},$$

where HDI_j is a dummy variable that takes the value of 1 for insurers that are in top quantile of internal models usage in 2008 and 0 for insurers that are in bottom quantile. $Post_t$ is a dummy variable that takes a value of 1 from 2008. The first three columns are for opaque bonds and the last three columns are for concentrated bonds. In columns I and IV, the dependent variable is log par value, in columns II and V, the dependent variable is par value scaled by total assets, and in columns III and VI, the dependent variable is par value scaled by regulatory capital. The sample is from 2004 to 2011 (four years before and after the crisis). Controls include RBC ratio and log assets. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	Opaque bonds			Concentrated holding bonds		
	I	II	III	IV	V	VI
$HDI_j \times Post_t$	0.364**	0.023***	0.233**	0.370*	0.019**	0.195**
	(0.157)	(0.008)	(0.112)	(0.207)	(0.009)	(0.096)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Insurer Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	352	352	352	352	352	352
R-squared	0.99	0.92	0.93	0.98	0.83	0.88

Table 13: Market Cornering for Small Bonds

The table shows the shift in issuance share for HDI and LDI in 2008. We estimate:

$$Issuance\ Share_{ijt} = \delta(HDI_j \times Small\ Bond_i) + \gamma(HDI_j \times Small\ Bond_i \times Post_t) + \alpha_{it} + \alpha_{jt} + \epsilon_{ijt},$$

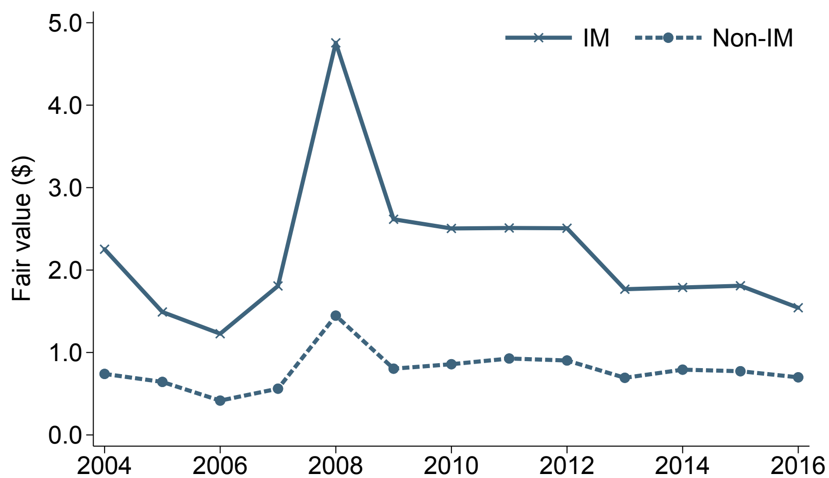
where HDI_j is a dummy variable that takes the value of 1 for HDI and a value of 0 for LDI. HDI are in the top quantile of internal models usage in 2008 and LDI are in the bottom quantile. $Small\ bonds_i$ is a dummy variable that takes the value of 1 for bonds with issuance size in bottom quartile and a value of 0 for bonds with issuance size in top quartile. $Post_t$ is a dummy variable that takes a value of 1 from 2008. Column I includes all bonds, column II only existing holdings, and column III new purchases. The sample is from 2004 to 2011 (four years before and after the crisis). Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	All	Existing	New Purchases
	I	II	III
$HDI_j \times Small\ Bond_i$	0.008	0.006	-0.002
	(0.008)	(0.008)	(0.010)
$HDI_j \times Small\ Bond_i \times Post_t$	0.012**	0.013**	0.032**
	(0.005)	(0.005)	(0.016)
Insurer × Year Fixed Effects	Yes	Yes	Yes
Bond × Year Fixed Effects	Yes	Yes	N.A.
Bond Fixed Effects	N.A.	N.A.	Yes
Observations	113,241	105,175	20,209
R-squared	0.67	0.66	0.74

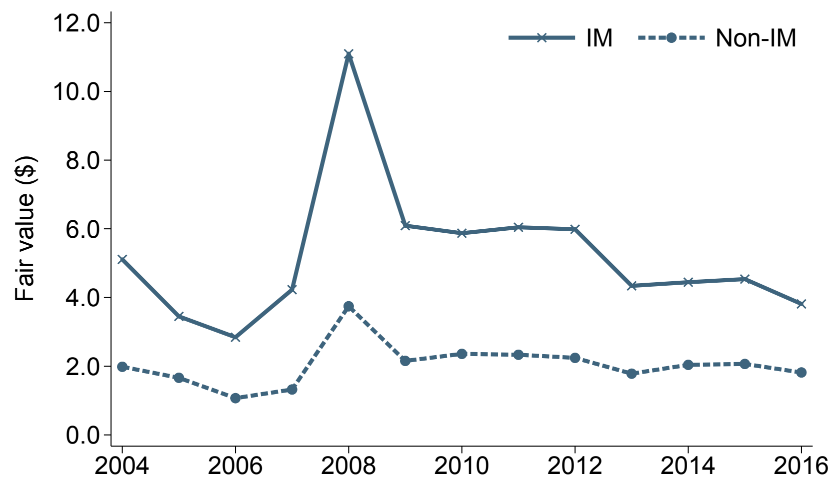
A. Additional Figures and Tables

Figure A.1: Cross Insurer Dispersion in Reported Fair Values

This figure shows the average cross-sectional standard deviation and range of reported fair values. We compute cross-sectional standard deviation and range for each bond at each point in time across insurers and then compute the average standard deviation and average range for internal model (IM) and non-internal model (non-IM) valued bonds separately. A bond is classified as internal model if at least one insurer valued it using an internal model in 2008. The sample includes bonds held in 2008.



(a) Standard Deviation



(b) Range

Figure A.2: Evolution of Reported Fair Values

The figure shows how fair values have changed during the financial crisis for bonds that were valued using internal models, as compared to bonds that were not valued by internal models. We compute the cross-sectional average of reported fair values for each bond at each point in time across insurers and then compute the mean for internal model (IM) and non-internal model (non-IM) valued bonds. A bond is classified as internal model if at least one insurer valued it using an internal model in 2008. The sample includes bonds held in 2008.

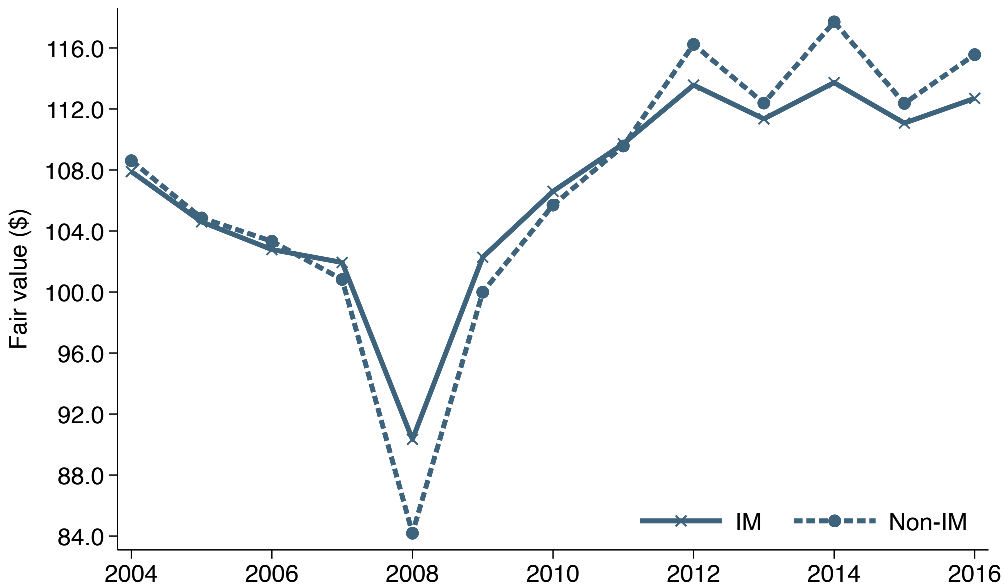


Figure A.3: Stale Prices

The figure shows the distribution of the difference in reported spreads between 2008 and 2007 at insurer-bond level, for bonds valued using internal models.

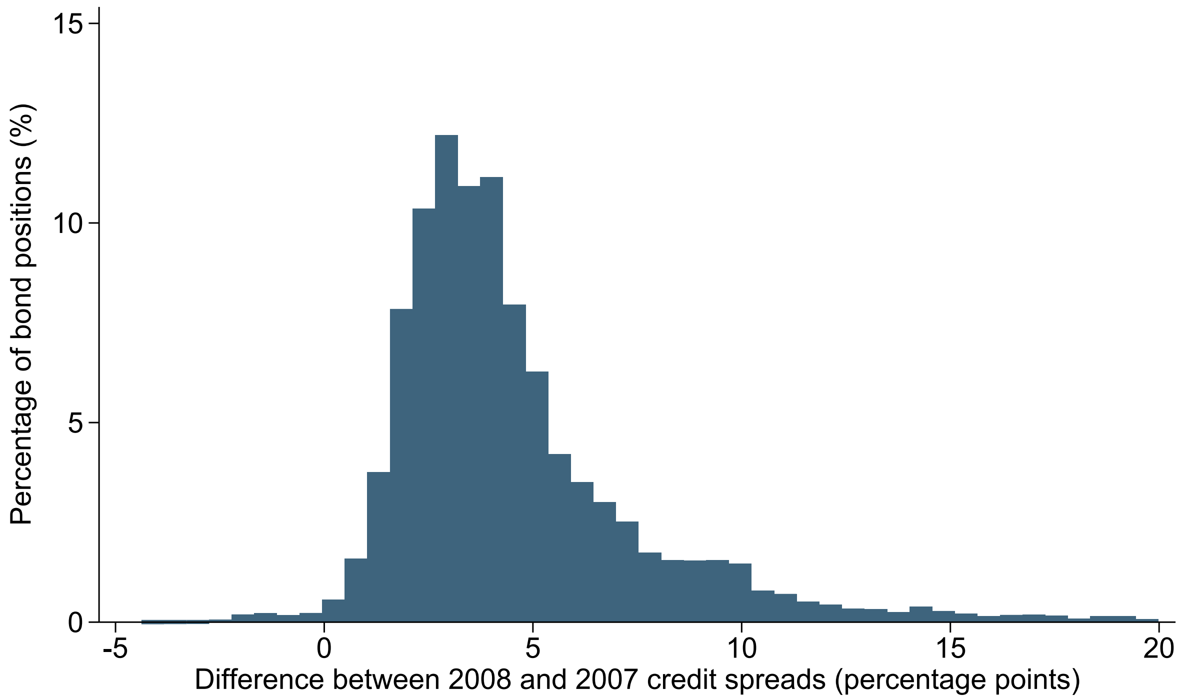


Figure A.4: Extrapolation

The figure shows the distribution of the difference in the growth rate of reported spreads between 2008 (growth from 2008 to 2007) and 2007 (growth from 2007 to 2006) at insurer-bond level, for bonds valued using internal models.

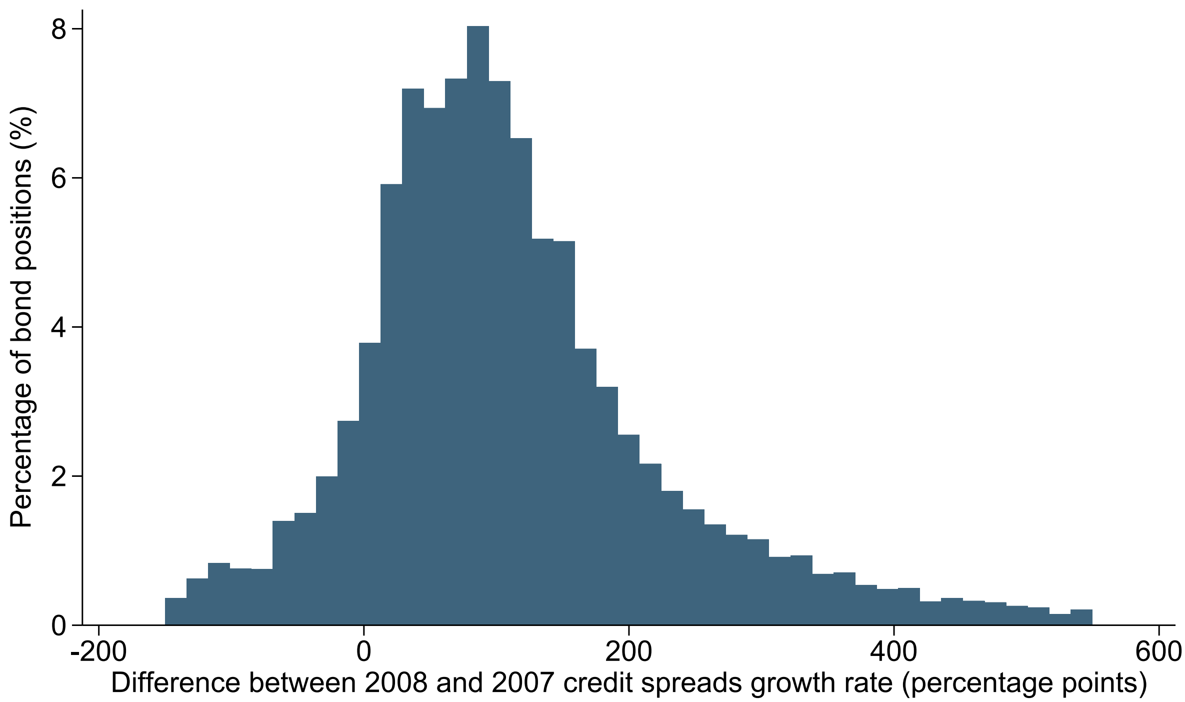


Figure A.5: Reported Credit Spreads by NAIC Rating Categories During the Financial Crisis

The figure shows the average credit spreads in 2008 for internal model (IM) and non-internal model (non-IM) valued bonds split by NAIC ratings. NAIC rating categories are 1 to 6, where NAIC 1 are AAA, AA, and A, NAIC 2 are BBB, NAIC 3 are BB, NAIC 4 are B, NAIC 5 are CCC and NAIC 6 are CC or below rated bonds. A bond is classified as internal model if at least one insurer valued it using an internal model in 2008. The sample includes bonds held in 2008.

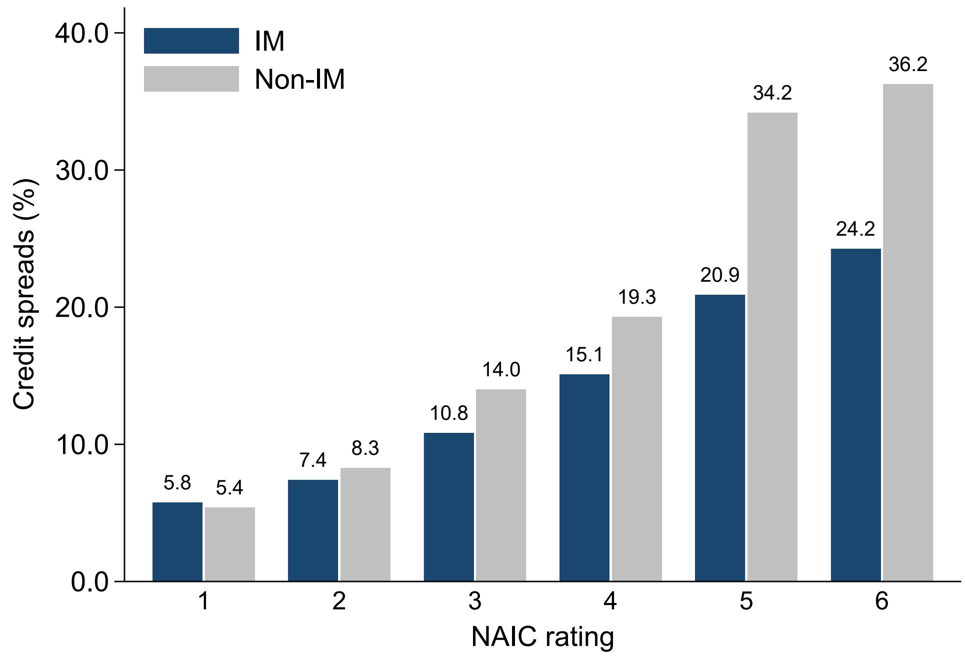


Table A.1: Correlation with Acquisition Spreads: Placebo Tests

The table shows the relationship between reported credit spreads and acquisition spreads for bonds valued by internal models in different years. We estimate:

$$CS_{ij} = \delta CS_{ij}^{Acq} + \alpha_i + \alpha_j + \epsilon_{ij},$$

where CS_{ij} is the reported credit spread of bond i held by insurer j, CS_{ij}^{Acq} denotes the credit spread of bond i at the time of acquisition by insurer j, and α_i and α_j are bond and insurer fixed effects. The sample includes only the insurer-bonds pairs that were valued by internal models in 2008. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	2005	2006	2007	2008	2009	2010	2011
	I	II	III	IV	V	VI	VII
CS_{ij}^{Acq}	0.157	0.162	0.133	0.305***	0.419***	-0.027	0.015
	(0.203)	(0.153)	(0.121)	(0.056)	(0.079)	(0.122)	(0.026)
R-squared	0.795	0.874	0.893	0.752	0.878	0.893	0.836
Observations	5061	5913	7171	8257	6864	5412	3622
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Insurer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table A.2: Misreporting within the Same Bond

The table compares levels of reported spreads when the same bond is held by more than one insurer and some of them use internal model and the others use traded prices or quotes. We estimate:

$$CS_{ij} = \delta IM_{ij} + \alpha_i + \alpha_j + \epsilon_{ij},$$

where CS_{ij} is the reported credit spread of bond i held by insurer j, IM_{ij} is a dummy variable for bond i that takes a value of 1 if insurer j valued the bond using an internal model, and α_i and α_j are bond and insurer fixed effects. We estimate the model separately for bonds held by two insurers, less than 5 insurers, and all insurers. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	Two Insurers	Less than 5 Insurers	All Insurers
	I	II	III
IM_{ij}	-0.015***	-0.007***	-0.000
	(0.005)	(0.003)	(0.002)
R-squared	0.926	0.938	0.953
Obs.	4008	10836	94364
Bond FE	Yes	Yes	Yes
Insurer FE	Yes	Yes	Yes

Table A.3: Fragmented State Level Reporting and Cross-sectional Dispersion

Table shows within and across state dispersion in reported prices and credit spreads. To measure the state level dispersion, we first compute the cross-sectional standard deviation of the reported fair values and credit spreads for each bond within a state. We then compute the mean for internal model (IM) and non-internal model (non-IM) bonds separately for all bonds within a state and then take a mean across US states. For state level analysis, a bond is classified as internal model if at least one insurer valued it using an internal model within a state. To measure the overall U.S. level dispersion, we compute cross-sectional standard deviation of the reported values for each bond across all states of U.S. and then compute the mean of all internal model (IM) and non-internal model (non-IM) valued bonds separately. For overall U.S. level analysis, a bond is classified as internal model if at least one insurer valued it using an internal model across any state.

	Within U.S. states		Overall U.S.	
	$\sigma(CS)$ (%)	$\sigma(FV)$ ($)	$\sigma(CS)$ (%)	$\sigma(FV)$ ($)
IM	1.1	4.26	1.55	4.5
Non-IM	0.27	0.83	0.7	1.2

Table A.4: Transactions in TRACE

Bonds that have more concentrated holding structures trade less than bonds that have less concentrated holding structures. We formally test this relationship after accounting for differences in bond and issuer specific characteristics by estimating the following specification:

$$Dummy_i^{TiN} = \delta(CO_i) + \beta X_i + \alpha_k + \epsilon_i,$$

where $Dummy_i^{TiN}$ is a dummy variable for bond i that takes a value of 1 if the bond had at least one transaction in 2008, CO_i is a dummy variable for bond i that takes a value of 1 if a bond is held by up to two insurers in 2008, X_i are bond level controls, and α_k are issuer fixed effects. Bond level controls include credit rating and maturity. The sample conditions on bonds that existed in 2008.[41] The variable of interest, δ, measures the difference in the probability of finding a transaction in TRACE between bonds with more concentrated holding structure and less concentrated holding structure. Table shows standard errors in parentheses. Standard errors are clustered at issuer level. Significance: * 10%; ** 5%; *** 1%.

We find that the probability of finding a transaction in TRACE for bonds with more concentrated ownership is 50 percentage points lower after controlling for rating and maturity (column I). In column II, we add issuer fixed effects, which helps control for other issuer characteristics not controlled by rating and maturity. δ is now identified by comparing bonds of the same issuer. We find that probability of finding a transaction is 22 percentage points lower for bonds with more concentrated ownership.

	$Dummy^{TiN}$	
	I	II
CO_i	-0.515***	-0.215***
	(0.017)	(0.016)
Constant	0.741***	
	(0.017)	
R^2	0.282	0.834
Observations	12994	9375
Issuer Fixed Effects	No	Yes
Controls	Yes	Yes

[41] As transactions of private placements are not reported in TRACE, we exclude them from sample.