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 substantially lower by 220 bps, as compared to bonds that are otherwise similar but valued using external sources. Misreporting is higher for bonds that are likely to be impaired and negatively affect regulatory ratios, for insurers that are constrained by regulatory capital, and for bond positions that are held by few insurers. Using novel data on U.S. state regulators, we document that misreporting is negatively correlated with the degree of supervision at the state level, but only for bonds held by multiple insurers. Supervision has limited impact on bonds held by fewer insurer due to the lack of reference prices available with state regulators. Consistent with these incentives, we show that insurers "corner the market" by holding a large fraction of a bond's issue, as this allows them to bypass regulatory scrutiny and facilitates the use of internal models. 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, mortgage- and asset-backed-securities, and private equity, trade less frequently. Lack of traded prices provides financial institutions the option to use internally developed models for asset valuation and potentially relax balance sheet constraints by inflating assets, which could be valuable especially in bad times when asset prices decline and the marginal value of an extra unit of wealth is high. While misstating assets is costly due to internal (corporate governance) and external (auditors, regulators, and investors) scrutiny, to the extent that the option to misreport is still valuable, it creates distorted incentives for portfolio selection and trading beyond what might be implied by standard risk-return characteristics of assets. Moreover, assessing the fragility of financial institutions becomes more challenging, particularly in bad times.

It is generally difficult to empirically verify whether financial institutions indeed misreport 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 have no available prices. Moreover, to observe any actual misreporting, we need that the option to use reporting discretion is valuable net of any costs of scrutiny, at least at certain times, for certain institutions, or for certain positions.

In this paper, we make progress by studying these incentives for the corporate bond holdings of U.S. life insurers. 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. Using this set-up, we show that life insurers misreport asset values using internally developed models during the financial crisis. Furthermore, we show that insurers hold a larger fraction of a bond's issue in order to "corner the market", as it allows them to bypass regulatory scrutiny and facilitates the use of internal models and misreporting.

U.S. life insurers hold corporate bonds at book value (historical cost) for regulatory reporting. Regulatory guidelines require insurers to mark down the value at which a bond is held when a bond's market value starts to fall below its book value, resulting in what is known as a "permanent impairment".[1] A permanent impairment results in 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

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

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, 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.[2] This implies that often corporate bonds are valued using models developed by the insurance companies 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. Second, 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 incentive 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, we first document significant dispersion in reported prices and implied credit spreads across insurers for the same bond and at the same point in time using holdings data from 2004 to 2016. 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.[3]

Second, instead of being driven by model uncertainty (Hansen and Sargent (2008)) or disagreement about fundamentals (Lintner (1969)), we show that the dispersion in reported

[2]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.

[3]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 (2015), which in extreme cases resulted in bail outs under TARP.

prices, particularly during the crisis, is due to an increase in reporting discretion. Reported prices are 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 non-investment grade bonds, implying that internal models allow insurers the discretion to report higher fair values which helps to relax balance sheet pressure in bad times.

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 external sources where there is no reporting discretion. Fourth, these effects are concentrated among insurers that are relatively more constrained by regulatory capital, as measured by the ratio of available capital to required capital.

Our findings on misreporting imply that the option to use internal models may create incentives for insurers to hold concentrated bond positions and therefore distort portfolio selection ex-ante.[4] The ability to bypass regulatory scrutiny and the absence of transaction prices to justify the use of internal models, are two conditions that are necessary to misreport asset values. Insurers can enable both these conditions by being a dominant holder of a bond's total issuance. By exercising market power and cornering the market, 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. In addition, holding concentrated position in a bond, decreases the overall number of market participants and the likelihood of trading and availability of reference prices.

We document a number of facts consistent with these ideas. First, 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 show that misreporting is negatively correlated with the degree and quality of supervision in a state. The higher the extent of supervision, the lower is the extent of misreporting. We proxy for the extent of supervision in a number of ways, including the total number of financial analysts and examiners employed by a regulator, number of discretionary exams conducted, and the total budget per insurer.

[4]Indeed in the data, insurance bond holdings are highly concentrated. 60% of the bonds are held by up to three insurers and such bonds have a significantly lower propensity to trade in the secondary market.

Crucially, the relationship exists only for bonds that have multiple owners and therefore multiple reference prices within the jurisdiction of the regulator and breaks down for bonds that have a single owner and therefore no reference price, implying that insurers have a greater ability to bypass regulatory scrutiny when they hold more concentrated positions.

Second, we show that indeed misreporting is 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. Third, 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.

After demonstrating a preference for concentrated positions, we test whether the portfolio compositions indeed get distorted using a shift in the regulation that made it easier for insurance companies to use internal models after 2008. We find that both dollar amounts and proportion of the total issue held increased for bonds with a small issuance size relative to bonds with a large issuance size for all new purchases after 2008. Moreover, these effects are concentrated within insurers that use internal models and not insurers that do not use internal models. 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. 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.[5] 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 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. Section 3 describes the data sources and provides an overview of the regulatory structure of the U.S. insurance sector. Section 4 presents the main empirical findings on the use of internal models to misreport assets. Section 5 documents linkages between misreporting, regulatory scrutiny, and a bond's holding structure and documents our findings on bond market cornering. Section 6 concludes.

[5]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.

2. Institutional Details

A large portion of U.S. life insurers' assets are in corporate bonds, for example, about 46% of total invested assets in 2013 (McMenamin, Paulson, Plestis, and Rosen (2013)). 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. Internal models allow insurance companies reporting discretion when they value corporate bond assets. This flexibility could be valuable because it allows to smooth fluctuations in regulatory or GAAP reporting, relax balance sheet constraints, avoid headline risk, or smooth performance driven compensation, features particularly valuable in bad times when the marginal utility of an extra unit of wealth is high.

We focus on the incentives arising from the regulatory framework for two reasons. First, prior literature has shown that U.S. life insurers operate subject to statutory regulation.[6] Moreover, the regulatory framework provides us heterogeneity in the incentives to use reporting discretion for the same bond and at the same point in time, but across insurers, allowing us to pin-down the mechanism cleanly. We describe the key features of the regulatory setting below.

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 to recognize "other-than-temporary-impairment" (OTTI) and mark down the value of the bond to its market value.[7] 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, insurers are forced to recognize losses, which negatively affect the total value of regulatory assets.

A key metric for state and federal 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:

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

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

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

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.[8]

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.

Permanent impairment is likely to occur when a bond's fair value starts to fall below its book value due to changes in the credit risk of the bond (NAIC SSAP No. 26).[9] The NAIC requires insurers to report the fair value of each position, along with the book value, to determine potential cases of permanent impairment. The reporting guidelines suggest the following. Wherever possible, insurers report traded prices or prices taken from external sources, which include NAIC's security valuation office, pricing services (e.g. IDC, Reuters, Bloomberg), and broker-dealers. However, in the event that it is not possible to obtain prices externally, insurers are allowed to compute the fair value of securities analytically using internal models.[10] Corporate bonds trade in over-the-counter markets and often a continuously observable price does not exist. Thus, for a large fraction of corporate bonds, the prices are obtained using internal models.

This gives some insures *both* the incentive and the ability 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 at which the bond was originally purchased.[11] Thus, we can use the

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

[9] 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."

[10] 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."

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

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.

It is surprising why there is not more regulatory oversight to check the veracity of reporting to begin with. However, the sheer number of bonds held by insurers which make monitoring resource intensive, decentralized reporting at the state level, and the lack of active trading and price benchmarks in the corporate bond market are all potential explanations for the seeming lack of monitoring. Crucially, as we will also discuss in depth in the next section, a key implication of this incentive structure is for insurers to exercise market power and hold a large share of the bond issue, which further impedes price discovery for some bonds.

3. Data

3.1. Bond Holdings Data

Insurance companies report fixed income and equity holdings at the position level at an annual frequency to state regulators, which we collect from the NAIC's Schedule D database. We restrict attention to corporate bonds positions. For each position, we observe the bond's CUSIP, the par value held, the NAIC credit rating categories, coupon paid, callable or not, asset backed or not, the purchase and maturity dates, price paid at acquisition, the book value at the time of acquisition, and the book value at which the bond is being held currently. NAIC rating categories are grouped as 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.[12] The sample spans from 2004 to 2016.

Although bonds are held at book value, insurers also have to report the "market value" of each position to the state regulators. The unique aspect of the data is that we observe an insurer's own valuation of a bond, in cases where traded prices or quotes from external pricing services are apparently unavailable.[13] Moreover, starting in the year 2008, we also observe how insurance companies obtained the fair value of each position. Figure 1 reports a breakdown of total number of bonds and total par value by the valuation method. 45% of the corporate bond positions as a share of total par value and 38% as a share of total number of bonds are valued using internal models. The remaining positions are valued using inputs

[12] See NAIC Risk Based Capital Guidelines (2013)

[13] There exists a non trivial fraction of bonds that are valued using both internal models and external sources depending on which company is valuing them. We exploit this feature as an alternative identification strategy in Section 4.3.

from external sources, which include NAIC's security valuation office, pricing services, and broker-dealers.[14] Henceforth, we refer to prices sourced from all external sources as "non-internal models".

As permanent impairment occurs due to a decline in the *credit risk* of a bond and not due to changes in interest rates, we compute the implied credit spreads for each position from reported prices. We proceed as follows. First, we compute the reported price by dividing the total reported market value of the position by the total par value of the position and then multiplying the ratio by 100, so that the computed prices correspond to a par value of $100. Second, using the computed price, bond's remaining maturity, coupon rate, and assuming a semi-annual payment schedule, we compute the implied yield-to-maturity (YTM) of the corporate bond position. In doing so, we exclude positions where par value, market value, maturity date, or coupon rate are not populated. Finally, to compute the credit spread, we subtract from the implied YTM of the corporate bond, the YTM of a comparable maturity treasury, where the YTM of treasuries are from Datastream.[15]

To understand the differences between bonds valued using internal models and bonds valued using external sources, we compare the key bond characteristics in Table 1. Our sample contains a total of 19,259 bonds from 9,615 issuers in 2008, approximately 40% of which are bonds valued by internal models. These bonds are similar in many dimensions. For example, the average (and median) rating for both internal model valued and non-internal model valued bonds is 2, which corresponds to a rating of BBB. The average remaining maturity is around 6 years for both types of bonds. Consistent with this, we find that both types of bonds have similar reported price and credit spreads during the non-crisis period and the acquisition costs are also roughly similar.

The holdings data are reported at the state subsidiary level which is the unit of operation for U.S. life insurers.[16] We first aggregate the bond positions at the insurance group level by using NAIC operating company code to group code mappings. Our final sample comprises of holdings data of 350 insurance groups in the U.S.. We next study the differences in ownership patterns across the two types of bonds. To do so, we aggregate the data at the bond level and compute the cross-sectional (across insurance group) average of dollar holding amount

[14] The main pricing services used are IDC, Reuters, and Bloomberg.

[15] We match the maturity of bond with the maturity of treasury to the closest month. Datastream provides the treasury YTM 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).

[16] For example, an insurer's subsidiary in Connecticut reports holdings separately from the same insurer's subsidiary in California.

and the duration for which each bond is held by insurers. We find that the average dollar holding amount for internal model valued bonds is higher at $12 million as compared to the average dollar holding amount for non-internal model valued bonds, which is at $7 million. Also, the average duration for which a bond is held is higher for internal model valued bonds (4.3 years) than non-internal model valued bonds (3.0 years). We return to these differences in the ownership patterns in the next section, where we describe the main empirical results.

3.2. U.S. State Regulatory Data

U.S. insurers are subject to regulation and supervision in their state of domicile and do not have a centralized federal regulator. We collect novel data on state regulators from the NAIC's annual "Insurance Department Resources Report". The reports are available from 2005 and contain information on the activities and resources of state insurance departments. Each report is organized in five sections: (i) staffing; (ii) budget and funding; (iii) examination and oversight; (iv) insurance producers; and (v) consumer services and anti-fraud. The statistics provided for each jurisdiction include the number of departmental staff, annual budgets, revenues collected, premium volume, number of insurers, and the number of consumer complaints filed.

Each state regulator conducts a number of "financial exams" to verify insurers' accounting methods, modeling procedures, and financial statement presentations. The focus of these exams is to ascertain whether insurers have complied with reporting guidelines and state regulations and any reporting discrepancies result in disciplinary "actions" such as delinquency orders, suspensions, and revocation of licenses. The financial exams are of two type: regular and discretionary. Regular exams are conducted at a predefined schedule and the frequency is governed by underlying state regulations. However, discretionary exams are conducted on an ad hoc basis depending on whether state regulators feel a need to conduct additional financial exams.

Table 2 documents summary statistics of these regulatory characteristics. For each characteristic, we compute a time-series average from 2005 to 2008 as we want an ex-ante measure of supervision to examine its relationship with misreporting. We present summary statistics of the time-series averages for the 43 U.S. states in our sample. There is substantial heterogeneity in the total number of financial analyst and examiners (hereafter examiners) and the total budget available with a state regulator to supervise the insurers domiciled in its state. On average, we have about 0.27 financial examiners allocated to a insurer. There is considerable variation across states in staffing, with some states employing only 0.07 finan-

cial examiners to supervise insurers. On the other hand, other states employ as many as 0.56 financial examiners per insurer (90th percentile). We see similar heterogeneity in total budget per insurer. While the average state regulator has about $0.2 million per insurer, the standard deviation is about equal in magnitude. As the regular exams are governed by regulatory requirements, we find considerably less variation in the frequency across states (standard deviation is around 33% of the mean). On the other hand, the frequency of discretionary exams varies considerably across states (standard deviation is around 150% of the mean), suggesting heterogeneity in the degree of supervision across states.

4. Internal Models and Reporting Incentives

4.1. The Impact of Internal Models on Reporting

We start by documenting stylized facts on the valuation patterns of corporate bonds across insurers. For each bond at every valuation date, we compute the cross-sectional (across insurers) standard deviation and range of reported prices and implied credit spreads. Figure 2 shows a time series plot from 2004 to 2016. Two key facts stand out. There is significant dispersion in reported prices and implied credit spreads for the same bond at the same point in time across insurers.[17] Moreover, this phenomenon is largely concentrated within bonds that are valued using internal models. Second, the dispersion increases substantially during the financial crisis. For example, the average cross-sectional standard deviation for bonds valued using internal models during the crisis is $5 for a par value of $100 and the average difference between the highest and the lowest reported price is $11. Credit spreads show similar trends. The average cross-sectional standard deviation of spreads is 160 bps and the average range is 330 bps during the crisis for internal model bonds.

We interpret the dispersion in reported prices as evidence supporting a systematic increase in the use of reporting discretion during the financial crisis. However, the dispersion in internal valuations can also result from disagreement about fundamentals (Lintner (1969)) and model uncertainty (Hansen and Sargent (2008)), both of which can be more pronounced in a crisis. In addition, it can be driven by model error. Our empirical set-up allows us to address these alternative explanations in a number of ways.

We first show the evolution of reported fair values and implied credit spreads over time.

[17] 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.

Bonds valued by internal models not just have a higher reported dispersion in credit spreads, but also have a lower decrease in prices (or lower increase in credit spreads) during the crisis. Figure 3 illustrates this. In general, the average reported fair values or credit spreads of bonds valued using internal models and non-internal models are similar throughout time. Before the crisis, both types of bonds are valued slightly above par at around \$104 and after the crisis at around \$110.[18] However, during the crisis, when bond prices crashed, we see a sharp difference in reported fair values and credit spreads for the two types of bonds. While bonds valued using non-internal models exhibit a sharp increase (decrease) in credit spreads (fair values), bonds valued using internal models have a significantly lower increase (decrease) in credit spreads (fair values). The difference between average fair values and spreads is as high as \$8 and 220 bps respectively during the crisis.

We next examine the reported credit spreads of bonds valued by internal models and non-internal model by various NAIC rating categories. Figure 4 plots the average credit spreads during the financial crisis. The credit spreads are consistently lower for internal model valued bonds for NAIC rating categories 2 to 6, but not for NAIC category 1 (AAA, AA, A) for which the reported spreads are slightly higher for internal model bonds. Moreover, the difference between the reported credit spreads of internal model and non-internal model valued bonds is much higher for non-investment grade bonds, which could be due to a higher likelihood of permanent impairment in low rated bonds.

To illustrate more formally that the differential change in implied credit spreads of internal model and non-internal model bonds during the crisis is not due to differences in bond characteristics, we estimate the following regression specification:

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

where $\overline{CS}_{it}$ is the average of the reported credit spreads for bond i at time t across all insurers, 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, X_{it} are bond level controls, and α_i and α_t are bond and time fixed effects. Bond level controls include credit rating and maturity. The regression conditions on bonds that existed in 2008 and the sample starts in 2004 and ends in 2016. The main coefficient of interest is γ, which measures the increase in credit spreads in 2008 for internal model bonds compared to all other years, relative to the same change for non-internal model bonds.

Table 3 documents the main findings. In our baseline specification, where we control for

[18] This rise is largely explained by the decrease in interest rates during this time.

credit rating and maturity, we estimate a negative and statistically significant coefficient, γ, (at the 1% level (column I)), which implies that the credit spreads for internal model bonds increase less than the non-internal model bonds. The economic magnitude of the difference is large and equal to 220 bps, as also seen in Figure 3. In column II, we add bond fixed effects and time fixed effects. Bond fixed effects allow us to control for time invariant bond characteristics, e.g. seniority, callable, coupon rate, covenants etc, that impact changes in credit spreads. As column II shows, the estimate does not change meaningfully.

In column III, we add issuer cross time fixed effects.[19] The coefficient of this specification is identified by comparing internal and non-internal bonds but issued by the same issuer and at the same point in time. This 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 control for disagreement about fundamentals and model uncertainty that are at the issuer level. The estimate is significant and the difference in change of spreads between internal model and non-internal model is 40 bps. We think of this as a lower bound of the effect we estimate. As we will discuss in Section 4.3, there could be limits to the use of discretion. When there are other bonds issued by the same issuer and priced by external sources or traded in the market, an insurance company may have limited power to use discretion.

4.2. The Role of Regulatory Incentives

A concern about comparing internal model and non-internal model bonds could be that somehow internal model bonds are different and this difference is correlated with the crisis, which would explain a lower increase in relative credit spreads. This is alleviated if we can compare the same bond but across different insurers. In this section, we document our findings from an identification strategy that addresses this concern.

The regulatory framework provides heterogeneity in the incentives to use discretion for the same bond at the same time, but across insurers. Life insurers report corporate bonds at book value. The regulatory guidelines require insurers to mark down the book value when a bond's market value starts to fall below its book value, resulting in permanent impairment. Permanent impairment reduces the amount of regulatory capital. Thus, 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 at which the bond was purchased. An insurer that acquired the bond at a higher cost, which translates to a higher book value, has the incentive to report

[19] We identify the issuer by the first six digits of a CUSIP, which are unique to the issuing company.

a price above 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 there are two insurers who hold a bond and both value the bond using internal models. 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.[20] In 2007, let us assume the bond was trading at \$90 but falls to \$60 during the crisis. Then, the regulatory framework provides heterogeneous reporting incentives because insurer A would like to report a price no less than \$70 to avoid impairment, while insurer B would like to report a price no less than \$80. This implies a positive relationship between acquisition cost (acquisition credit spread) and reported price (reported credit spread) for bonds valued using internal models.

Illustration 1 depicts the idea graphically. There is a bunching of reported prices above \$70 for insurers that acquired the bond at \$70 and similarly above \$80 for insurers that acquired the bond at \$80. Thus, the relationship between reported fair value and acquisition cost is expected to be positive for bonds valued using internal models. However, if a bond is valued using external sources, then there is no flexibility and we should find no relationship between acquisition cost and reported price.

To test the relationship between acquisition cost (acquisition credit spread) and reported price (reported credit spread) formally, we estimate the following regression specification:

$$CS_{ij} = \gamma IM_{ij} + \delta CS_{ij}^{Acq} + \lambda(CS_{ij}^{Acq} \times IM_{ij}) + \alpha_i + \alpha_j + \epsilon_{ij}, \tag{2}$$

where CS_{ij} denotes the implied 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, 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. A bond can be valued by both internal model or by external sources by different insurers. Thus, IM_{ij} is not constant at the bond level and does not get absorbed by bond fixed effects. We discuss this in more detail later. The sample includes all bonds held in 2008.

[20] We ignore amortization over the life of the bond.

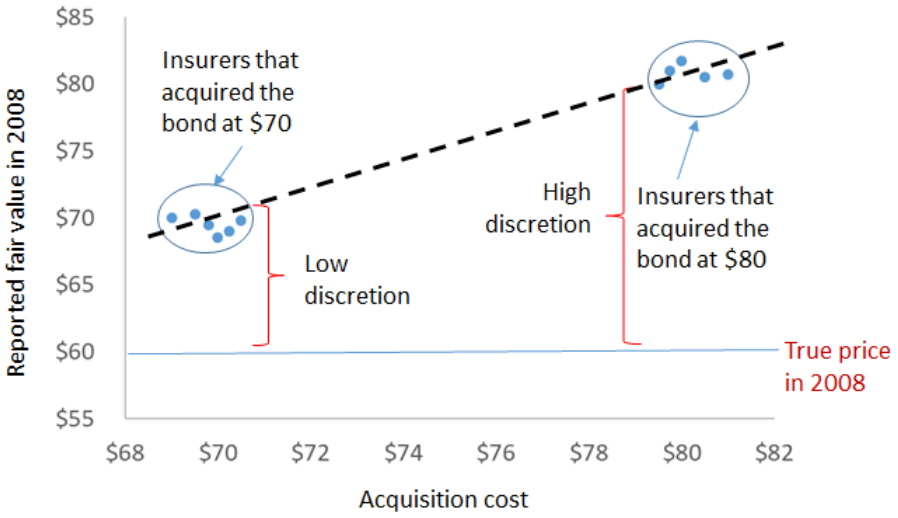


Illustration 1: Identification Strategy

Coefficient of interest are δ and λ which measure the relationship between reported credit spread of a bond in 2008 and its credit spread at acquisition, when the bond is not valued by an internal model and when the bond is valued by an internal model respectively. As we add bond fixed effects, δ identifies the relationship between reported credit spreads and credit spread at acquisition, by comparing the credit spread 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 a component of model error that does not vary at the bond level, e.g. modeling of the macro-economic variables.

Table 4 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 the credit spreads at acquisition.[21] The magnitude is large: a 100 bps difference in credit spreads at acquisition results in a 30 bps higher reported credit spreads. In contrast, there is no relationship between reported credit spreads and the credit spread at acquisition 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 coefficient λ (at the 1% level) and an insignificant δ, which imply 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

[21] 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.

that acquired the bond at a lower credit spread, as this helps to reduce the likelihood of permanent impairment. Moreover, this only holds for bonds valued by internal models.

Moreover, the positive relationship between reported credit spreads and the credit spread at acquisition is mainly concentrated among insurers that have low RBC ratio. Insurers have different incentives to use discretion depending on their level of regulatory capital. To test this, we exploit the heterogeneity in RBC ratio across insures in 2007 and split our sample in three groups: low, medium, and high RBC ratio. The "low" ("high") group are insurers in the bottom quartile of RBC ratio and thus have the highest (lowest) incentive to avoid permanent impairment. Table 5 reports the findings from estimating equation (2) on the three sub-samples. The relationship between reported credit spreads and the credit spread at acquisition is mainly concentrated and highest in magnitude for the "low" group, i.e. among insurers that are most constrained by regulatory capital.

5. Cornering the Market: Implications for Bonds Market Concentration

The extent to which an insurance company can misreport bond valuations depends on two underlying conditions. First, the ability of insurers to surpass 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 valuations. 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 both these conditions creates incentives to hold more concentrated positions and distorts ex-ante portfolio selection in corporate bonds. Bonds owned by fewer insurers implies that regulators have lesser number of discrete price points to compare. In addition, an insurer has greater control on the amount of trading that can take place in the bond if it owns a large market share in a bond. Indeed, in the data, the holding patterns are highly concentrated. Figure 5 shows a distribution of the number of insurers holding a particular bond. Over 46% of bonds are held by just one insurer and over 60% of the bonds are held by up to three insurers only.

We empirically illustrate these incentives and the impact on portfolio selection in two broad steps. First, we motivate the preference for concentrated positions by showing that concentrated ownership structure helps to bypass regulatory scrutiny, that misreporting is higher in concentrated positions, and that bonds owned by fewer insurers trade less. After establishing these preferences, we examine the impact on insurers' portfolio compositions.

We show that concentration positions increased after a regulatory shift that made it easier to use internal models for reporting bond valuations.

5.1. Regulatory Supervision and Price Opaqueness

5.1.1. Bypassing Regulatory Supervision

Regulatory Supervision and Misreporting

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 6 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 3, column II) and compute the main coefficient of interest γ_k for each state k separately.[22] For ease of interpretation we define misreporting for state k as:

$$Misreporting_k = -(\gamma_k). \tag{3}$$

Thus, higher values of $Misreporting_k$ indicate higher misreporting. Figure 6 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

[22]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.

(51%). At the same time, 18% of states have negligible and 31% states have lower degrees of 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 (3), $Supervision_k$ 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 7 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.

Quantifying Misreporting in Concentrated Positions

We next show that indeed misreporting is higher in bonds that are held by lower number of insurers. We estimate the specification in equation (1) to capture the differential effect for bonds with more concentrated holding as follows:

$$\begin{aligned}\overline{CS}_{it} = \lambda(CO_i \times IM_i \times Crisis_t) + \gamma(IM_i \times Crisis_t) + \delta(CO_i \times Crisis_t) + \\ + \beta X_{it} + \alpha_i + \alpha_t + \epsilon_{it},\end{aligned} \tag{4}$$

where 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, which is the median number of insurers holding a bond. The rest of the specification is same as in equation (1). The main coefficient of interest is λ, which

measures whether there is a differential increase in the credit spreads in 2008 for internal model bonds that have more concentrated holding structure as compared to internal model bonds that have less concentrated holding structure.

Table 8 documents the findings. λ is negative and significant (at the 5% level). This implies that within bonds that are valued by internal models, those that have 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, non-internal model bonds have the maximum increase in reported spreads during the crisis, followed by internal model bonds with less concentration, and finally followed by internal model bonds with high concentration. The difference in credit spreads between more and less concentrated holding bonds is close to 60 bps on average, which is one-third of the average difference between internal and non-internal model credit spreads during the crisis. Thus, there is more misreporting in the bonds that have lesser number of reference credit spreads.

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 7 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 B.1 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 Composition

Our results imply that insurers that have the ability to use internal models, ex-ante, may prefer to hold the entire (or a large enough share) of a bond's total issue. By exercising market power and "cornering the market", insurers can create at least two conditions that facilitate misreporting. First, it reduces the availability of reference prices (and increases

the search cost of regulators). Second, it reduces the total number of participants in the secondary market, which helps to decrease transactions and quotes from broker/ dealers. However, at the same time, holding a large share in a bond could be detrimental as it leads to lower diversification and more capital requirements that arise due to concentration limits.[23] Holding a higher dollar amount in bonds that have small issuance sizes helps solve this trade-off problem.[24]

To test the idea that insurers that have the ability to use internal models corner markets and be the dominant holder in bonds with small issuance sizes, we use variation along three dimensions. First, we split our sample of bonds into two groups by total issuance size: small and large, where we define the bonds that are in the bottom quartile of issuance sizes in 2008 as small and all other bonds are defined as large. Second, we split insurers into two groups: (i) IM insurers are insurers that used internal models in 2008 and (ii) non-IM insurers did not use internal models at all in 2008. We expect that market cornering would arise more from insurers that use internal models.

Third, we exploit time series variation in the ability and willingness of insurers to use internal models. First, a shift in the regulation made it easier for insurers to use internal models after 2008. Prior to 2008, NAIC's SVO (Securities Valuation Office) acted as the main provider of information on bond valuations to insurers. SVO obtained bond valuations from public transactions, brokers-dealers, and from analytical models. In 2008, a NAIC task force amended the rules and permitted 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. Thus, the role of SVO as a source of bond valuations declined after 2008. Second, the financial crisis which resulted in a large decline in insurers' regulatory positions and the ensuing uncertainty about the future recovery of bond spreads created significant incentives for an increased use of internal models.

Figure 8a plots the evolution of the *maximum* proportion held in bonds with small issuance sizes. For each bond, we compute the maximum proportion held by any insurer and then compute an average value separately for IM and non-IM insurers. We plot the *maximum* proportion held, and not proportion held, as we are interested in quantifying the holdings of the insurer that is the dominant holder of a bond. We see an increase in the

[23]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.)

[24]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.

maximum proportion held for small bonds for IM insures (including a big jump in 2008), but do not see a similar increase for non-IM insurers. In figure Figure 8b, we repeat the same exercise for large bonds, which shows that these effects are concentrated within small bonds.[25]

We formally test this using the following triple differences specification, where we compare the relative change in the dollar holding amounts and proportion held of small vs. large bonds, for IM vs. non-IM insurers, before and after the crisis. We estimate:

$$Cornering_{ijt} = \gamma(IMInsurer_j \times SmallBond_i \times Post_t) + \delta(IMInsurer_j \times SmallBond_i) + \alpha_{it} + \alpha_{jt} + \epsilon_{ijt}. \tag{5}$$

Table 9 presents the results. In all specifications we add $Bond \times Year$ and $Insurer \times Year$ fixed effects to control for any time variant bond and insurer characteristics. We find that both the dollar amount and proportion held in small bonds by IM insurers increased after the crisis relative to the same change for IM insurers holdings of large bonds and non-IM insurers holdings of small and large bonds (Columns 1 and 3). However, we see the results get weaker when we introduce $Insurer \times Bond$ fixed effect (Columns 2 and 4). We expect the results to get weaker, as in line with "buy and hold" nature of insurers bond holdings there is not much time series variation in a $Insurer \times Bond$ pair. This suggests that our results are driven by new purchases.

To formally check this, we re-estimate equation (5) but condition it only on the new bonds that were added in a insurer's portfolio in any given year. Table 10 presents the result. In line with the previous test, we take $Bond \times Year$ and $Insurer \times Year$ fixed effects to control for any time variant bond and insurer characteristics. As we only have one observation for each $Insurer \times Bond$ pair, we do not add $Insurer \times Bond$ fixed effects. We find that IM insurers increased the dollar amount and proportion held in new purchases of small bonds after the crisis relative to the same change for IM insurers' new purchases of large bonds and non-IM insurers' new purchases of small and large bonds. Taken together, these results imply that the option to use internal models distort the ex-ante portfolio compositions of insurers.

[25] This exercise is conducted on all insurers in the sample. For robustness, we conduct the same exercise on a subset of insurers that have similar size, as measured by total assets. Our findings are similar.

6. Conclusion

Using corporate bonds as a setting, in this paper, we show that insurance companies misreport the prices of bonds for which traded prices do not exist and that are priced using internally developed models, to improve their regulatory capital positions during the financial crisis. We show that misreporting is heterogeneous across U.S. states and correlates with the degree of regulatory supervision in the state.

Our results imply that ex-ante insurers have a preference for concentrated bond positions. To avoid regulatory scrutiny, insurers misreport more in positions that are held by fewer number of insurers, as a concentrated ownership implies lower number of reference points and a higher search cost for regulators. We empirically demonstrate that the ability of regulators to check the veracity of reporting increases when a bond is held by multiple insurers within a state. Concentrated positions also help insurers to limit trading in the secondary market, which further facilitates the use of internal models and misreporting. Using a shift in the regulation that made it easier to use internal models, we show an increase in concentration in bonds with smaller issuance size.

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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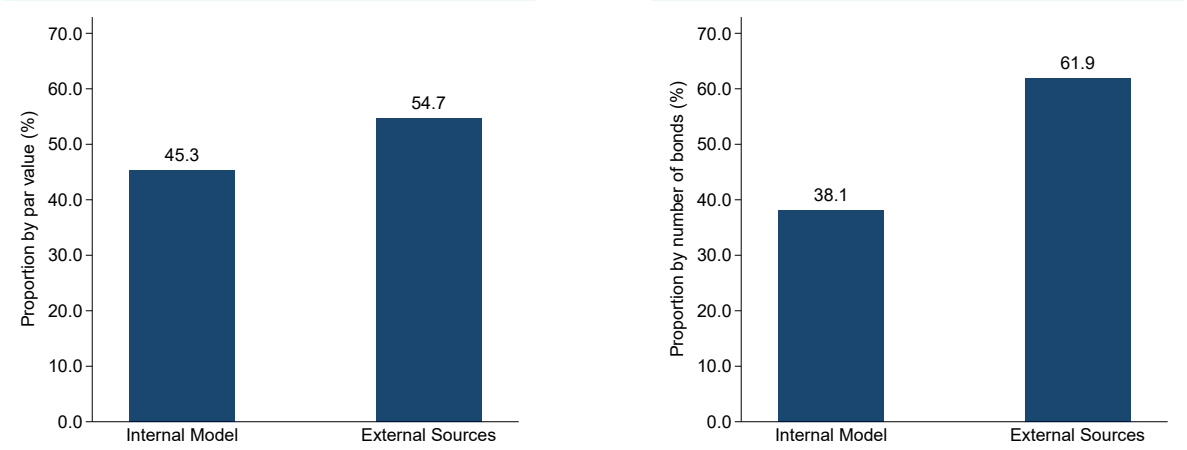
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I. Figures

Figure 1: How do Insurance Companies Value Corporate Bonds?

The figure shows the breakdown of the corporate bond holdings data by valuation method in 2008. Figure (a) plots the share of total par value held and figure (b) plots the share of total number of bonds. External sources include NAIC's security valuation office, pricing services (e.g. Bloomberg and IDC), and brokers.

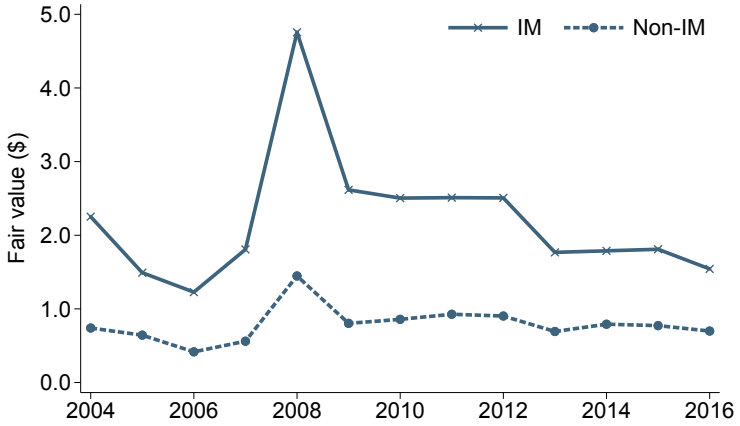


(a) By Total Par Value

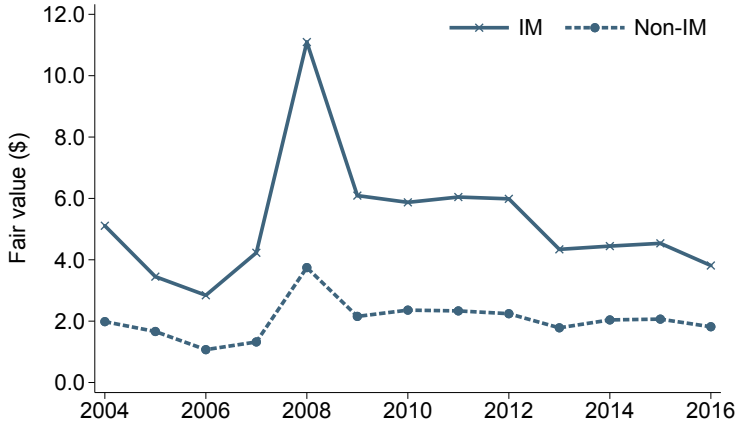
(b) By Total Number of Bonds

Figure 2: Cross-sectional Dispersion of Reported Fair Values and Credit Spreads

This figure shows the average cross-sectional standard deviation and range of reported fair value and credit spreads. We compute cross-sectional standard deviation (sd) 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. Figure (a) and figure (b) plot the average standard deviation and range of reported fair values. Figure (c) and figure (d) plot the average implied credit spreads.



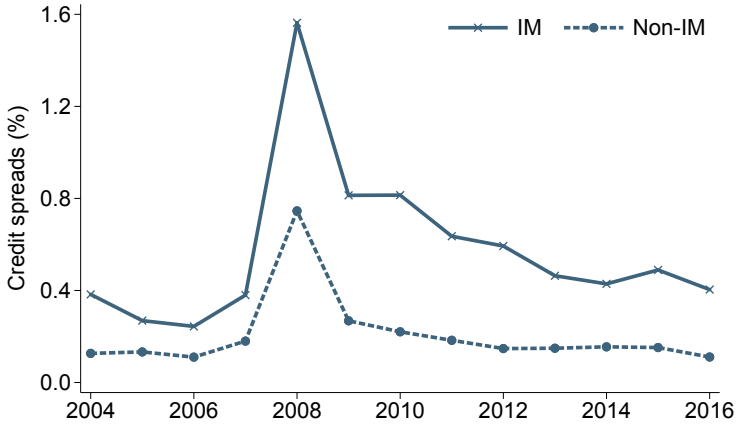
(a) Fair Values (sd)



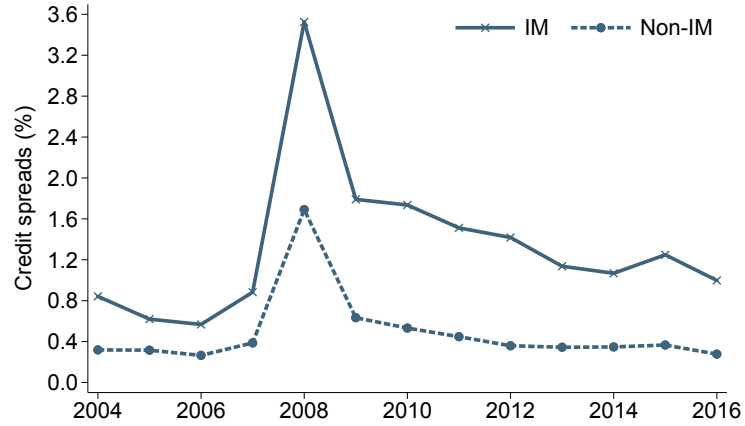
(b) Fair Values (range)

Figure 2: Cross-sectional Dispersion of Reported Fair Values and Credit Spreads (continued)

This figure shows the average cross-sectional standard deviation and range of reported fair value and credit spreads. We compute cross-sectional standard deviation (sd) 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. Figure (a) and figure (b) plot the average standard deviation and range of reported fair values. Figure (c) and figure (d) plot the average implied credit spreads.



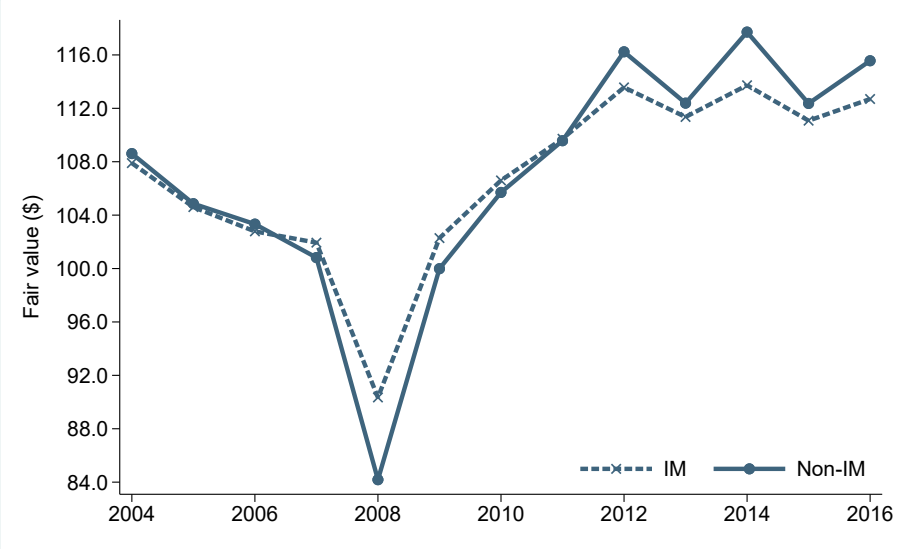
(c) Credit Spreads (sd)



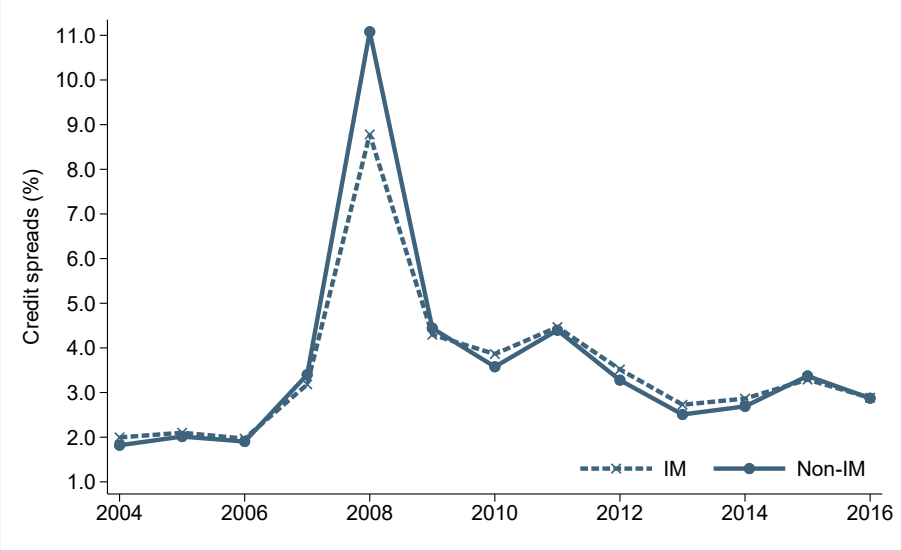
(d) Credit Spreads (range)

Figure 3: Evolution of Reported Fair Values and Credit Spreads

The figure shows how fair value and 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 fair values and 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 (a) plots the reported fair values and figure (b) plots the credit spreads.



(a) Fair Values



(b) Credits Spreads

Figure 4: 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. 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. NAIC rating categories are grouped category 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.

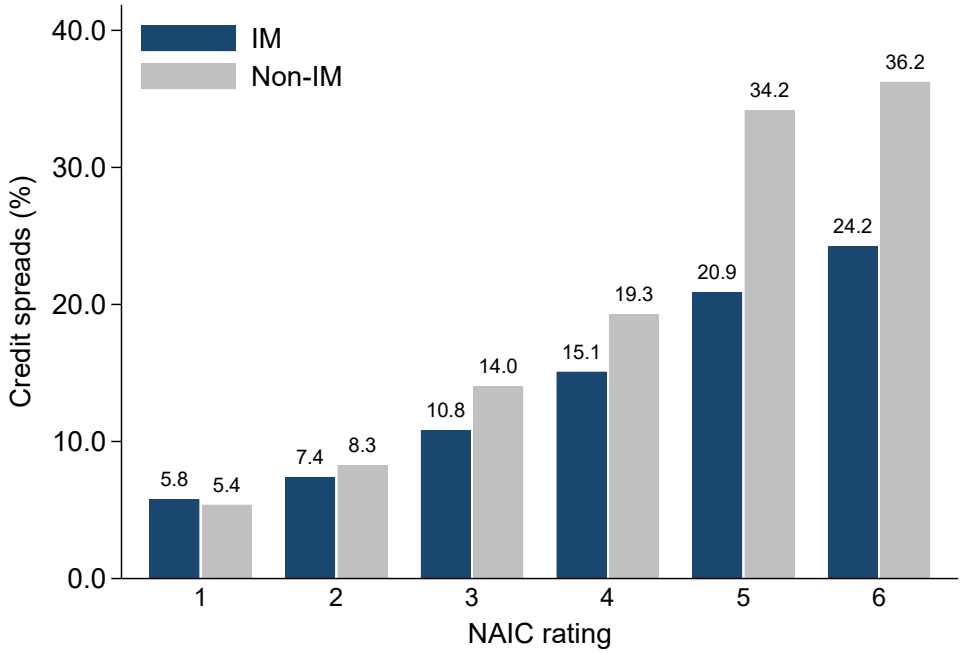


Figure 5: Concentration in Holding Structure of Corporate Bonds

The figure shows the distribution of total number of insurance companies holding a particular corporate bond. The sample includes corporate bonds held by insurance companies in 2008.

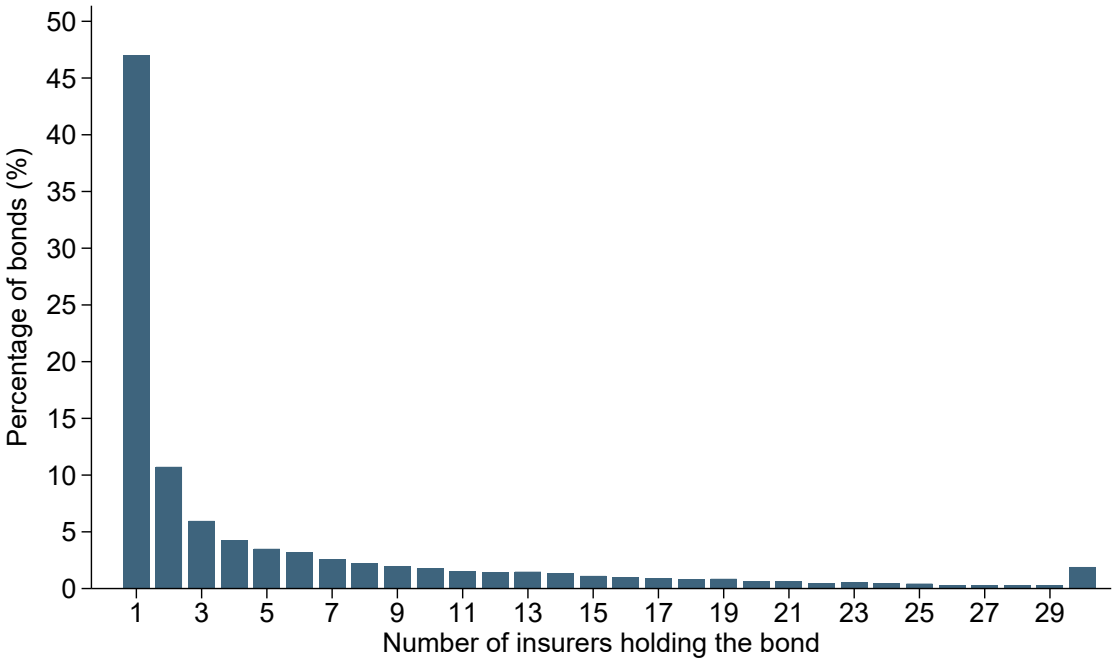


Figure 6: Cross-sectional Heterogeneity in Misreporting Across States

The figure shows the difference between the credit spreads of the bonds valued using external sources and the bonds valued using internal models for different US states. To quantify the difference, we re-estimate the specification in equation (1) with bond and year fixed effects and compute the main coefficient of interest γ_j for each state j separately. The red triangles represent states where γ_j is statistically significant at the 5% level and blue circles are states where the coefficient is insignificant.

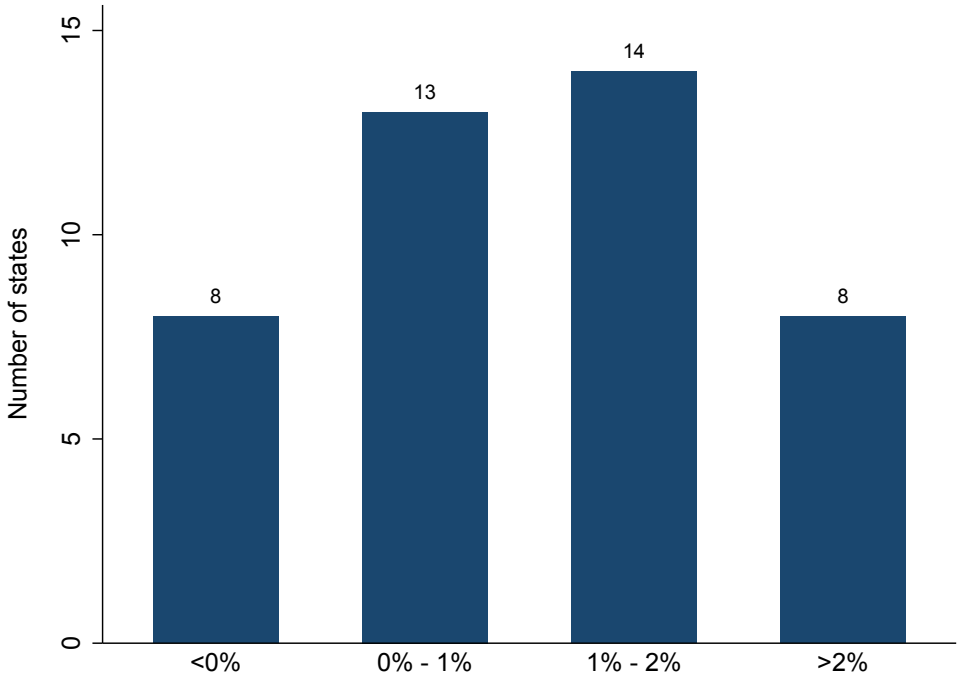


Figure 7: Number of Transactions in TRACE

The figure shows the number of TRACE transactions during the crisis for bonds that had a highly concentrated holding structure, i.e bonds that were held by up to two insures, as compared to bonds that had less concentrated holding structure, i.e bonds that were held by more than two insures.

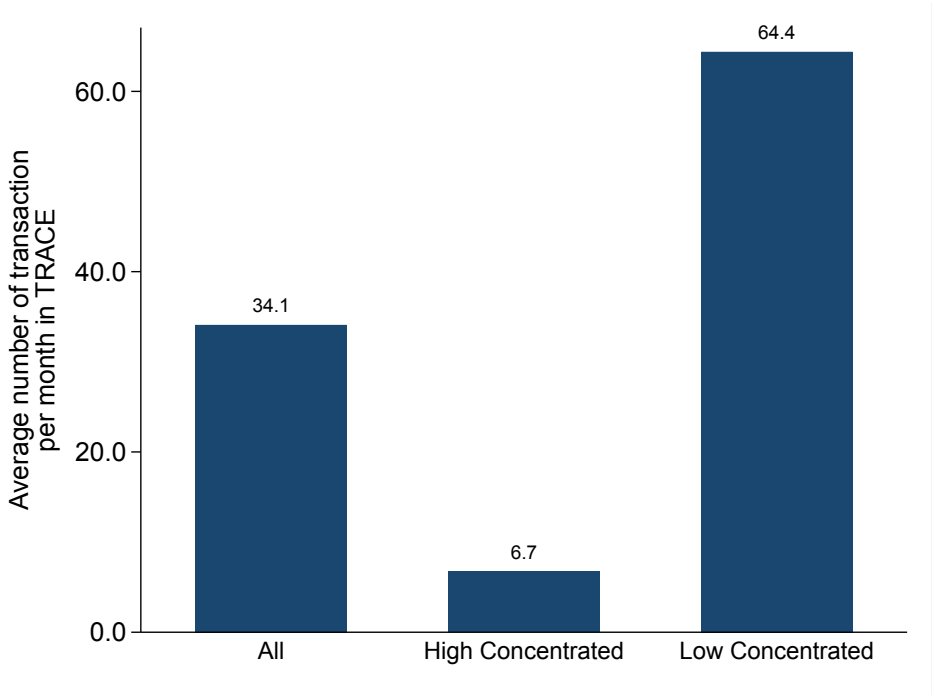
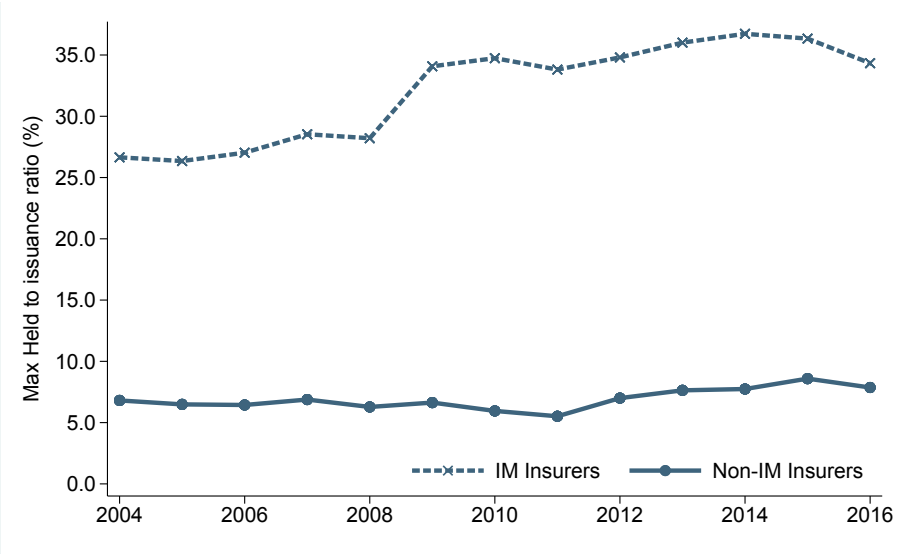
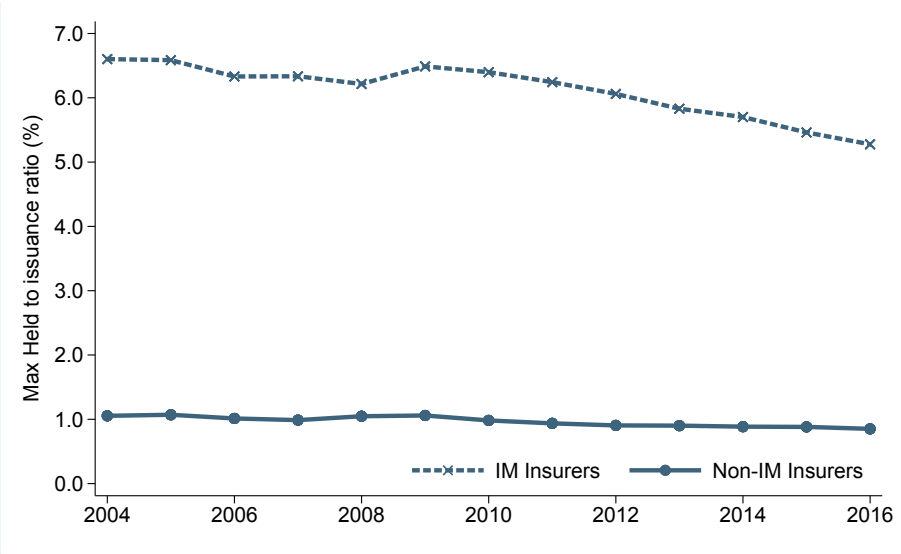


Figure 8: Implications for Portfolio Composition

The figure shows the maximum proportion held of a bond issuance size by insurers that used IM for valuation in 2008 and insurers that did not use IM for valuation in 2008. Figure (a) plots the average of maximum proportion held of a bond issuance for bonds with small issuance size and figure (b)plots the average of maximum proportion held of a bond issuance for bonds with large issuance size.



(a) Small Issuance Size Bonds



(b) Large Issuance Size Bonds

II. Tables

Table 1: Summary Statistics: Bond Holdings

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

	Mean	StDev	P10	P25	Median	P75	P90
Panel a: Internal model							
Number of bonds	7340						
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
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
Number of insurers holding the bond	5.61	7.73	1.00	1.00	2.00	7.00	15.00
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						
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
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
Number of insurers holding the bond	5.23	7.36	1.00	1.00	1.00	6.00	15.00
Duration held (years)	3.04	2.99	0.38	0.88	2.05	4.42	6.75

Table 2: U.S. State Regulator's 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
Domestic insurers	170.03	154.27	44.75	65.50	110.25	207.75	381.75
Examiners per domestic insurer	0.27	0.19	0.07	0.13	0.22	0.34	0.56
Budget per domestic insurer (USD million)	0.20	0.19	0.05	0.08	0.15	0.32	0.38
Discretionary exams per domestic insurer	0.02	0.03	0.00	0.00	0.00	0.02	0.05
Regular exams per domestic insurer	0.23	0.08	0.13	0.17	0.22	0.29	0.32
Observations	43						

Table 3: Internal Models and Misreporting During the Financial Crisis

The table shows the evolution of credit spreads of bonds valued by internal models in comparison to bonds valued by non-internal models during the financial crisis. 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 average of the reported credit spreads for bond i at time t across all insurers, 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, X_{it} are bond level controls, and α_i and α_t are bond and time fixed effects. Bond level controls include credit rating and maturity. The regression conditions on bonds that existed in 2008 and the sample starts in 2004 and ends in 2016. The main coefficient of interest is γ, which measures the increase in credit spreads in 2008 for internal model bonds compared to all other years, relative to the same change for non-internal model bonds. For column I, a constant is estimated but not reported. Table shows standard errors in parentheses. Standard errors are clustered at 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 4: The Role of Regulatory Incentives

The table shows the relationship between reported credit spreads during crisis and at acquisition. 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} denotes the reported credit spread of bond i held by insurer j, CS_{ij}^{Acq} denotes the implied credit spread of bond i at the time of acquisition 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). Coefficient of interest are δ and λ which measure the relationship between reported credit spread of a bond in 2008 and its credit spread at acquisition, when the bond is not valued by an internal model and when the bond is valued by an internal model respectively. Table shows standard errors in parentheses. Standard errors are clustered at 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 5: Regulatory Incentives - Cross-sectional Split by Regulatory Constraints

The table shows the relationship between implied credit spreads during crisis and at acquisition 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} denotes the implied credit spread of bond i held by insurer j, CS_{ij}^{Acq} denotes the implied credit spread of bond i at the time of acquisition 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. Coefficient of interest are δ and λ which measure the relationship between reported credit spread of a bond in 2008 and its credit spread at acquisition, when the bond is not valued by an internal model and when the bond is valued by an internal model respectively. Table shows standard errors in parentheses. Standard errors are clustered at 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 6: Fragmented State Level Reporting and Cross-sectional Dispersion

Table shows the average cross-sectional standard deviation of reported fair values and credit spreads in 2008. 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) valued bonds separately for all bonds within a state and then take an 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 7: 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 $Misreporting$ denotes the level of misreporting by insurers in state k and *Supervision* denotes the level of supervision by regulator in state k. Supervision is measured using three different proxies: 1) Number of financial analysts and examiners state has per domestic insurer; 2) Number of discretionary exams state conducts per domestic insurer; and 3) Regulators budget per domestic insurer. X_k represents the controls. Controls include mean RBC ratio and mean log assets of the insurers in each state. $Misreporting$ and *Supervision* are standardised by dividing them with their standard deviation. All Significance: * 10%; ** 5%; *** 1%.

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

Table 8: Concentrated Positions and Misreporting

The table shows how changes in reported credit spreads during the financial crisis depend on the valuation method and holding structure of the bonds. We estimate:

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

	I	II
$CO_i \times IM_i \times Crisis_t$	-0.006**	-0.004
	(0.002)	(0.002)
$IM_i \times Crisis_t$	-0.019***	-0.003**
	(0.001)	(0.001)
$CO_i \times Crisis_t$	0.003	0.001
	(0.002)	(0.002)
R^2	0.661	0.923
Observations	122974	89043
Controls	Yes	Yes
Bond Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	NA
Year × Issuer Fixed Effects	No	Yes

Table 9: Market Cornering for Small Bonds

The table shows how holding size and proportion held for small bonds has increased after the crisis relative to large bonds for insures that used internal models in 2008 . We estimate:
(1)
$Cornering_{ijt} = \delta(IMInsurer_j \times SmallBond_i) + \gamma(IMInsurer_j \times SmallBond_i \times Post_t) + \alpha_{it} + \alpha_{jt} + \epsilon_{ijt}$

	Log(Par Value)		Proportion Held	
	I	II	III	IV
IM Insurer × Small Bond	-0.184***		0.037***	
	(0.052)		(0.004)	
IM Insurer × Small Bond × Post	0.107**	0.045**	0.016***	-0.001
	(0.048)	(0.021)	(0.004)	(0.001)
R-squared	0.662	0.967	0.587	0.975
Observations	1272347	1172945	1272347	1172945
Insurer × Year Fixed Effects	Yes	Yes	Yes	Yes
Bond × Year Fixed Effects	Yes	Yes	Yes	Yes
Insurer × Bond Fixed Effects	No	Yes	No	Yes

Table 10: Market Cornering for Small Bonds (New Purchases)

The table shows how holding size and proportion held for new purchases of small bonds has increased after the crisis relative to large bonds for insures that used internal models in 2008. We estimate:

$$Cornering_{ijt} = \delta(IMInsurer_j \times SmallBond_i) + \gamma(IMInsurer_j \times SmallBond_i \times Post_t) + \alpha_{it} + \alpha_{jt} + \epsilon_{ijt}$$

	Log(Par Value)	
	I	II
IM Insurer × Small Bond	-0.198***	0.036***
	(0.050)	(0.004)
IM Insurer × Small Bond × Post	0.192***	0.024***
	(0.073)	(0.008)
R-squared	0.702	0.624
Observations	242013	242013
Insurer × Year Fixed Effects	Yes	Yes
Bond × Year Fixed Effects	Yes	Yes

A. Alternative Identification Strategy

In our sample, there exists a non trivial fraction of bonds that are simultaneously valued using both internal model and external sources depending on which insurance company is valuing them.[26] We use this cross-sectional heterogeneity of the valuation method of a same bond at same point in time to check the robustness of our findings on reporting discretion and concentrated holding structure. We estimate the following cross-sectional regression:

$$CS_{ij} = \gamma(IM_{ij}) + \delta(CO_i \times IM_{ij}) + \alpha_i + \alpha_j + \epsilon_{ij}, \tag{A.1}$$

where, as before, CS_{ij} denotes the implied 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, 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, $CO_i \times IM_{ij}$ captures the interaction term, and α_i and α_j are bond and insurer fixed effects. The time period for the regression is 2008 and the sample includes all bonds held in 2008. γ measures the average difference in reported credit spreads between bonds valued by internal models and bonds valued using external sources. δ measures whether the ownership pattern of a bond has any impact on this difference.

Table A.1 documents our findings. In all specifications, we add bond fixed effects, which allows us to compare the same bond across insurers. As a bond can be valued by both internal model or by external sources by different insurers, IM_{ij} is not constant at the bond level and does not get absorbed by bond fixed effects. Insurers that use internal models to value a bond and hold bonds that have more concentrated holding structure, report credit spreads that are 80 bps less as compared to bonds that had less concentrated holding structure. Moreover, bonds not valued by internal models do not depict this heterogeneity. In more stringent specification, we also take insurer fixed effects to control for insurer specific characteristics, such as RBC ratio, leverage, etc. (column II), and find no meaningful difference in our estimates.

[26] Out of the 19,259 bonds that exist in our sample in 2008, 7,340 bonds are valued using internal models by at least one insurer. Out of these 7,340 bonds, 50% are valued both by internal models and external sources by different insurers.

Table A.1: Results from an Alternative Identification Strategy

The table shows how the cross-sectional dispersion in reported credit spreads of the same bond across insurers in 2008 depend on the valuation method and holding structure of the bonds. Table shows standard errors in parentheses. Standard errors are clustered at insurer level. Significance: * 10%; ** 5%; *** 1%.

	I	II
IM_{ij}	-0.000	0.001
	(0.001)	(0.002)
$CO_i \times IM_{ij}$	-0.008***	-0.009***
	(0.003)	(0.003)
R^2	0.952	0.953
Observations	94371	94364
Bond Fixed Effects	Yes	Yes
Insurer Fixed Effects	No	Yes

B. Concentrated Ownership and Bond Transactions

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:

$$Dummy_i^{TiN} = \delta(CO_i) + \beta X_i + \alpha_k + \epsilon_i, \tag{B.1}$$

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. As transactions of the private placement bonds are not reported in TRACE, we exclude them from sample. The variable of interest is δ that measures the difference in probability of finding a transaction in TRACE between bonds with more concentrated holding structure and less concentrated holding structure.

Table B.1 documents the results. 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.

Table B.1: Transactions in TRACE

Table shows the difference in probability of finding a transaction in TRACE depending on a bond's holding concentration. Table shows standard errors in parentheses. Standard errors are clustered at issuer level. Significance: * 10%; ** 5%; *** 1%.

	$Dummy^{TiN}$	
	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