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

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Abstract

Exploiting position-level heterogeneity in regulatory incentives to misreport and novel data on regulators, we document that U.S. life insurers inflate the values of corporate bonds using internal models. We estimate an additional $9-$18 billion decline in regulatory capital during the 2008 crisis, i.e., a 30% greater decline than what was reported. Supervision helps dissuade misreporting, but only when close pricing benchmarks exist. Insurers, in response, strategically shift asset selection toward bonds where price verification is harder, and corner small bonds. Our findings have consequences for assessing the fragility of financial institutions and for understanding the price discovery of corporate bonds.

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Capital regulation critically hinges on the values of the assets that financial institutions hold. However, a wide class of assets trade less frequently or hardly at all. In the absence of observable market prices, regulators permit the use of internal models, taking advantage of institutions' expertise in valuation. However, internal models introduce agency problems as institutions can exploit discretion and report inflated asset values, especially when asset prices decline and regulatory constraints are binding. In an attempt to dissuade institutions, regulators closely monitor financial reporting. Thus, it is unclear whether and the ways in which institutions exploit reporting discretion. One possibility is that institutions shift asset selection toward positions that lack close benchmarks, which makes reporting less verifiable and supervision less effective. Reporting discretion, therefore, can distort asset selection beyond what might be implied by the standard risk-return characteristics of assets, and can make it harder to assess the fragility of institutions, particularly in bad times.[1]

In order to quantify the extent and implications of the incentive problems, we face three main challenges. First, the market values of assets valued using internal models are mostly unobserved. Thus, it is difficult to verify whether institutions exploit discretion. Second, to understand the extent to which regulators dissuade misreporting, we need heterogeneity in the intensity of supervision. Finally, to examine how asset selection is affected, we need incentives or the ability to exploit discretion to vary over time, across institutions, or across assets. We study U.S. life insurers' corporate bond investments and exploit a unique setting that provides heterogeneous regulatory reporting incentives to different insurers for the same bond.[2] We also exploit novel data on different state regulators' resources for monitoring reporting and variation over time in the ability and the incentives to use internal models. Using this setting, we show that life insurers inflate the values of corporate bonds to alleviate regulatory constraints, and shift asset selection strategically to bypass regulatory supervision.

We first tackle the question in an ex-post sense, i.e., conditional on the selection of assets, we ask for which insurers, times, and bonds are the incentive problems most severe? Life insurers hold corporate bonds at book value (historical cost). However, assets are revised down from the existing book values to the prevailing market values when bonds are "impaired", i.e., when the market values have declined "sufficiently" below the book values due to permanent changes in credit risk. Thus, the incentive to misreport varies across insurers for the same bond depending on the book value at which the bond is being held. For example, suppose insurers A and B hold the same bond at book values \$70 and \$80,

[1]Koijen and Yogo (2019) link demand for certain asset characteristics with asset prices. Agency frictions are the building blocks of the intermediary asset pricing literature; see e.g., He and Krishnamurthy (2013).

[2]Similar regulatory incentives also create distorted trading incentives. See Milbradt (2012) and Ellul, Jotikasthira, Lundblad, and Wang (2015).

respectively. Consider what happens if the market value of the bond declines to $72 in 2008. Insurer A has no incentive to misreport because A is required to continue holding the bond at $70. However, B has incentives to misreport because if B reports truthfully, the bond could be revised from $80 down to $72. As the same bond can be held by different insurers at different book values, e.g., because bonds were acquired at different costs, we get variation in the regulatory incentives to report different values for the same bond across insurers.

Life insurers report corporate bonds at the security level. For every position, we observe the book values and the market values at which each individual insurer holds the bond. We also observe whether the market values are obtained from internal models or sourced externally, e.g., from traded prices, broker quotes, or pricing services. The market values of a large fraction of corporate bonds are obtained using internal models, e.g. over 40% of the corporate bond assets for MetLife and Prudential (the two largest insurers). In addition, for a significant fraction of bonds, some insurers use internal models even when other insurers have sourced valuations externally. This allows us to compare the gap between internal and external values of the same bond, in addition to examining whether the reported values of the same bond line up according to the regulatory incentives described above.

Exploiting these two features of our setting, we show that insurers that use internal models report credit spreads that are on average 120 bps lower than insurers that use external sources to value the same bond, during the financial crisis. The systematic under-reporting of spreads occurs when revisions in assets are likely. Thus, external valuations of the same bond reflect higher risk than what is implied by insurers' own assessments of the risk of the bond, when regulatory incentives to misreport exist. Crucially, there is no gap between internal and external spreads when asset revisions are not likely and regulatory incentives are absent. The gap increases as we move from investment grade (100 bps) to high yield (300 bps) bonds, i.e., bonds for which the likelihood of an impairment is the highest. The gap also increases as the magnitude of the expected asset revision goes up, i.e., the regulatory incentives to misreport become stronger. Moreover, misreporting is the most pronounced for constrained insurers that have low capital relative to regulatory requirements and for whom the marginal value of an extra dollar of regulatory capital is the highest.

We estimate that had valuations been truthfully reported in 2008, life insurers would have had to revise their regulatory capital down by an additional $9-$18 billion in aggregate, which is more than 30% higher than the decline reported in 2008. A vast majority of the revisions are concentrated within the largest 20 insurers and the magnitudes are comparable to alternative ways by which insurers eased regulatory constraints during the crisis, e.g., government bailouts, raising equity, redacting dividends, selling policies at a discount (Koijen and Yogo (2015a)), and gains trading (Ellul, Jotikasthira, Lundblad, and Wang (2015)).

We next ask exactly how insurers bypass state regulators' scrutiny at such a large scale. As each insurer is regulated and supervised in their state of domicile, we quantify the extent of misreporting in each individual state. Using novel data on the resources available to state regulators for verifying bond valuations, we document two facts. First, the misreporting across states is negatively correlated with the intensity of supervision in a state, measured in a number of ways, including the total number of financial examiners, the number of discretionary exams, and the total budget per insurer within a state. Second, the negative relationship exists only for bonds with multiple holders, i.e., bonds for which regulators have reference prices available to compare reported values, but does not exist for bonds with single holders for which regulators have no reference prices for comparison.

Furthermore, we document that insurers have a lower capacity to exploit reporting discretion if reference prices or close pricing benchmarks exist. Sorting bonds by the number of insurers holding a bond, we show that the gap between internal and external spreads is the largest when a bond has just two holders (470 bps), and declines sharply as the number of holders increases. Using private placements as a proxy for price opaqueness, we document that the gap between internal and external spreads is 340 bps greater when prices are more opaque than when they are less. Finally, using bonds of private companies and single issues of companies as proxies, we document higher misreporting when close pricing benchmarks are not available. Thus, insurers have a greater ability to bypass scrutiny when asset values are harder to verify due to the lack of reference prices or price benchmarks. Supervision helps to alleviate the agency problems, but only when reported prices are easily verifiable.

A number of additional findings help to rule out alternative explanations of our results. First, misreporting mainly occurs in 2008 and 2009, when insurers are constrained. Moreover, the same insurer misreports when asset revisions are likely but not when revisions are not likely, and ultimately revises assets down in later years. Thus, disagreement, i.e., more optimistic insurers reporting higher values, or uncertainty about model parameters are less likely to explain the differences in reported values across insurers. Second, we find no evidence of insurers reporting stale prices or extrapolating from past changes in prices. Third, the difference in regulators' ability to restrict misreporting across various type of bonds implies that regulatory forbearance does not fully explain why insurers bypass regulators. Fourth, our results are not due to endogenous matching between insurers and state regulators because otherwise we should observe a negative relationship between misreporting and supervision, both for bonds that have reference prices and for bonds that have single holders.

Finally, we ask whether and the ways in which insurers' asset selection responds to the incentive problems that arise from having reporting discretion. To test this, we exploit time series variation in insurers' ability and incentives to use internal models. From 2008, insurers were no longer required to source or authenticate bond valuations from the National Association of Insurance Commissioners (NAIC) Securities Valuations Office, which increased insurers' ability to use internal models. Moreover, the widening of credit spreads and the decline in regulatory capital during the crisis increased insurers' incentives to exploit discretion. We uncover two distinct channels that help insurers minimize the costs of regulatory scrutiny. First, we document that insurers that exploit more discretion hold a significantly higher fraction of assets in bonds for which price verification is harder (e.g., bonds with few holders, opaque prices, and that lack external benchmarks), relative to insurers that exploit less discretion. Crucially, insurers that exploit more discretion increase the fraction invested in these bonds, both going into 2008, and also for a few years after.

Second, we document that insurers that exploit more discretion also corner new issues of small bonds by acquiring a significant fraction of the a bond's issuance amount in and after 2008. We show that cornering helps insurers in two ways. By holding a larger share of a bond's issuance amount, insurers reduce the number of reference prices with state regulators. Moreover, it also helps to limit secondary market trading, which then increases the likelihood of using internal models. Thus, the incentive problems that arise from having reporting discretion not only create distortions in favor of bonds where price verification is harder to start with, but could also exacerbate the price discovery of small bonds, especially since life insurers are the largest investors in the U.S. corporate bond market.

By exploiting reporting discretion, insurers indirectly control the extent to which impairments can be enforced by regulators. This may well be useful if market fluctuations are due to temporary liquidity shocks, in ensuring that patient investors such as life insurers continue to insulate assets from short term market movements (Chodorow-Reich, Ghent, and Haddad (2018)) and do not exacerbate crises (e.g., through fire sales). However, if market fluctuations are due to fundamental shocks, then having reporting discretion makes it harder to assess the fragility of insurers, which can lead to sub-optimal real decisions and can delay corrective regulatory actions (e.g., Savings and Loans crisis). Moreover, if policyholders suffer a loss of confidence in regulators' ability to determine solvency, it could amplify self-fulfilling runs (see e.g., The Executive Life crisis and Foley-Fisher, Narajabad, and Verani (2019)).

Related Literature: This paper is related to the broader literature that studies insurers' incentive problems and the resulting impact on ownership and trading of fixed income securities, in particular driven by regulatory constraints. Our paper most closely relates to

Ellul, Jotikasthira, Lundblad, and Wang (2015) who show that insurers participate in gains trading and do not sell assets that have large unrecognized losses; Ellul, Jotikasthira, and Lundblad (2011) who provide evidence of fire sale in downgraded corporate bonds induced by regulatory pressures; and Becker, Opp, and Saidi (2020) who show that insurers hold more high yield MBS and crowd out other investors in new issuances, following a reduction in capital requirements.[3] We identify that having discretion over reported values is a quantitatively important channel using which insurers alleviate regulatory constraints. We are also the first to uncover the distortions in asset selection that arise from these incentives.

Second, our paper contributes to the upcoming literature on the heterogeneity in oversight across regulators and the implications for regulated entities and financial fragility.[4] We show that regulators' resources and supervision vary significantly across U.S. states. Lower supervision in some states is suggestive of regulatory forbearance, consistent with Tenekedjieva (2019) who shows that insurance commissioners are less strict due to post-term career concerns. We are the first to study the extent to which regulatory supervision helps to limit the use of reporting discretion. We show that tighter supervision helps to dissuade misreporting in assets for which price verification is easier and insurers bypass regulators through strategic asset selection. This suggests that insurers do not perceive the costs of regulatory scrutiny to be negligible. Our estimates of capital revisions and prior estimates of shadow costs of capital during the crisis (Koijen and Yogo (2015a)) can be useful to quantify the costs of regulatory scrutiny across states. Our finding that supervision mainly limits misreporting when reference prices exist shows the importance of having a central repository of valuations and highlights one benefit of a centralized regulatory structure.[5]

Third, our paper is related to the banking literature on the use of internal risk models for estimating capital requirements of loans (Behn, Haselmann, and Vig (2016) and Plosser and Santos (2018)).[6] We show that misreporting occurs even in traded assets where the use of discretion is seemingly costlier as external valuations are available. Moreover, since we have heterogeneous incentives at the position level for the same insurer, we can pin-point the exact links between regulatory incentives and misreporting, and since corporate bonds are traded, we can quantify the extent of misreporting more accurately. Our paper also relates to

[3] Also see Becker and Ivashina (2015) who show that insurers prefer to hold higher rated bonds, but systematically shift toward higher yielding bonds within a rating category and Ge and Weisbach (2019) who show that financially flexible insurers assign higher portfolio weights to risky and illiquid corporate bonds.

[4] See Agarwal, Lucca, Seru, and Trebbi (2014). Kisin and Manela (2019) and Eisenbach, Lucca, and Townsend (2019) explore the determinants of this heterogeneity; and Hirtle, Kovner and Plosser (2019) document the positive impact of supervision on bank performance.

[5] See Ben-David et. al. (2020), who document that centralized supervision reduces banks' risk taking.

[6] Begley, Purnanandam, and Zheng (2017) find that low equity capital banks under-report risk exposures.

the hedge funds literature on smoothing returns, which however captures a different motive (fees) and a different interaction (between funds and investors) relative to our setting.[7]

Our paper also helps to understand concentration in the ownership patterns of corporate bonds. Prominent explanations for concentration go back to Bolton and Scharfstein (1996), who propose that lower number of creditors increase coordination and bargaining power during renegotiation. In our set up, preference for concentration derives from insurers' ability to more easily bypass regulatory scrutiny of reported values when number of holders are few. We also document a preference for small and price opaque bonds. Thus, our findings help to better understand the objective function and preferences of life insurers, which are the key building blocks for the intermediary asset pricing (He and Krishnamurthy (2013)) and characteristics based asset pricing (Koijen and Yogo (2019)) literature.

The paper is organized as follows. Section 1 provides an overview of the regulatory framework for U.S. life insurers and describes the data sources. Section 2 documents how internal models are used to misreport asset values. Section 3 studies how insurers bypass state regulators. Section 4 documents the impact on asset selection. Section 5 concludes.

1. Institutional Background and Data

Having discretion over reported values can 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. We focus on regulatory incentives for two reasons. First, prior literature has shown that life insurers operate subject to statutory regulation.[8] Second, the regulatory framework provides heterogeneous reporting incentives to different insurers for the same bond, allowing us to cleanly pin down whether insurers exploit discretion due to regulatory constraints. We describe the key features of the regulatory setting below.

1.1. Regulatory Reporting

1.1.1. Reporting Guidelines

Life insurers hold corporate bonds at book value (historical cost) for statutory (regulatory) reporting, unless a bond is permanently impaired, in which case insurers are forced

[7] See e.g., Cassar and Gerakos (2011) and Agarwal, Daniel, and Naik (2011).

[8] See Koijen and Yogo (2015a, 2015b, 2016, 2017), Sen and Humphry (2016), Ge (2016) for liability side; Becker and Ivashina (2015), Ellul et. al. (2011, 2015) for asset allocation; and Sen (2018) for risk management decisions.

to recognize "other-than-temporary-impairment" and revise assets down from their book values to their prevailing market values. Permanent impairment occurs when a bond's value declines because of a permanent deterioration in the underlying credit risk and not because of shifts in interest rates (NAIC SSAP No. 26). However, mark-to-market fluctuations in credit spreads, in general, do not impact the value of the regulatory assets. Only when a bond is deemed impaired, insurers are forced to revise assets by the regulators, which then negatively impacts the value of the regulatory assets and capital.[9]

To track potential cases of impairments, regulators require life insurers to report the "market values" of each position, along with the book values. However, the regulators do not specify the exact threshold at which impairments take place. The reporting guidelines suggest that wherever possible, insurers first report traded prices or prices taken from other external sources, which include quotes from broker-dealers and pricing services such as IDC, Reuters, and Bloomberg. Where it is not possible to obtain prices from external sources, insurers are allowed to compute the market values "analytically" using "internal models". The guidelines are not specific about what the models should be.[10] Moreover, unlike banks' internal risk and capital models, the internal models for bond valuations are not validated by the regulators or subjected to model governance standards.

1.1.2. Corporate Bond Holdings

Each insurance company submits regulatory filings in their state of domicile,[11] and reports fixed income holdings at the position level annually.[12] We collect these data from the NAIC's Schedule D database and restrict our sample to corporate bond positions, which account for over 40% of life insurers' general account assets. Crucially, we observe insurers' own calculations of market values (prices) for each position and whether the market values are obtained from internal models or external sources. For each position, we observe other holding characteristics, including the book value at which the bond is being held, the total par value, the date of purchase, and the price paid at acquisition. We also observe various bond characteristics, including the CUSIP, the NAIC credit rating category (described below), coupon, maturity, and other special features, e.g., whether the bond is callable, putable, or convertible. We aggregate positions at the group level by using the operating company code to group code mappings. The sample spans from 2004 to 2016.

[9] See the NAIC Valuation Manual (2016), Ellul et. al. (2015), and Appendix C of this paper.

[10] For example, the models may entail "adjusting and applying the spreads of close benchmark bond(s)", which include bonds of similar ratings from the same issuer or another issuer in the same industry.

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

[12] These holdings include treasuries, municipal bonds, asset backed bonds, and corporate bonds.

1.1.3. Prevalence of Internal Models

Because a large fraction of corporate bonds trade infrequently and in over-the-counter markets, often, prices are not observed continuously. Thus, the market values for a large fraction of bonds are obtained using models developed by insurers who hold the bonds. Table 1 reports the internal models share (i.e., the fraction of the total par value in corporate bond assets that is valued using internal models) for the largest insurers in 2008. For example, MetLife and Prudential (both in the top 5) have more than 40% of their corporate bond assets valued by internal models. We also observe that for a significant fraction of bonds, internal models are used even when external valuations are available (Table A.1), a feature we exploit to identify misreporting.

1.2. Regulatory Incentives to Misreport

A key metric that state regulators use to determine capital adequacy and that rating agencies use 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 NAIC stipulates that insurers compute the 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; each category is then assigned a risk weight. NAIC 1 are AAA, AA, and A rated bonds; NAIC 2 are BBB; NAIC 3 are BB; NAIC 4 are B; NAIC 5 are CCC; and NAIC 6 are CC or below. NAIC category 1 (6) attracts the lowest (highest) risk weights.[13]

Impairment introduces variability in RBC ratios for two reasons. First, there is a negative impact on regulatory capital (the numerator of the ratio) because bond assets are revised downwards. Second, if the impairment is accompanied with a rating downgrade, there is a simultaneous increase in the required capital (the denominator of the ratio). Both forces become stronger during a downturn, such as the 2008 financial crisis. This gives some insurers the incentives to exploit discretion and report higher market values for positions that face a higher likelihood of impairment and a subsequent revision in assets. The incentive to report a higher market value depends on the book value at which a bond is being held, which in turn

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

depends on the cost at which the bond was originally purchased. As the initial purchase cost may vary across insurers, e.g. due to the timing of the purchase, the same bond can be held at different book values by different insurers.[14] This feature provides useful heterogeneity in the incentives to exploit reporting discretion for the same bond at the same time but across different insurers.

1.3. How are Prices Sourced and Verified?

The Role of SVO: The NAIC Securities Valuations Office (SVO) is primarily responsible for assigning the NAIC credit rating category to corporate bonds held by insurers. The SVO also provides bond valuations to insurers, however in a diminished capacity since 2008. The SVO does not produce bond valuations itself. It acts as an aggregator of valuations, which it sources from public transactions, brokers-dealers, pricing services, and from insurers' analytical models.[15] Before 2008, insurers had to directly source the bond valuations from the SVO. If the valuations were not available, insurers could obtain valuations from external sources or internal models, but had to still authenticate the valuations with the SVO.

Even though the SVO's validation was required, it does not imply that insurers had no discretion over reported values prior to 2008. Prominent instances of insurers exploiting reporting discretion have been documented as far back as the early 1990s. For example, The Executive Life Insurance Company, which was the largest life insurer in California, misreported bond values to the state regulator during the high yield bond market crash in 1990.[16] However, from 2008, the SVO's role as a provider of bond valuations has diminished and insurers' discretion over reported values has increased further because a NAIC task force has allowed insurers to obtain valuations directly (from public transactions, third-party sources, and internal models) bypassing the need to go to the SVO.

State Regulators: U.S. insurers are regulated in their state of domicile, and state regulators are responsible for safeguarding the solvency of insurers domiciled in their state. Verifying the accuracy of regulatory reporting is a key part of this objective, for which state regulators conduct financial examinations and employ a large number of financial examiners and analysts. Financial examinations investigate a company's accounting methods and modeling procedures, verify and validate what is presented in the annual statements, and

[14] The book value of a bond is the amortized value of the price paid at the time of bond acquisition.

[15] For example, the SVO clarifies that the valuations it provides should not be considered as "the price at which a security could or should be bought or sold at the market place". See Purposes and Procedures Manual of the NAIC Securities Valuation Office (2007).

[16] See United States General Accounting Office (1992).

test whether the company has complied with reporting guidelines and state regulations.[17] Financial examiners specialize in these activities and are trained in the use of specialized computer audit software.[18] Any reporting discrepancy results in disciplinary actions such as delinquency orders, suspensions, and the revocation of licenses. There are two types of financial exams: regular and discretionary. Regular exams typically occur every three to five years, while discretionary exams occur on an ad hoc basis, when state regulators decide that special circumstances warrant more frequent examinations.

To understand the extent to which regulatory supervision dissuades misreporting, we collect novel data on the resources available with each state regulator to monitor financial reporting from the NAIC's Insurance Department Resources Reports, which provide key statistics on the resources and regulatory activities of individual states' insurance departments annually. We describe these data in Section 3.

2. Internal Models and the Use of Reporting Discretion

2.1. Comparing Reported Credit Spreads Across Bonds

We start by comparing the reporting patterns across corporate bonds. Because impairment occurs when bond values shift due to a decline in the credit risk and not due to changes in interest rates, we compute the implied credit spreads for each position using reported prices.[19] Figure 1 shows the evolution of reported credit spreads (and Figure A.1 shows prices) for bonds valued using internal models (IM) and external sources (non-IM). The average reported spreads (and prices) of IM and non-IM bonds are similar throughout time, except during the 2008 crisis, when the spreads (and prices) sharply diverge. Both IM and non-IM bonds exhibit a significant increase in credit spreads during the crisis; consistent with misreporting, however, the reported spreads during the crisis are systematically lower (and prices are higher) for bonds valued by internal models.

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

$$\overline{CS}^{R}_{b,t} = \gamma(IM_b \times Crisis_t) + \beta X_{b,t} + \alpha_b + \alpha_t + \epsilon_{b,t}, \tag{1}$$

[17] For details, see Insurance Department Resources Reports.

[18] States employ a number of staff for other supervisory activities: these staff include supervisors, actuaries, captive specialists, market conduct supervisors, market conduct examiners, and anti-fraud staff.

[19] We convert bond prices into yields and then subtract the yields of a comparable maturity treasury. See Appendix B for details.

where $\overline{CS}^R_{b,t}$ is the cross-insurer average reported credit spread for bond b at time t; IM_b is a dummy variable that takes the 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 the value of 1 if the year is 2008 and 0 otherwise; $X_{b,t}$ denotes bond level controls, which include credit ratings and maturity; and α_b and α_t are bond and time fixed effects, respectively. The regression includes all bonds held by insurers in 2008 and tracks the average credit spreads of these bonds from 2004 to 2016. The main coefficient of interest is γ, which measures the gap between the increase in credit spreads in 2008 (relative to all the other years) for IM bonds and the same increase in credit spreads in 2008 for non-IM bonds.

Table 2 documents the main findings. γ is negative and statistically significant at the 1% level (column I), which implies that the increase in credit spreads for IM bonds is significantly lower than the increase for non-IM bonds in 2008. The economic magnitude of the difference is large and equal to 190 bps, as also seen in Figure 1. The coefficient on $Crisis_t$ is 690 bps, which captures the average increase in credit spreads for all bonds during the crisis. In column II, we add bond and time fixed effects. Bond fixed effects help to control for the impact of time invariant bond characteristics (e.g., seniority, callablity, coupon rate, covenants etc) on credit spreads to the extent that these characteristics do not impact spreads in a different way during the crisis. Column II shows that γ remains statistically significant and economically similar in magnitude. Columns III to VI show that the difference in the reported spreads of IM and non-IM bonds increases as we move from investment grade to high yield bonds.

One concern about comparing IM with non-IM bonds is that the bond characteristics could be different and that these differences impact valuations in a different way during the crisis. Table A.2 shows that IM and non-IM bonds have similar distributions of credit ratings and remaining maturity. The median rating is 2, which corresponds to a rating of BBB, and the median remaining maturity is around six years for both groups.[20] A higher proportion of IM bonds are callable (26%) than non-IM bonds (17%), but the call option is less likely to be in-the-money since bond values declined in 2008.[21] Nonetheless, there could be other omitted bond characteristics, e.g., covenants, that impact valuations differently in 2008 than in other years.[22]

[20] To keep the maturity distributions similar for IM and non-IM bonds, we restrict the across-bond analysis to bonds with maturities between one and thirty years. Including bonds with maturity less than one year and greater than thirty years does not affect our estimate meaningfully.

[21] Furthermore, our results are not sensitive to the inclusion of callable bonds in the sample. The fraction of bonds with other specials features (e.g., putable, convertible etc) are trivial. We do not report these characteristics.

[22] An obvious omitted variable is a bond's liquidity. However, because IM bonds are more likely to be illiquid, liquidity should result in spreads of IM bonds to be wider than non-IM bonds. In that sense, our

Our setting allows us to make progress because the regulatory framework provides heterogeneous reporting incentives to different insurers for the same bond. Figure A.2 shows that the reported spreads vary significantly across insurers for the same bond. Moreover, the cross-insurer dispersion in spreads is particularly high during the financial crisis and for internal model bonds.[23] We next examine whether these differences in reported values across insurers for the same bond line up with the regulatory incentives.

2.2. *Comparing Reported Credit Spreads: Same Bond Across Insurers*

2.2.1. *Identification Strategy and Measurement of Incentives to Misreport*

Because impairments result in revisions in assets from the existing book value (BV) down to the prevailing market value (MV), the incentive to misreport varies across insurers for the same bond depending on the BV at which the bond is being held (see Section 1). We can therefore identify positions where an insurer has incentives to misreport, i.e., $\text{Incentive}_{b,i} = 1$ as follows:

$$\text{Incentive}_{b,i} = \begin{cases} 1, & \text{if Asset Revision}_{b,i} > 0 \\ 0, & \text{otherwise and} \end{cases} \tag{2}$$

$$\text{Asset Revision}_{b,i} = (BV_{b,i} - MV_b)^+ \; [\mathbb{1}_{IMP_{b,i}}]. \tag{3}$$

Equation (2) says that insurer i has an incentive to misreport the market value of bond b when assets are likely to be revised down. Equation (3) says that asset revisions occur when (a) $BV > MV$, and (b) a bond is impaired. $\mathbb{1}_{IMP_{b,i}}$ is an indicator variable that identifies whether impairment takes place for bond b held by insurer i.

To measure the incentives to misreport, we need three inputs: (i) BV for each position, which we observe in the data; (ii) an estimate of a bond's true MV; and (iii) an estimate of whether impairment is likely. To estimate a bond's true MV, we compute the cross-insurer average reported price of a bond, only using valuations of insurers obtaining prices from external sources. To identify potential cases of impairments, we uncover the historical impairment rule, i.e., for each rating category, we identify the thresholds below which impairments have occurred during our sample period.[24] Appendix C reports the thresholds.

across-bond estimates provide a lower bound of the true extent of misreporting.

[23] In line with this, Cici, Gibson, and Merrick (2011) show dispersion in month-end valuations of the same corporate bond held by different mutual funds. Dispersion increases during periods when the bond-market return volatility is high.

[24] Our strategy for measuring incentives to misreport assumes that insurers observe the BV, the prevailing

2.2.2. *Comparing Internal Model Spreads with External Spreads During the Crisis*

To quantify the extent of misreporting, we estimate the specification below, which compares the spreads obtained from internal models and the spreads sourced externally during the financial crisis for the same bond:

$$(4) \qquad CS^R_{b,i} = \gamma_1 IM_{b,i} + \gamma_2(Incentive_{b,i} \times IM_{b,i}) + \gamma_3 Incentive_{b,i} + \alpha_b + \alpha_i + \epsilon_{b,i},$$

where $CS^R_{b,i}$ is the reported credit spread of bond b held by insurer i, $IM_{b,i}$ is a dummy variable that takes a value of 1 if insurer i valued bond b using internal models, $Incentive_{b,i}$ is defined as in Equation (2), and α_b and α_i are bond and insurer fixed effects, respectively. Bond fixed effects allow us to compare the reported spreads of the same bond across insurers. Insurer fixed effects control for insurer characteristics that do not vary at the bond level, such as RBC ratio, leverage, and risk aversion. Moreover, insurer fixed effects help control for model error to the extent that it occurs at the insurer level and does not vary from bond to bond, e.g., the modeling of macro-economic variables. The analysis focuses on the 2008 financial crisis, when IM and non-IM spreads diverge (Figure 1). The sample includes all bonds held in 2008.

The coefficients of interest are γ_1 to γ_3. γ_1 measures the average difference in the level of reported spreads for positions valued using IM, as compared to positions valued using external quotes or traded prices. γ_2 measures whether the difference increases for positions where regulatory incentives to misreport exist. Finally, γ_3 measures whether the spreads are different when misreporting incentives exist versus when these incentives do not exist, in the absence of internal models. Thus, γ_3 captures the tendency to search for the lowest quoted spread.

Table 3 documents three main facts. First, column I shows that γ_1 is statistically insignificant, and that γ_2 is negative, significant (at the 1% level), and large in magnitude. This implies that when misreporting incentives *do not exist* (and asset revision is unlikely), there is no difference in the reported spreads between an insurer that uses internal models and one that uses external sources to value the bond. However, when incentives *exist* (and asset revision is likely), insurers that use internal models report spreads that are lower by an average of 120 bps as compared to insurers that use external sources to value the same bond. In other words, there is no gap between internal and external spreads when regulatory

MV, and form an expectation about impairment, before deciding what asset value to report. As annual statutory filings are prepared in the first quarter of the subsequent year, this assumption about the sequence of events is justified.

incentives to misreport are absent. However, the gap is as large as 120 bps on average when revisions in regulatory assets are likely.

Second, while these effects hold true across all rating categories (columns II-IV), the magnitude of the misreporting that stems from these regulatory incentives and the use of internal models increases as we move from investment grade to high yield bonds, in line with the results in Table 2. γ_2 is close to 100 bps for AAA, 60 bps for BBB, 150 bps for BB, and 510 bps for bonds rated B and below. The large magnitudes within high yield bonds are due in part to their higher spreads in 2008 (Figure A.3).[25] Moreover, a higher fraction of credit spreads in lower rated bonds is due to expected default (Almeida and Philippon (2007), Huang and Huang (2012)). Thus, we expect a higher likelihood of permanent impairment and greater incentives to misreport asset values in lower rated bonds.[26]

Third, γ_3 is negative and statistically significant. Thus, misreporting occurs even when internal models are not used but when the regulatory incentives exist (and asset revision is likely). This suggests that insurers have a tendency to over-report bond values by finding the lowest quoted spread for a bond. Our estimates suggest that when misreporting incentives exist, insurers report a quote that is on average 50 bps lower than the quote when misreporting incentives do not exist.[27]

To visually illustrate the extent of misreporting, for every position that is valued by internal models in 2008, we compute the deviation of the reported spreads from the highest externally sourced spread for the same bond. The highest spread helps account for the tendency to misreport with quotes (Table 3) and provides a better estimate of the prevailing external spreads than does the average quote. Figure 2 shows the distributions of these deviations split into two groups: (i) positions where incentive to misreport exists and (ii) positions where incentive does not exist. The stark contrast in the two distributions is evident. When asset revision is likely, the bulk of the positions are to the left of zero, i.e., the large majority of spreads that are reported using internal models are lower than the prevailing external estimates. In contrast, when asset revision is not likely, the deviations are more evenly distributed around zero.[28]

[25] Figure A.3 plots the average credit spreads in 2008 for each rating category separately. The non-IM spreads for BBB is 830 bps as compared to 1400 bps for BB bonds.

[26] The credit spread consists of expected default (cash flow component) and of risk premium (e.g., compensation for default and liquidity risk).

[27] Similarly, Cassar and Gerakos (2011) find that hedge fund managers that source prices from dealer quotes (exchange) exhibit higher (lower) return smoothing.

[28] Even when impairment is not likely, there are instances when internal model spreads are lower than the prevailing external estimates. This phenomena could be driven by other incentives to misreport e.g., GAAP reporting, performance linked compensation.

2.2.3. *Correlation Between Reported Spreads in 2008 and Acquisition Spreads*

An alternative way to think about the misreporting incentives is in terms of the magnitude of the asset revision. The amount of revision is given by the difference between the BV of the bond for insurer i and the MV of the bond (see Equation (3)). Thus, insurers that acquire the bond at a higher (lower) cost, i.e., a higher (lower) BV, have higher (lower) incentives to misreport asset values. Thus, we expect a positive correlation between acquisition cost (acquisition credit spreads) and reported price (reported credit spreads) for bonds valued using internal models. If all insurers report truthfully, then we expect no correlation between reported and acquisition spreads. Similarly, if a bond is valued using traded prices or external quotes, then insurers have less reporting discretion, and we expect a weak positive relationship, or none at all, between reported and acquisition spreads.

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

$$CS^{R}_{b,i} = \lambda_1 CS^{Acq}_{b,i} + \lambda_2 (CS^{Acq}_{b,i} \times IM_{b,i}) + \lambda_3 IM_{b,i} + \alpha_b + \alpha_i + \epsilon_{b,i}, \qquad (5)$$

where $CS^{Acq}_{b,i}$ is the prevailing spread for bond b at the time it was acquired by insurer i. All the remaining variables are defined as before. Bond fixed effects allow us to measure the correlation between reported and acquisition spreads by comparing the spreads of the *same* bond across insurers. λ_1 measures the baseline correlation for all bonds and λ_2 measures whether the correlation increases for positions that were valued using internal models.

Table 4 documents that there is a positive and statistically significant relationship between the reported and the acquisition credit spreads when we restrict the sample to positions valued by internal models (column I). The magnitude is large: a 100 bps difference in credit spreads at acquisition results in a 42 bps higher reported credit spreads. In contrast, there is no relationship between reported and acquisition credit spreads for positions valued by external sources (column II). Column III shows that λ_2 is positive and statistically significant, implying that when insurers acquire a bond at a higher spread, they are more likely to report a higher spread, as compared to insurers that acquired the same bond at a lower spread. Thus, misreporting is higher in positions where asset revisions are likely to be higher.

Impact of regulatory constraints: The incentive to exploit reporting discretion also varies in the cross-section of insurers, depending on their regulatory constraints. Insurers that are more constrained for regulatory capital are more likely to report higher bond values in order to avoid asset revisions which further reduce regulatory capital. To test this, we split insurers in three groups based on the RBC ratios in 2007 (low, medium, and high) and re-estimate Equation (5). Insurers in the low (high) group are in the bottom (top) quartile of RBC ratio, i.e., are the most (least) constrained, and thus have the highest (lowest) incentives to avoid asset revisions. Table 4 shows that the positive relationship between reported and acquisition credit spreads is highest (lowest) in magnitude for low (high) RBC insurers. Moreover, the coefficient on $IM_{b,i}$ is negative and statistically significant for low RBC insurers. Thus, on average, low RBC insurers report lower spreads (relative to available external spreads for the same bond) when they use internal models, by as much as 130 bps. Thus, misreporting is the highest for insurers that are most constrained and for whom the marginal value of an extra unit of regulatory capital is the highest.

The new approach, which tests whether the acquisition and reported spreads are correlated, helps mitigate a number of potential challenges with the previous approach, which compares internal models spreads with external spreads. First, the previous approach requires that we observe an external and an internal model spread for the same bond. Thus, in implementing the previous approach, we ignore bonds which are valued using internal models by all holders, which is a substantial fraction of total bonds (Table A.1). The new approach allows us to consider all positions valued by internal models. Second, book values could also be misreported. Thus, the new approach uses acquisition spreads, which are based on traded prices and therefore are less likely to misreported. Third, the previous approach relies on accurately measuring the impairment thresholds and market values. The new approach is free of these measurement challenges because we do not need to exploit the discontinuity in incentives, which requires the use of impairment thresholds and market values.

2.3. Disagreement, Model Uncertainty, or Stale Prices?

The decision to purchase at a certain valuation is connected to insurers' own assessment of assets, which also impacts the valuations that they report in subsequent periods. Thus, an issue in interpreting the positive correlation between reported and acquisition spreads as an evidence of misreporting is that the positive relationship could simply result from a disagreement about fundamentals across insurers (Lintner (1969)). For example, more optimistic insurers would place a higher value on a bond both at acquisition and at all subsequent periods than would less optimistic insurers. Similarly, uncertainty about model parameters (Hansen and Sargent (2008)) could also lead insurers to attach higher values both at acquisition and in subsequent periods.

We document a number of facts that go against these alternative interpretations. First, placebo tests in alternative years show that the positive relationship between acquisition and reported spreads only exists in 2008 and 2009 when balance sheets were constrained, but not in other years (Table A.3). Second, we show that the *same* insurer is more likely to misreport when asset revisions are likely than when asset revisions are not likely. Third, insurers choose to use internal models even when an external valuation is available. Moreover, they report a spread that is on average lower than the external spread. In other words, external valuations of the same bond reflect higher risk than what is implied by the insurers' internal assessment of the bond's riskiness. Fourth, we show that insurers that use internal models are more likely to revise assets down at a future point in time (Table A.4).

Another concern could be that in the absence of traded prices, some insurers report stale prices from 2007. If some insurers report stale prices and others report true prices, then we may uncover a lower increase in spreads for positions valued using internal models in 2008 on average. To test this, Figure A.4 (a) shows a distribution of the difference in reported spreads between 2008 and 2007 for positions valued using internal models in 2008. If insurers report stale prices, then we expect a large mass concentrated at zero, which is not the case in the data. Similarly, insurers could also extrapolate from past changes in spreads. Figure A.4 (b) shows a distribution of the difference in growth rates in reported spreads between 2008 and 2007. If insurers extrapolate using past growth rates, we expect a large mass concentrated at zero, however we do not find it to be the case in the data.

2.4. Forecasting Revisions in Regulatory Capital

A significantly large proportion of corporate bonds are valued using internal models. In addition, Table A.2 shows that the holding size of internal model bonds is almost twice as large as the holding size of non-internal model bonds. These facts indicate that the revisions in regulatory assets (and capital) that would have occurred in the absence of reporting discretion can be economically significant. To quantify what would have been the actual decline in regulatory capital had insurers reported valuations truthfully, we forecast the revisions in regulatory capital in 2008. The revised capital for 2008 is equal to the reported capital minus the revisions in assets that should have happened in the absence of misreporting.

$$C_i^{Revised} = C_i^{Reported} - \sum_b \text{Asset Revision}_{b,i} \Big|_{\text{IM, Misreport}}, \tag{6}$$

where asset revisions are calculated as in Equation (3), with the exception that we only consider positions valued by internal models and positions where the reported market value exceeds our estimate of the prevailing market value for the bond.[29]

[29] We only compute revisions for positions valued by internal models and ignore positions where misreporting occurred using quotes.

The prevailing MV for positions valued by internal models are computed by sorting bonds into two groups. Bonds belonging to group I are valued using external sources by at least one insurer in the sample. We use the lowest price sourced externally as an estimate of the prevailing MV in order to account for the tendency to use quotes to misreport (Table 3). Bonds belonging to group II are valued using internal models by all insurers; thus we do not have an external price benchmark. We create a pricing matrix of the average percentage change in prices between 2008 and 2007 for various rating and maturity buckets, using bonds for which traded prices or quotes exist in both 2008 and 2007. To estimate the prevailing MV for bonds in group II, we assign price changes by matching rating and maturity.

Table 5 shows that in aggregate, life insurers should have revised their regulatory capital down by an additional $9 billion (considering group I bonds only) to $18 billion (considering both group I and II bonds), which translates to 3% to 5% of the reported capital in 2008. Our estimates imply a decline in regulatory capital of between 14% and 16%, which is more than 30% higher than the 11% decline insurers reported in 2008.

A vast majority of the revisions are concentrated within the largest 20 insurers, where our estimates imply a revision of between 18% to 20%, significantly higher than the 15% decline reported. We find the highest revisions for Ameriprise, Prudential, and Principal Financial, all of which also applied for the Troubled Asset Relief Program (TARP) in 2008-09. In the case of Ameriprise, the reported decline in capital was 10.7%, however it should have been as high as 32%. In the case of MetLife, the additional revision is $1.8 billion, which is 80% of the total common equity that MetLife raised in October 2008. There is also significant heterogeneity even within the largest 20 insurers. Notably, we find negligible revisions in capital for TIAA, AXA, and Hartford. Overall, these facts are consistent with insurers' significant attempts to recapitalise during the financial crisis by using government bailouts, raising common equity, redacting dividends, selling policies at a discount (Koijen and Yogo (2015a)), and gains trading (Ellul et. al. (2015)).[30]

3. Bypassing Regulatory Supervision

A key question is how exactly insurers bypass state regulators and exploit reporting discretion at such a large scale.[31] Regulators may face a number of challenges in monitoring the veracity of regulatory reporting, e.g., because insurers hold a large number of bonds, because

[30] Also see McDonald and Paulson (2015) for other accounts of the health of the insurance sector during the financial crisis.

[31] Other stakeholders, both within the firm (corporate governance) and outside the firm (auditors) also help to rein in these incentives (see e.g., Shleifer and Vishny (1986) and Edmans, Gabaix, and Landier (2009)). As we focus on the regulatory incentives to misreport, we restrict attention to state regulators.

reporting is decentralized at the state level, and because of the lack of active trading and price benchmarks in the corporate bond market. In addition, regulators' actions may be driven by the interests of the insurers domiciled in their states or their own personal interests, which result in regulatory forbearance and lax supervision. In this section, we analyse the extent to which supervision dissuades misreporting and whether insurers bypass supervision by selecting into positions that make reporting less verifiable.

3.1. Reporting Discretion and Intensity of Supervision

3.1.1. Heterogeneity in Misreporting Across States

We start by documenting that misreporting varies significantly across states. To quantify misreporting in each state, we estimate Equation (1) and compute the main coefficient of interest γ separately for each state. Misreporting in state s, $Misreporting_s = -(\gamma_s)$. γ_s measures the gap between the increase in credit spreads in 2008 (relative to all the other years) for IM bonds and the increase in credit spreads in 2008 (relative to all the other years) for non-IM bonds, after accounting for bond characteristics, bond fixed effects, and time fixed effects. The negative sign helps interpret higher values of γ_s as higher misreporting.[32] We estimate Equation (1) instead of Equation (4) as we also want to quantify the misreporting for bonds that are held by only one insurer (see below).

Figure 3 documents the significant heterogeneity in misreporting across states by splitting states into four groups: no misreporting ($\gamma_s = 0$ or below), low (γ_s = 0%-1%), medium (γ_s = 1%-2%), and high (γ_s = 2%-3%). A substantial fraction of states have an estimated misreporting that is statistically significant and economically large, e.g., Texas and Illinois (over 200 bps) and New York and Massachusetts (over 100 bps). At the same time, a number of states have almost negligible misreporting, e.g., California and Georgia.

We next document that misreporting is higher in the states where the incentives to misreport are stronger. Ellul, Jotikasthira, Lundblad, and Wang (2015) document that certain state regulators are more likely to reflect market prices in regulatory reporting, i.e., some states may have a lower impairment threshold and a higher propensity to issue asset revisions. Thus, insurers domiciled in these states could have greater incentives to misreport asset values. To identify states that have a higher preference for market based measures, we use the various proxies in Ellul et. al. (2015). Table 6 documents that misreporting is higher in states that have a preference for market based measures. This further corroborates

[32] As before, the regression only conditions on the bonds that existed in a state in 2008. A bond is classified as internal models if at least one insurer domiciled in a state values the bond using internal models.

the fact that insurers exploit more discretion when the regulatory incentives are stronger.

3.1.2. U.S. State Regulators' Characteristics

To understand the extent to which supervision helps to dissuade misreporting, we collect novel data on each state insurance departments' resources and regulatory activities. These data include number and type of staff, annual budget, revenue collected, number of examinations conducted, and number of actions taken at the state level.[33] Focusing specifically on the resources available to monitor financial reporting, we construct three proxies to measure the intensity of supervision at the state level, $Supervision_s$: (i) the total number of financial examiners and analysts (hereafter examiners) employed in a state, (ii) the total number of financial exams (regular and discretionary) conducted in a state, and (iii) the total budget of the state insurance department. 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 for two reasons. First, it provides an ex-ante measure of supervision. Second, it allows us to capture a full cycle of exams, which occur every 3 to 5 years.

Table A.5 documents the summary statistics on state regulators' characteristics. There is significant heterogeneity in the resources available to monitor financial reporting across states. On average, there are 0.27 examiners per insurer in a state, i.e., one examiner is assigned to roughly four insurers.[34] However, there is considerable heterogeneity across states, 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, but 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.

3.1.3. Misreporting and Supervision

To understand how the different measures for intensity of supervision correlate with the documented misreporting in a state, we estimate the following regression:

$$Missreporting_s = \alpha + \kappa(Supervision_s) + \beta X_s + \epsilon_s, \tag{7}$$

[33] See the description of NAIC's annual Insurance Department Resources Reports in Section 1.
[34] Examiners refer to both financial examiners and analysts that audit regulatory filings.

where $Missreporting_s$ denotes misreporting in state s, as described before. However, we split the population of bonds into two groups. The first group consists of internal model bonds that are held by multiple insurers within a state, which implies that state regulators have a reference price available to compare reported values. The second group consists of internal model bonds that are held by a single insurer within a state, which implies that the state regulator has no reference price for comparison. In both cases, the control group are all non-internal model bonds. As it is difficult to verify prices when reference prices are unavailable, splitting our measure of misreporting in this manner allows us to understand the extent to which supervision is effective and where it breaks down.

Table 7 documents two main facts. First, there is a negative relationship between misreporting and the intensity of supervision in a state when we consider bonds that have reference prices available. In columns I, II, and III, we document statistically significant and negative correlations between misreporting and the number of examiners, discretionary exams, and budget per insurer. As the heterogeneity in misreporting across states also depends on the characteristics of insurers domiciled in the states, we control for two key insurer characteristics: average log assets and RBC ratio. As Section 2 shows, larger insurers are more likely to use internal models and to exploit discretion. Similarly, low RBC insurers (constrained) are more likely to misreport asset values. κ is negative and statistically significant after controlling for these confounding variables.

Second, the negative relationship between misreporting and the intensity of supervision in a state does not exist for bonds with single holders, for which state regulators have no reference prices for comparison. Columns IV, V, and VI document statistically insignificant relationships between misreporting and all three measures of supervision, suggesting that insurers may have a greater ability to bypass regulatory scrutiny when they hold positions where asset values are harder to verify due to a lack of reference prices. In other words, supervision helps to alleviate the extent to which insurers can misreport asset values, but only when asset values are easier to verify.

The main problem with making this inference is that the matching between an insurer and the state regulator is endogenously determined through an insurer's choice of domicile (Agarwal, Lucca, Seru, and Trebbi (2014)). Insurers that are more likely to misreport could choose states with lax supervision. Thus, a negative correlation between misreporting and supervision does not necessarily imply that regulators change insurers' behavior. However, if the insurers' choice to domicile in lax states is driving our results, then we should observe a negative relationship between misreporting and supervision, not only for bonds that have reference prices, but also for bonds that have single holders, which we do not see in the data.

3.2. Impeding Price Verification

To further explore the idea that bonds with fewer reference prices allow for greater reporting discretion, we next examine how misreporting varies with different bond and holding characteristics.

3.2.1. Number of Holders

We start by evaluating how misreporting varies with number of insurers holding a bond. To do so, we re-estimate Equation (4) on three sub-groups of bonds: (i) bonds with only two holders (i.e., the median number of holders); (ii) bonds with three to five holders; and (iii) bonds with more than five holders. Bonds with just one holder get dropped as estimating Equation (4) requires that bonds be held by at least two insurers.

Table 8 shows that γ_2, which measures the gap between internal and external spreads where regulatory incentives to misreport exist, is negative and statistically significant across all sub-groups of bonds. However, the greatest misreporting occurs in bonds with just two holders ($\gamma_2 = 470$ bps), i.e. the insurer that obtains spreads from internal models reports spreads on average 470 bps lower than the insurer that uses external sources to value the same bond. When the number of holders are between three and five, the gap is still high at 180 bps; and as the number of holders increases to more than five, the gap reduces further to about 80 bps. Furthermore, we observe greater misreporting for bonds with few holders even when internal models are not used, but when regulatory incentives to misreport exist, e.g., by searching for the highest quote. Thus, greater misreporting in bonds with few holders happens more generally, both when insurers use internal models and when they obtain values from external sources. Overall, these results suggest that misreporting is greater when bonds have a concentrated holding structure, i.e., when there are few insurers holding a bond.

3.2.2. Opaque Prices and Lack of External Benchmarks

Insurers may also have a limited capacity to exploit reporting discretion if a bond is traded frequently or if close pricing benchmarks exist because regulators can verify reporting using external benchmarks. Corporate bonds have a wide spectrum of price opacity and liquidity, ranging from very liquid bonds, e.g., bonds issued by large and publicly listed firms, to very illiquid bonds, e.g., privately placed bonds issued by private corporations. We use several proxies to identify bonds that have opaque prices and bonds that lack close external benchmarks. Specifically, we use (i) privately placed bonds as a proxy for price opaque bonds. We also use (ii) bonds of private companies, (iii) orphan bonds, i.e. bonds that are the only issue of a company, and (iv) foreign bonds as proxies for bonds that lack close external benchmarks.

To facilitate the comparison between internal and external spreads, we estimate Equation (1) instead of Equation (4) as we have limited cases in the data where the valuations of the same bond are obtained from both internal and external sources for these four type of bonds. To do so, we interact a dummy variable $Type_b$ with $IM_b \times Crisis_t$, in separate regressions, where $Type_b = 1$ if a bond is privately placed, issued by a private company, is an orphan, or issued by a foreign company, and 0 otherwise. We include bond and time fixed effects, and control for credit ratings and maturity. Table 9 shows that the coefficient attached to the triple interaction term, which measures whether the gap between internal and external spreads is different for these four type of bonds, is statistically significant and economically large in most cases. We document that misreporting is higher for private placements than non-private placements by 340 bps; for private bonds than public bonds by 230 bps, and for orphan bonds than non-orphan bonds by 90 bps. Overall, our results suggest that supervision has its limits; insurers are able to bypass verification when bonds have few holders, have opaque prices, and lack close benchmarks.

3.2.3. Beliefs About Regulatory Forbearance

The fact that insurers exploited reporting discretion at such a large scale, and in particular exploited discretion more in bonds for which price verification is harder, allows us to understand insurers' ex-ante beliefs about regulators' future actions during the crisis. Tenekedjieva (2019) documents that state regulators are lax due to insurance commissioners' post-term career concerns. Widespread presence of lax regulation could have led insurers to believe that supervision will also be lax and that misreporting will not be verified in 2008. If this were the case, we should have found similar misreporting across different types of bonds irrespective of whether the bond values are easily verifiable or not, e.g., between private placements and non-private placements. However, in an overwhelming number of cases we find greater misreporting in bonds for which reporting is more difficult to verify, suggesting that ex-ante insurers expected tighter supervision.

There is also evidence for ex-post regulatory forbearance. Becker, Opp, and Saidi (2020) show that regulators provided capital relief by eliminating capital requirements when a large fraction of mortgage-backed securities got downgraded after the financial crisis and insurers' capital constraints became binding. If insurers believed that ex-post regulators will not strictly impose impairments (e.g., because regulators perceived the bond market turmoil in 2008 to be a temporary dislocation than a permanent deterioration of credit risk), then insurers would have reported valuations truthfully. However, we find that insurers misreported valuations in a large way and that misreporting occurred predominantly in positions with a higher likelihood of impairment and therefore asset revisions, suggesting that ex-ante insurers expected regulators to not be lenient in imposing impairments. Overall, these facts imply that insurers do not expect ex-post leniency and do not perceive the costs of exploiting discretion due to regulatory scrutiny (e.g., due to fines, revocation of license, or loss of reputation) to be negligible and that they minimize these costs by misreporting more in positions that are harder to verify.[35]

4. Ex-ante Asset Selection and Bond Market Cornering

In this section, we study whether insurers shift asset selection strategically in response to these incentive problems. Our findings suggest that the extent to which insurers can misreport asset values depends on two underlying conditions. First, the ability of insurers to bypass regulatory scrutiny. Thus, insurers would like to hold bonds that provide fewer reference prices to regulators, making it harder for regulators to pin down the true value of the bond. Second, the lack of trading in a bond significantly increases the likelihood that internal models are used for bond valuations. Thus, insurers might be unwilling to trade themselves and will avoid holding bonds where the propensity that other insurers might trade is high. Thus, asset selection could be distorted toward bonds with few holders, opaque prices, and that lack external benchmarks, in order to maximize the use of reporting discretion.

4.1. Asset Composition

We start by documenting stylized facts on the composition of insurers' bond portfolios. First, a vast majority of corporate bonds held by life insurers have just a handful of holders. Figure 4 highlights the highly concentrated ownership pattern for life insurers in aggregate in 2008. Close to 50% of bonds have just one holder, and over 65% of the bonds have just three or fewer holders. Life insurers are also one of the largest holders of price opaque bonds, such as privately placed debt.[36]

Second, there is significant heterogeneity across insurers in the holdings of (i) concentrated (those with two or fewer holders) and (ii) opaque (private placements, bond of private

[35] Koijen and Yogo (2015a) estimate that the average insurer is willing to accept a marginal reduction in profit of $0.96 in order to raise its regulatory capital by $1 in November 2008. This estimate of the shadow cost of capital during the crisis, along with our estimates of the total decline in capital avoided by misreporting can be used to quantify the expected costs of regulatory scrutiny across states.

[36] For example, life insurers accounted for close to 50% of the total outstanding and 70% of the new issues in 2016 (Source: Authors' calculation based on data from Private Placement Monitor).

companies, orphan, and foreign) bonds.[37] Moreover, the heterogeneity in these holdings correlates with the use of internal models. To illustrate this, we spilt insurers into two groups: (i) High Discretion Insurers (HDI) are insurers in the top quantile of internal models share in 2008; (ii) Low Discretion Insurers (LDI) are insurers that use internal models and are in the bottom quantile of internal models share in 2008.[38] Table 10 shows that the median HDI holds a significantly higher fraction of its corporate bond assets in concentrated and opaque bonds (25% and 40%) as compared to the median LDI (7% and 18%). Across the different types of opaque bonds, HDI held higher shares than LDI: 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%). In sum, HDI held exactly the types of bonds for which there is a greater propensity to use internal models and for which misreporting was higher in 2008.

It is unclear, however, whether the selection of concentrated and opaque bonds is related to these incentive problems or whether selection is independent and the observed misreporting happens ex-post. For example, HDI could have better technology than LDI for holding bonds to maturity. Insurance liabilities are long-dated and are less prone to runs (Paulson, Rosen, Mohey-Deen, and McMenamin (2012)). Moreover, some insurers could simply have better screening and monitoring technology. As a result, HDI could have a higher propensity to hold bonds that are better suited as buy-and-hold investments (e.g., privately placed debt) or to hold a large fraction of a bond's total issuance, taking advantage of better screening and sophisticated monitoring.

To understand whether asset selection responds to the incentive problems that arise from having reporting discretion, we exploit time series variation in insurers' ability and incentives to use internal models (and exploit reporting discretion). The decline in the role of the SVO increased insurers' ability to use internal models and discretion over reported values from 2008 (see Section 1.3). Moreover, the widening of credit spreads, combined with the large decline in insurers' regulatory capital during the crisis, suggests greater incentives to exploit discretion at the same time. This variation allows us to study how asset composition shifts over time and in the cross-section of insurers. In particular, insurers that exploit more discretion have greater incentives to select into concentrated and opaque bonds, relative to insurers that exploit less discretion. Thus, we estimate the following regression:

$$Holding\ Share_{i,t} = \sum_{t=1,2,3,4} \delta_t (HDI_i \times Period_t) + \beta X_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t}, \tag{8}$$

[37] The median bond has two holders.

[38] Internal models share is the fraction of the total par value in corporate bond assets that is valued using internal models. See Section 1.

where $Holding\ Share_{i,t}$ is the total par value in concentrated or opaque bonds for insurer i, scaled by the total assets of the insurer. HDI_i proxies for the willingness to exploit reporting discretion in the cross-section. The sample includes HDI and LDI, i.e., insurers that are in the top and bottom quantile of internal models share in 2008; and HDI_i takes a value of 1 for HDI and 0 for LDI. $X_{i,t}$ are controls, including log(assets) and RBC ratio. α_t are time fixed effects and α_i are insurer fixed effects, which control for insurer-level non-time-varying demand for certain types of bonds.

To understand how selection shifts, we split the sample into various periods ($Period_t = 1, 2, 3, 4$): (1) pre-crisis (2005-2007), (2) during the crisis (2008), (3) immediately following the crisis (2009-2011), and (4) post-crisis (2012-2016). All comparisons are relative to the pre-crisis period, thus, δ_t measure the shifts in the differences in the holding share between HDI and LDI in periods 2, 3, and 4 relative to the difference in the holding share during the pre-crisis period. To the extent that selection responds to these incentive problems, we expect significant δ_t. Moreover, we expect a higher impact in asset selection for HDI relative to LDI, thus, δ_t are expected to be positive.

Table 11 documents two main facts. First, δ_2 is positive and statistically significant for both concentrated and opaque bonds. Thus, there is a shift in the holding share in the year 2008 relative to the holding share before 2008 for HDI vis-a-vis LDI, providing evidence of shifts in selection *before* insurers misreported asset values at the end of 2008. In other words, insurers that exploit more discretion (HDI) increased the share of concentrated and opaque positions going into the crisis, relative to LDI, which further expanded the share of assets where it was possible to use internal models to value bonds.

Second, δ_3 is positive and statistically significant, and δ_4 is insignificant for both concentrated and opaque positions. This implies that the distortions in asset selection persist even after the crisis, potentially because balance sheets remained constrained or because it became easier to use internal models due to the obsolescence of the SVO. Moreover, these effects are economically large. The gap in holding share between HDI and LDI increased by roughly 2 percentage points going into the crisis and in the three years after, relative to their respective levels during the pre-crisis period. As insurers are highly levered, this estimate translates to roughly 20 percentage points of total capital, providing some insurers a large proportion of assets to insulate against volatility in regulatory capital in bad times.

The main identifying assumption is that the internal models share is uncorrelated with the shift in the technology to hold bonds to maturity. This could happen, for example, if business models shift differently for HDI relative to LDI, which might explain the resulting differential shift in asset selection. However, there are a number of factors that suggest this is not likely. First, we condition our analysis only on insurers that used internal models, as they are likely to be different in unobserved characteristics from insurers that never used internal models. HDI and LDI differ in the extent to which they use internal models in 2008, but not in *whether* they use internal models. Second, we use total assets and the RBC ratio to control for differences in business models across insurers, which might give rise to a different demand for certain types of bond. To corroborate further, Figure 5 shows that there is a positive relationship between internal models share and growth in the holdings of concentrated and opaque bonds between the pre-2008 period and after, even when we only analyze the largest 20 insurers, who likely have similar liability and asset compositions. We further address concerns related to cross-insurer comparisons in the next section.

4.2. Bond Market Cornering and Implications for Price Discovery

In this section, we explore another important way by which insurers expand the set of bonds that can be valued by internal models. Insurers can either hold small shares in a large number of bonds for which price verification is harder (e.g., privately placed debt) or acquire large shares in any bond (including publicly traded bonds) and limit secondary market trading, which we dub as "cornering".[39] By holding a large share of a bond's total issuance amount, insurers effectively reduce the number of reference prices, which helps minimize scrutiny, and limit secondary market trading, which helps increase the propensity for internal models valuation. While cornering creates conditions conducive for exploiting discretion, it also effectively makes publicly traded bonds behave like private bonds, which statutorily have few holders and limited trading.[40]

We document a numbers of facts consistent with these ideas by studying the dynamics of *issuance share*, i.e., the share of a bond's total issuance amount purchased by insurers. As private placements statutorily have fewer holders (and limited secondary market trading), it is difficult to study whether insurers hold a large fraction in order to exploit discretion. We therefore restrict attention to publicly traded bonds. We focus on purchases of new issues, where we expect these incentives to play out more strongly as insurers tend to trade less

[39]While traditionally, market cornering occurs when investors exercise market power to exploit trading gains (Allen, Litov, and Meiet (2006)), our interpretation of cornering relies on the use of market power to make assets more price opaque.

[40]Private placements are sold to a limited number of sophisticated investors, often life insurers. Retail investors are restricted from holding these bonds. Thus, ownership patterns are less diversified.

often and hold bonds to maturity. We estimate the following regression:

$$Issuance\ Share_{b,i,t} = \sum_{b=1,2,3,4} \theta_b (HDI_i \times Dist_t \times Size_b) + \sum_{b=1,2,3,4} \delta_b (HDI_i \times Size_b) + \alpha_{i,t} + \alpha_b + \epsilon_{b,i,t}, \tag{9}$$

where $Issuance\ Share_{b,i,t}$ is the total par value of bond b held by insurer i at time t, scaled by the total issuance amount of bond b. HDI_i is defined as in Equation (8). $Dist_t$ is a dummy variable that takes a value of 1 for the years 2008 to 2011, when asset selection is distorted, and 0 for the years 2005 to 2007. Due to the low number of observations, we pool all years together instead of estimating separate coefficients for each year as we did in Section 4.1. $Size_b$ are sub-groups of bonds' total issuance amount, which we describe below. $Insurer \times Year$ fixed effects allow us to control for time varying shifts in demand at the insurer level. Bond fixed effects control for non-time varying bond characteristics that impact holding patterns. Because a purchase of a new issue only appears at one point in time, we do not control for time varying bond characteristics or take $Bond \times Year$ fixed effects.

While holding a large share of a bond's total issuance amount allows for greater reporting discretion, it is also detrimental for portfolio diversification and could result in higher capital requirements stemming from concentration limits. Holding higher shares in bonds with a small issuance amount helps solve this trade-off problem.[41] Therefore, we split issuance size into various sub-groups ($Size_b = 1, 2, 3, 4$): (1) less than \$145 million (<1st quartile) (small bonds), (2) \$145-\$300 million (1st to 2nd quartile), (3) \$300-\$500 million (2nd to 3rd quartile), (4) over \$500 million (>4th quartile) (large bonds). All comparisons are relative to bonds with issuance amount more than \$500 million, thus, θ_b measure the shifts in the differences in the issuance share held in new purchases between HDI and LDI for the three issuance amount sub-groups as compared to the same difference for large bonds, during the years 2008 to 2011 relative to prior years.

Table 12 column I presents the estimations on all bonds. First, θ_1 is positive and statistically significant, while θ_2 and θ_3 are both positive but insignificant. Thus, during the period when asset selection was distorted and insurers amassed a greater share of positions with few holders (see Section 4.1), issuance share increased in new purchases of bonds with issuance amount under \$145 million. Second, columns II to IV show that the shift in issuance share for bonds under \$145 million is greater as we move to the lower rated bonds (NAIC 2 and

[41] 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.

NAIC 3+ categories), where the likelihood of impairment and the incentives to misreport asset values are higher. For example, issuance share shifted by 3.5 percentage points in all new purchases, by 9.0 percentage points in NAIC 2, and by 4.2 percentage points in NAIC 3 and beyond.

It is natural that insurers would hold a higher share of the total issuance amount for small rather than for large bonds, e.g., because of the existence of minimum dollar investment thresholds stemming from search and monitoring costs. While Insurer × Year fixed effects allow us to control for time varying demand shocks at the insurer level, a challenge to identification might arise if the shocks are different for small bonds (rather than large bonds) for reasons unrelated to reporting discretion. Our identification comes from the shift in the incentives to acquire large shares of the issuance amount over time and not simply from the differences in levels between HDI and LDI. An alternative explanation of these findings, i.e., a different demand shock, would have to simultaneously illustrate why demand shifts for small bonds, much more for HDI than LDI, precisely when these incentives are strong and not in later years, and in bonds where incentives to misreport are the greatest.[42]

In order to illustrate the magnitudes more clearly and to show that alternative demand shocks are unlikely to explain these findings, we show how the distribution of issuance share of new purchases have shifted for HDI relative to LDI within small bonds. We divide issuance share into three buckets: (i) below 10%, (ii) 10% to 20%, and (iii) above 20%. Figure 6 shows the fraction of the total par value that is held within each bucket of issuance share during the two sub-periods 2005-2007 and 2008-2011. For HDI, over 80% of the new purchases are in the below 10% and 10% to 20% buckets of issuance share between 2005 and 2007. In contrast, a majority of the new purchases between 2008 and 2011 shift to the above 20% bucket. Furthermore, for LDI, there is no shift in the distribution of issuance share.

What do these magnitudes imply about the ease with which insurers exploit reporting discretion? To understand this, we explore the relationship between issuance share and (i) the number of holders, which quantifies the number of available reference prices with state regulators, and (ii) the availability of traded prices, which impacts insurers' propensity for using internal models. At the end of each year, we compute the cross-insurer average of issuance share for each bond. We also compute the total numbers of *insurers* holding a bond. Figure 7 (a) shows that, not surprisingly, the relationship between average issuance share and the number of holders is negative. However, the relationship is highly convex. As issuance share falls under 10%, the number of holders increases sharply to the range of four

[42] We find that after 2011 the difference in issuance share between HDI and LDI for small bonds diminishes.

to six. For issuance share over 20%, however, there are fewer than two holders of a bond.

The NAIC guidelines specify that internal models should be used when traded prices or quotes are not available. We examine how issuance share correlates with a bond's trading in the secondary market. To identify bond transactions, we merge our sample of bonds with the TRACE database.[43] Figure 7 (c) shows that the average number of monthly trades for small (large) bonds range from 5 to 20 (25 to 150). Not surprisingly, the relation between issuance share and trading in the subsequent year is negative.[44] There is also a steep decline in the number of transactions as issuance share increases, and conversely, trading increases sharply as issuance share falls under 10%. For issuance share over 20%, however, bonds tend to trade less than five times per month. In the Appendix, we formally test whether bonds with two holders or less (i.e., where the issuance share is greater than 20%) trade less than bonds with more than two holders, after accounting for differences in bond and issuer characteristics. Table A.6 shows that even when we compare bonds from the same issuer, the likelihood of trading for a bond with two holders or less is lower than the trading for a bond with more than two holders by up to 27 percentage points.[45]

5. Conclusion and Broader Implications

In this paper, we document that during the financial crisis, U.S. life insurers used internal models to over-report the value of a large fraction of corporate bonds in order to improve their regulatory capital positions. In aggregate, we estimate an additional decline in regulatory capital of between \$9-\$18 billion, which is 30% higher than the decline that 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 held by few insurers, that have opaque prices, and that lack external price benchmarks. Using novel data on state regulators, we show that supervision helps mitigate this behavior, but that supervision is ineffective when close pricing benchmarks do not exist and regulators cannot compare reported values. We show that in response insurers strategically shift asset selection toward bonds for which price verification is harder and that they corner new issues of small bonds, both of which provide insurers greater discretion over reported values.

By exploiting reporting discretion, insurers indirectly control the extent to which impair-

[43] Number of transactions is the number of buy-and-sell trades reported in TRACE every month divided by two, as each buy trade corresponds to one (or more) sell trades. For bonds that do not report any trades in TRACE in a given month, we count zero trades. Removing these bonds or using alternative ways to identify transactions (e.g., only counting sells or buys) do not change these conclusions.

[44] We measure issuance share at time t and transactions during the year $t + 1$.

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

ments can be enforced by regulators. If market fluctuations are a result of temporary liquidity shocks, which is often a feature of financial crises, and if regulators are too strict in implementing impairments ex-post, then avoiding impairments is not necessarily a problem as it can shield balance sheets from unnecessary market fluctuations. By not fully incorporating impairments, institutions avoid responding to temporary fluctuations that can exacerbate financial crises (e.g., through the fire sale of assets). This allows patient investors like insurers to better perform the role of asset insulators (Chodorow-Reich, Ghent, and Haddad (2018)).[46] However, if market fluctuations are due to fundamental shocks, then exploiting reporting discretion in a regulatory system with weak oversight is problematic because it provides imprecise signals about the fragility of the financial sector, which can lead to suboptimal real decisions, delay corrective actions from regulators, e.g., during the Savings and Loans crisis (Kroszner and Strahan (1996)), and amplify self-fulfilling runs (Foley-Fisher, Narajabad, and Verani (2019)).

Our paper makes two main policy implications. First, our results highlight one problem of having a decentralised regulatory structure. We document that the availability of reference prices helps dissuade misreporting. A decentralized structure reduces the number of available reference prices as a bond can be held by two insurers domiciled in two different states. A centralized structure or a well functioning national office (e.g., the SVO) provides access to valuations reported by insurers from other states, which could make monitoring less difficult. Second, our findings could be helpful to design regulatory initiatives aimed at increasing price discovery in bonds markets (e.g., MiFID). We uncover a new channel for why price opaque bonds might be preferred and why small bonds might be cornered by life insurers. Our findings have consequences for understanding the price discovery of these assets, as life insurers are the largest investors in the U.S. corporate bond market.

Finally, the incentives described in the paper also apply more broadly to other financial institutions and other asset classes that share similar characteristics. For example, pension funds and endowments hold large portfolios of private assets, e.g., private equity and real estate, which also suffer from a high degree of price opacity. Understanding the way that financial institutions employ reporting discretion across asset classes is helpful to properly assess the fragility of the financial system as a whole in bad times.

[46] This is often the argument made in favor of historical cost accounting. See e.g., Plantin, Sapra, and Shin (2008) and Heaton, Lucas, and McDonald (2010).

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I. Figures

Figure 1: Evolution of Reported Credit Spreads

The figure shows how credit spreads changed during the financial crisis for bonds valued using internal models (IM), as compared to bonds valued using external sources (non-IM). We compute the cross-insurer average of the reported credit spreads for each bond at each point in time and then compute the means for the IM and non-IM categories. A bond is classified as internal model if at least one insurer valued it using internal models in 2008. The sample includes all bonds held by insurers in 2008.

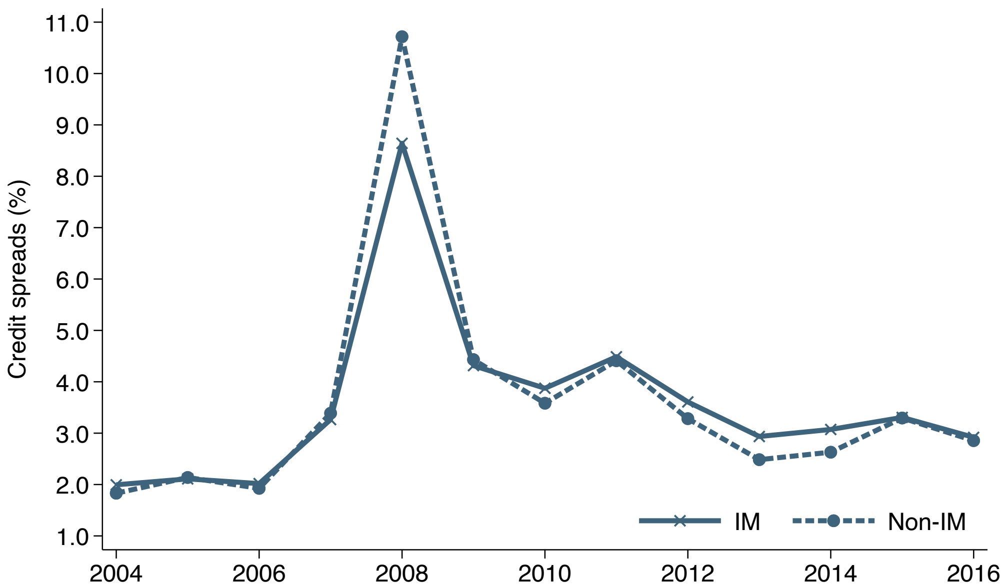
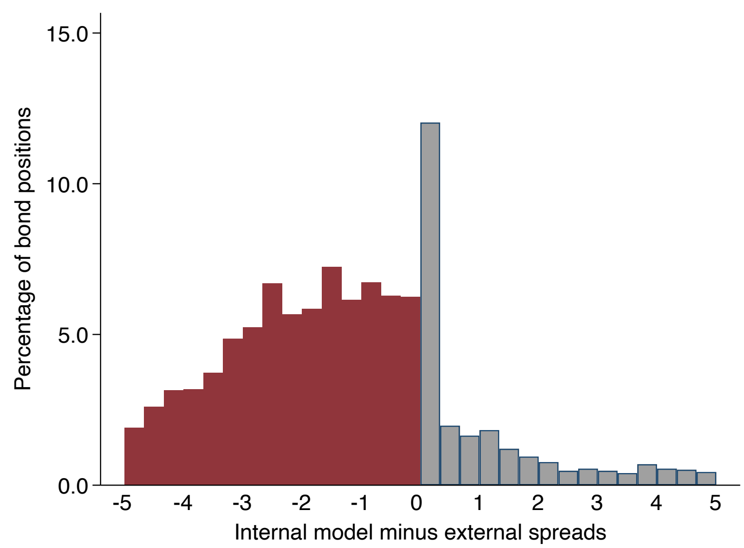
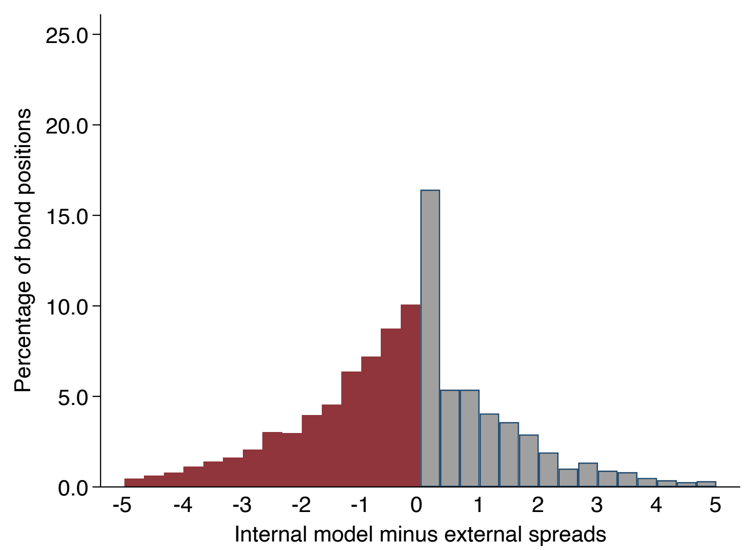


Figure 2: Deviation of Internal Model Spreads from External Spreads

The figure shows a distribution of the deviations of the internal model spreads from the external spreads for the same bond. Positions are split into two groups. Panel (a) shows the distribution for the positions where incentives to misreport exist and Panel (b) shows the positions where the incentives do not exist. The X axis is the deviation of the internal model spreads from the highest externally sourced spread for the same bond. The Y axis is the percentage of positions. Positions left (right) of zero indicate that internal model spreads are lower (higher) than the externally sourced estimate and are shaded in red (gray). We only show the bonds that are valued using both internal models and external sources in 2008.



(a) Incentive to misreport



(b) No incentive to misreport

Figure 3: Misreporting Across U.S. States

The figure shows the extent of misreporting in 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_s separately for each state s. For exposition, we split states into four groups by the estimated misreporting: no misreporting (0% or below), low (0%-1%), medium (1%-2%), and high (2%-3%). For example, 1%-2% implies an estimated misreporting of between 100 to 200 bps.

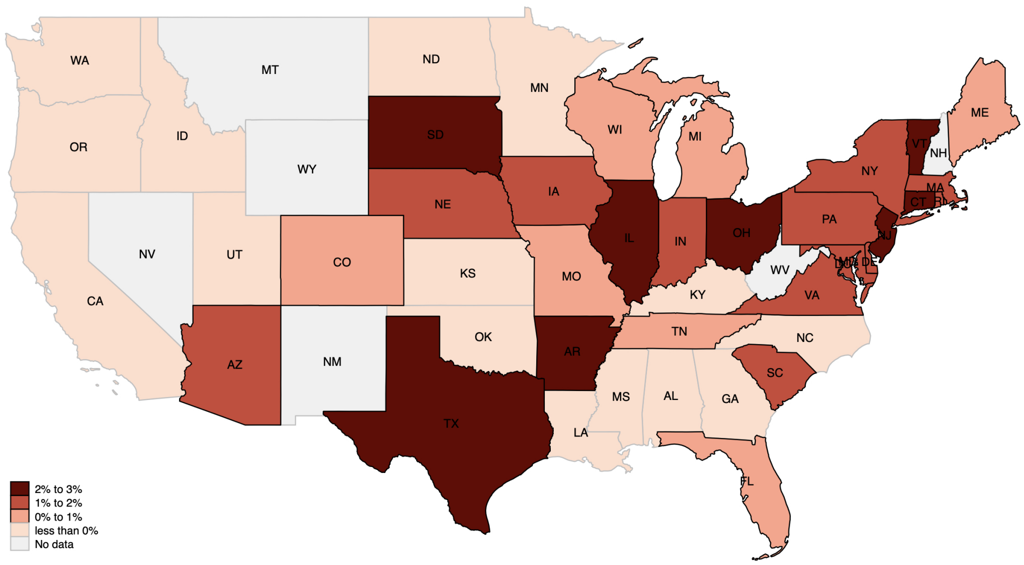


Figure 4: Concentration in the Holding Structure of Corporate Bonds

The figure shows a distribution of the number of insurers holding a bond in 2008. We plot the percentage of bonds on the Y axis and number of insurers holding the bond on the X axis.

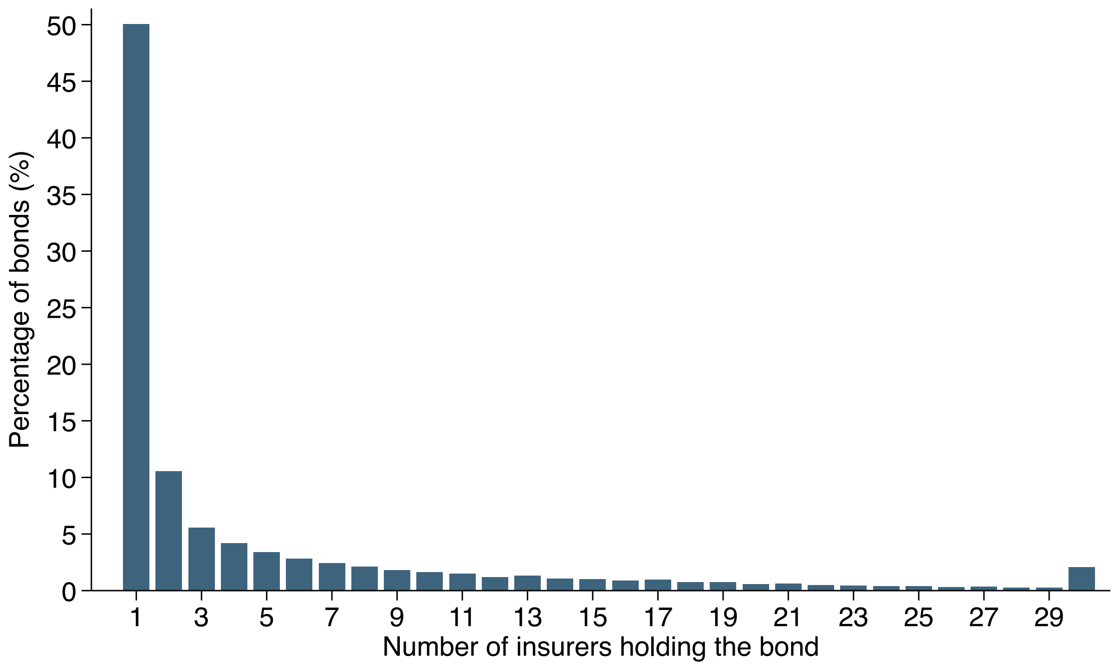


Figure 5: Shift in Asset Selection

The figure shows a scatter plot of the internal models share in 2008 (X axis) and the holdings growth (Y axis) in opaque and concentrated bonds for the largest insurers (by total assets). The Y axis is the log change in the total par value held in opaque and concentrated bonds between 2006 and 2010. Bonds are defined as opaque if they are privately placed, are issued by a private company, are orphan, or are issued by a foreign company. Bonds are defined as concentrated if they are held by up to two insurers.

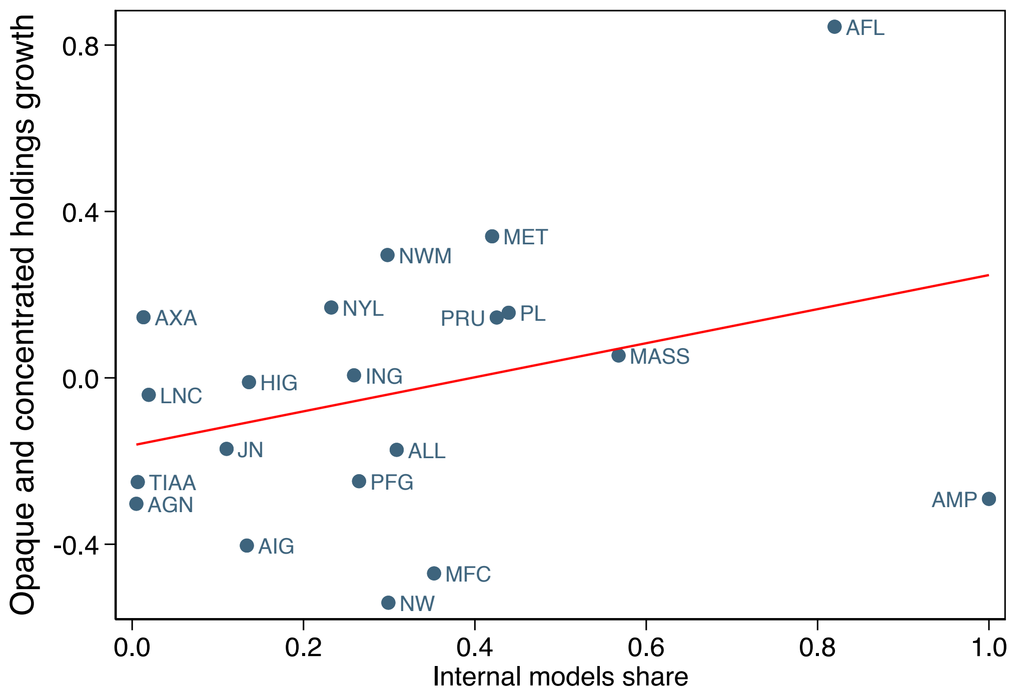
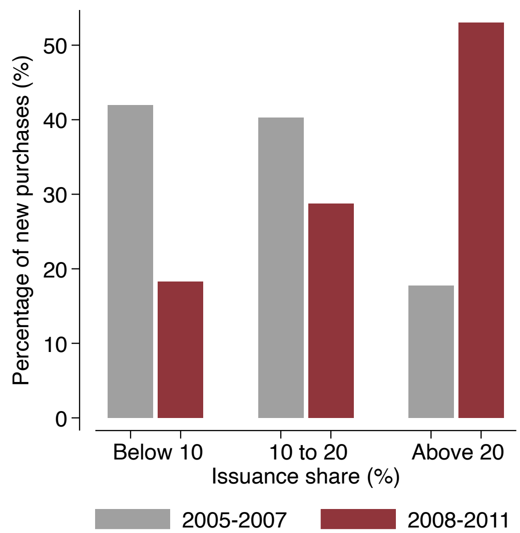
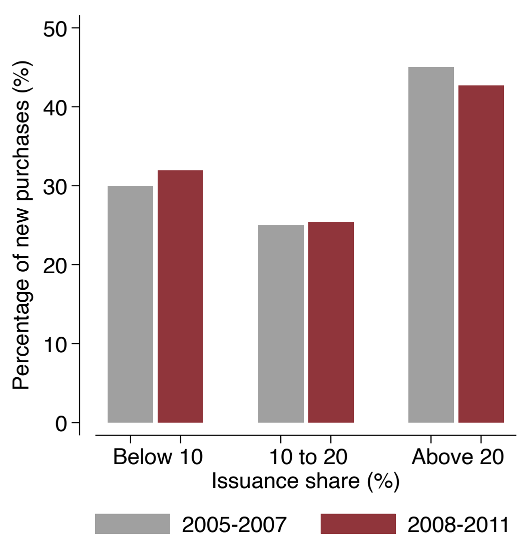


Figure 6: Shift in the Distribution of Issuance Share

The figure shows how the distribution of the issuance share of new purchases have shifted for HDI relative to LDI within small bonds between 2005 to 2007 and 2008 to 2011. The X axis shows the three buckets of issuance share: (i) below 10%, (ii) 10% to 20%, and (iii) above 20%. The Y axis shows the percentage of new purchases by the total par value. The figure only shows the NAIC rating category 2.



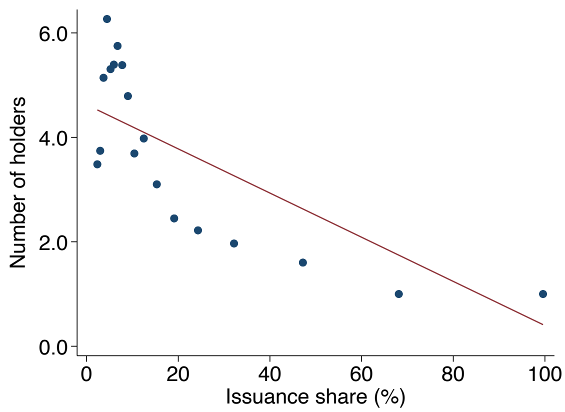
(a) High Discretion Insurers



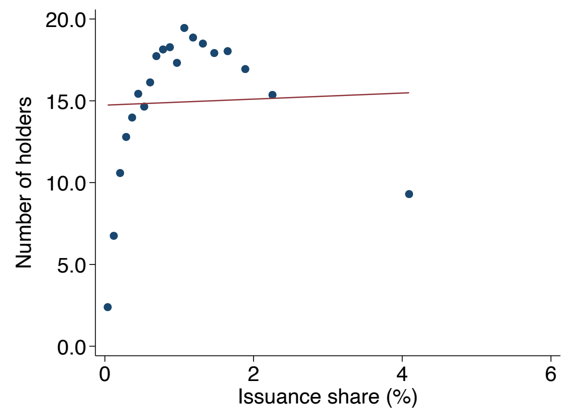
(b) Low Discretion Insurers

Figure 7: Issuance Share and the Ease of Reporting Discretion

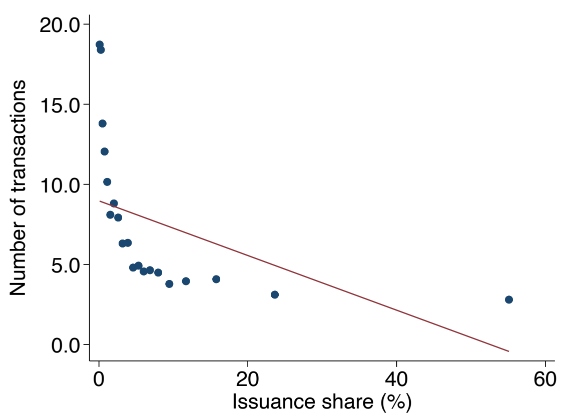
The figure shows the relationship between issuance share and (i) the number of insurers holding a bond and (ii) the number of transactions reported in TRACE. Panels (a) and (b) show bin scatter plots between the average number of insurers holding a bond (Y axis) and the cross-insurer average of the issuance share for each bond (X axis). Panels (c) and (d) show bin scatter plots between the average number of transactions reported in TRACE (Y axis) and the cross-insurer average of the issuance share for each bond (X axis). Small bonds have an issuance amount under $145 million (1st quartile) and large bonds have an issuance amount over $500 million (4th quartile).



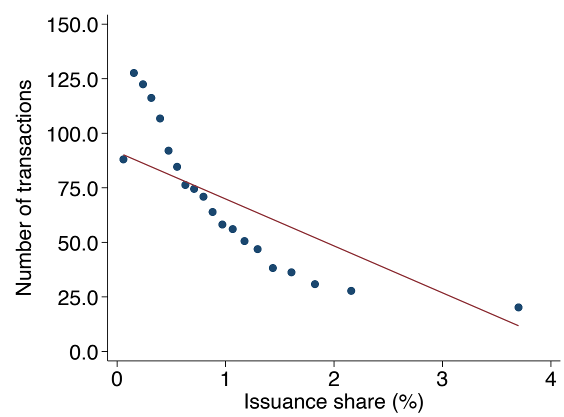
(a) Small bonds



(b) Large bonds



(c) Small bonds



(d) Large bonds

II. Tables

Table 1: Prevalence of Internal Models

The table reports 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 the ratio of the total par value of bonds valued using internal models to the total par value of all bonds in an insurer's portfolio. Total assets are as of 2007.

Insurer	Total assets ($ Billion)	Internal models share (%)
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: Comparing Internal Model Spreads with External Spreads Across Bonds

The table shows the difference in the credit spreads between the bonds valued using internal models and the bonds valued using external sources during the financial crisis as compared to other periods. We estimate:

$$\overline{CS}^{R}_{b,t} = \gamma(IM_b \times Crisis_t) + \beta X_{b,t} + \alpha_b + \alpha_t + \epsilon_{b,t},$$

where $\overline{CS}^{R}_{b,t}$ is the cross-insurer average reported credit spread for bond b at time t. IM_b is a dummy variable that takes the 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 the value of 1 if the year is 2008, and 0 otherwise. $X_{b,t}$ are bond level controls, which include credit ratings and maturity. α_b and α_t are bond and time fixed effects, respectively. The regression includes bonds held by insurers in 2008 and tracks the average credit spreads of these bonds from 2004 to 2016. NAIC 1 are AAA, AA, and A; NAIC 2 are BBB; NAIC 3 are BB; and NAIC 4+ are B or below rated bonds. Table shows standard errors in parentheses, clustered at the bond level. Significance: * 10%; ** 5%; *** 1%.

	All		NAIC 1	NAIC 2	NAIC 3	NAIC 4+
	I	II	III	IV	V	VI
$IM_b \times Crisis_t$	-0.019***	-0.020***	0.000	-0.010***	-0.032***	-0.077***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.006)
IM_b	0.001***					
	(0.000)					
$Crisis_t$	0.069***					
	(0.001)					
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bond Fixed Effects	No	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes	Yes	Yes	Yes
Observations	136,797	135,321	57,819	47,574	11,592	14,508
R-squared	0.40	0.64	0.57	0.70	0.70	0.66

Table 3: Comparing Internal Model Spreads with External Spreads of the Same Bond During the 2008 Crisis

The table compares the spreads obtained from internal models and the spreads sourced externally during the financial crisis for the same bond when the incentives to misreport exist as compared to when they do not. We estimate:

$$CS^R_{b,i} = \gamma_1 IM_{b,i} + \gamma_2(Incentive_{b,i} \times IM_{b,i}) + \gamma_3 Incentive_{b,i} + \alpha_b + \alpha_i + \epsilon_{b,i},$$

where $CS^R_{b,i}$ is the reported credit spread of bond b held by insurer i. $IM_{b,i}$ is a dummy variable that takes a value of 1 if insurer i valued bond b using internal models. $Incentive_{b,i}$ is a dummy variable that takes a value of 1 if insurers i has incentives to misreport the value of bond b. α_b and α_i are bond and insurer fixed effects, respectively. The sample includes the bonds that are valued by both internal models and external sources in 2008. NAIC 1 are AAA, AA, and A; NAIC 2 are BBB; NAIC 3 are BB; and NAIC 4+ are B or below rated bonds. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	All Bonds	AAA,AA,A	BBB	BB	B or below
	I	II	III	IV	V
$Incentive_{b,i} \times IM_{b,i}$	-0.012***	-0.010***	-0.006***	-0.015**	-0.051**
	(0.004)	(0.003)	(0.002)	(0.006)	(0.021)
$IM_{b,i}$	0.002	0.001	0.003	-0.007	0.020
	(0.002)	(0.001)	(0.002)	(0.006)	(0.013)
$Incentive_{b,i}$	-0.005***	0.001	-0.004***	-0.001	-0.025**
	(0.002)	(0.002)	(0.001)	(0.004)	(0.011)
Bond Fixed Effects	Yes	Yes	Yes	Yes	Yes
Insurer Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	42,554	18,795	18,777	3,138	1,579
R-squared	0.90	0.84	0.87	0.91	0.91

Table 4: Correlation Between Reported Spreads in 2008 and Acquisition Spreads and the Impact of Regulatory Constraints

The table shows the relationship between the reported credit spreads in 2008 and the acquisition credit spreads. We estimate:

$$CS^{R}_{b,i} = \lambda_1 CS^{Acq}_{b,i} + \lambda_2 (CS^{Acq}_{b,i} \times IM_{b,i}) + \lambda_3 IM_{b,i} + \alpha_b + \alpha_i + \epsilon_{b,i},$$

where $CS^{R}_{b,i}$ is the reported credit spread of bond b held by insurer i. $CS^{Acq}_{b,i}$ is the prevailing spread for bond b at the time it was acquired by insurer i. $IM_{b,i}$ is a dummy variable that takes a value of 1 if insurer i valued bond b using internal models. α_b and α_i are bond and insurer fixed effects, respectively. The sample includes all bonds held in 2008. Column I and column II only show positions valued by internal models and external sources, respectively. Columns III to VI include all bonds. The Low, Medium, and High RBC groups include insurers that were in the bottom, middle two, and top quartile of RBC ratio in 2007, respectively. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	IM	Non-IM	All	Low RBC	Medium RBC	High RBC
	I	II	III	IV	V	VI
$CS^{Acq}_{b,i}$	0.424***	0.016	0.024	0.015	0.029	0.030
	(0.129)	(0.015)	(0.015)	(0.020)	(0.021)	(0.037)
$IM_{b,i}$			-0.003	-0.013***	-0.003	-0.007
			(0.002)	(0.003)	(0.002)	(0.004)
$CS^{Acq}_{b,i} \times IM_{b,i}$			0.150***	0.631***	0.129**	0.066
			(0.055)	(0.162)	(0.056)	(0.051)
Bond Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Insurer Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,161	93,584	106,018	15,518	78,754	5,240
R-squared	0.82	0.95	0.94	0.96	0.94	0.97

Table 5: Forecasting Revisions in Regulatory Capital

The table shows the counterfactual revisions in regulatory capital in 2008 assuming insurers had reported bond valuations truthfully. We compute the decline in capital as of 4th quarter 2008 relative to the capital at the end of 4th quarter 2007. Superscripts over an insurer's name indicate recapitalisation events in 2008 or 2009, where T = a government bailout (e.g., TARP); E = raising equity; and D = redacting dividends.

Insurer	Reported decline in capital		Asset revision $ billion		Revised decline in capital
	$ billion	%	I	I & II	%
MetLife^{E}	4.0	13	1.5	2.3	18 to 21
Prudential Financial^{T,E,D}	1.7	12	0.7	1.6	17 to 24
AIG^{T,D}	8.0	22	0.7	1.1	24 to 25
Hartford^{T}	1.5	10	0.1	0.1	11
Manulife Financial^{E,D}	2.0	22	0.2	0.8	25 to 31
TIAA	4.3	18	0.0	0.0	18
Aegon^{T,D}	2.1	18	0.0	0.0	18
New York Life	1.1	6	0.7	0.8	9 to 10
ING^{T,D}	1.1	13	0.2	0.3	16 to 17
AXA^{D}	5.2	51	0.0	0.0	51
Northwestern Mutual	2.6	14	0.7	1.0	18 to 20
Lincoln National^{T,E,D}	0.9	13	0.1	0.1	14
Principal Financial^{T}	-0.5	-11	0.4	0.5	-3 to -1
Massachusetts Mutual	0.7	6	0.4	0.6	10 to 12
Nationwide	0.6	15	0.1	0.2	18 to 19
Pacific Life	0.7	15	0.3	0.4	21 to 23
Allstate^{T,D}	-0.2	-4	0.1	0.6	-1 to 9
Ameriprise Financial^{T}	0.4	11	0.7	0.7	32
Jackson National	1.1	14	0.1	0.1	15 to 16
Genworth Financial^{T,D}	-0.5	-9	0.2	0.3	-6 to -4
All insurers	41.7	11	9.3	18.3	14 to 16

Table 6: Misreporting and Regulators' Preference for Market-Based Measures

The table shows the relationship between misreporting in a state in 2008 and the state regulator's preference for market based measures. We estimate:

$$Missreporting_s = \alpha + \kappa(\textit{High M2M State}_s) + \beta X_s + \epsilon_s,$$

where $Misreporting_s$ denotes misreporting in state s and $\textit{High M2M State}_s$ is a dummy for state s that takes the value of 1 if the state is defined as a high "mark-to-market". The definitions are from Ellul et. al. (2015). X_s are control variables, including the mean RBC ratio and the mean log assets of all insurers within a state. Table shows robust standard errors in parentheses. Significance: * 10%; ** 5%; *** 1%.

	Misreporting		
	I	II	III
Baseline_s	0.012*		
	(0.007)		
$\text{Alternative } 1_s$		0.019**	
		(0.007)	
$\text{Alternative } 2_s$			0.006
			(0.007)
Controls	Yes	Yes	Yes
Observations	43	43	43
R-squared	0.14	0.24	0.10

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:

$$Misreporting_s = \alpha + \gamma(Supervision_s) + \beta X_s + \epsilon_s,$$

where $Misreporting_s$ denotes misreporting in state s and $Supervision_s$ denotes the intensity of supervision in state s, measured in three ways: (i) the total number of financial examiners and analysts employed in a state; (ii) the total number of discretionary exams (regular and discretionary) conducted in a state, and (iii) the total budget of the state insurance department. We scale each variable by the number of insurers domiciled in a state. X_s are control variables, including the mean RBC ratio and the mean log assets of all insurers within a state. $Misreporting_s$ and $Supervision_s$ are standardised by scaling them with their standard deviations. With (No) Reference Price indicates misreporting computed for bonds with more than one (only one) holder. Table shows robust standard errors in parentheses. Significance: * 10%; ** 5%; *** 1%.

	With Reference Price			No Reference Price		
	I	II	III	IV	V	VI
Number of examiners$_s$	-0.254***			-0.019		
	(0.093)			(0.102)		
Discretionary exams$_s$		-0.175*			0.065	
		(0.091)			(0.099)	
Budget$_s$			-0.177*			-0.010
			(0.103)			(0.098)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	43	43	43	43	43	43
R-squared	0.15	0.12	0.12	0.17	0.17	0.17

Table 8: Misreporting and Holding Structure of Bonds

The table shows the relationship between misreporting and the number of insurers holding a bond. We estimate the regression below, separately for bonds held by two, three to five, and more than five insurers:

$$CS^R_{b,i} = \gamma_1 IM_{b,i} + \gamma_2(Incentive_{b,i} \times IM_{b,i}) + \gamma_3 Incentive_{b,i} + \alpha_b + \alpha_i + \epsilon_{b,i},$$

where $CS^R_{b,i}$ is the reported credit spread of bond b held by insurer i. $IM_{b,i}$ is a dummy variable that takes a value of 1 if insurer i valued bond b using internal models. $Incentive_{b,i}$ is a dummy variable that takes a value of 1 if insurers i has incentives to misreport the value of bond b. α_b and α_i are bond and insurer fixed effects, respectively. The sample includes the bonds that are valued by both internal models and external sources in 2008. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	Two	Three to Five	Above Five
	I	II	III
$Incentive_{b,i} \times IM_{b,i}$	-0.047***	-0.018***	-0.008**
	(0.012)	(0.003)	(0.003)
$IM_{b,i}$	-0.002	-0.003	0.004**
	(0.007)	(0.004)	(0.002)
$Incentive_{b,i}$	-0.061*	-0.031**	-0.003**
	(0.035)	(0.013)	(0.001)
Bond Fixed Effects	Yes	Yes	Yes
Insurer Fixed Effects	Yes	Yes	Yes
Observations	1,092	4,575	38,500
R-squared	0.92	0.87	0.91

Table 9: Misreporting and Bonds' Price Opaqueness and Lack of External Benchmarks

The table shows the difference in misreporting for various types of bonds. We estimate:

$$\overline{CS}^{R}_{b,t} = \gamma_1(IM_b \times Crisis_t \times Type_b) + \gamma_2(IM_b \times Crisis_t) + \gamma_3(Crisis_t \times Type_b) \\ + \beta X_{b,t} + \alpha_b + \alpha_t + \epsilon_{b,t},$$

where $\overline{CS}^{R}_{b,t}$ is the cross-insurer average reported credit spread for bond b at time t. IM_b is a dummy variable that takes the 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 the value of 1 if the year is 2008, and 0 otherwise. $Type_b$ is a dummy variable that takes the value of 1 if the bond is privately placed (column I), is issued by a private company (column II), is orphan, i.e. is a single issuance of a company (column III), or is issued by a foreign company (column IV), and 0 otherwise. $X_{b,t}$ are bond level controls, which include credit ratings and maturity. α_b and α_t are bond and time fixed effects, respectively. The regression includes the bonds held by insurers in 2008 and tracks the average credit spreads of these bonds from 2004 to 2016. Table shows standard errors in parentheses, clustered at the bond level. Significance: * 10%; ** 5%; *** 1%.

	Private Placements	Private Firms	Orphan	Foreign
	I	II	III	IV
$IM_b \times Crisis_t \times Type_b$	-0.034***	-0.023***	-0.009***	0.004
	(0.003)	(0.003)	(0.003)	(0.003)
$IM_b \times Crisis_t$	-0.006***	-0.012***	-0.018***	-0.024***
	(0.002)	(0.002)	(0.001)	(0.003)
$Crisis_t \times Type_b$	0.014***	0.008***	0.009***	-0.006**
	(0.003)	(0.003)	(0.002)	(0.003)
Controls	Yes	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	135,321	135,321	135,321	135,321
R-squared	0.64	0.64	0.64	0.64

Table 10: Composition of Bond Portfolios

The table shows the distribution of the share of the total par value of the corporate bond portfolio that is opaque or that has a concentrated holding structure in 2008. Panel (a) provides descriptive statistics for insurers that are in the bottom quantile of internal models share (LDI) and panel (b) provides descriptive statistics for insurers that are in the top quantile of internal models share (HDI). Bonds are defined as opaque if they are privately placed, are issued by a private company, are orphan, or are issued by a foreign company. Bonds are defined as concentrated if they are 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	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	25.25	22.46	2.37	7.88	20.51	36.64	52.67

Table 11: Shift in Asset Composition

The table documents the shift in the quantity of opaque and concentrated bonds over time and in the cross-section of insurers, depending on insurers' willingness to exploit reporting discretion. We estimate:

$$\textit{Holding Share}_{i,t} = \sum_{t=1,2,3,4} \delta_t(\textit{HDI}_i \times \textit{Period}_t) + \beta X_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t},$$

where $\textit{Holding Share}_{i,t}$ is the total par value in opaque or concentrated positions for insurer i scaled by the total assets of the insurer. $\textit{HDI}_i$ proxies for the willingness to exploit reporting discretion in the cross-section. The sample includes HDI and LDI, i.e. insurers that are in the top and bottom quantile of internal models share in 2008, respectively, and $\textit{HDI}_i$ takes the value of 1 for HDI and 0 for LDI. $\textit{Period}_t$ is a category variable, that splits the sample into four periods: pre-crisis (2004-2007), during the crisis (2008), immediately following the crisis (2009-2011), and post-crisis (2012-2016). $X_{i,t}$ are controls, including log(assets) and RBC ratio. α_t are time fixed effects and α_i are insurer fixed effects. Bonds are defined as opaque if they are privately placed, are issued by a private company, are orphan, or are issued by a foreign company. Bonds are defined as concentrated if they are held by up to two insurers. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	Opaque	Concentrated
	I	II
$\text{HDI}_i \times \text{Period}_{t=2008}$	0.022***	0.017**
	(0.008)	(0.008)
$\text{HDI}_i \times \text{Period}_{t=2009 \text{ to } 2011}$	0.017*	0.025***
	(0.010)	(0.009)
$\text{HDI}_i \times \text{Period}_{t=2012 \text{ to } 2016}$	0.001	0.008
	(0.012)	(0.011)
Controls	Yes	Yes
Insurer Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	433	433
R-squared	0.80	0.90

Table 12: Bond Market Cornering in Small Bonds

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

$$Issuance\ Share_{b,i,t} = \sum_{b=1,2,3,4} \theta_b (HDI_i \times Dist_t \times Size_b) + \sum_{b=1,2,3,4} \delta_b (HDI_i \times Size_b) + \alpha_{i,t} + \alpha_b + \epsilon_{b,i,t},$$

where $Issuance\ Share_{b,i,t}$ is the total par value of bond b held by insurer i at time t, scaled by the total issuance amount of bond b. HDI_i is defined as in equation (8). $Dist_t$ is a dummy variable that takes the value of 1 for the years 2008 to 2011, and 0 for the years 2005 to 2007. $Size_b$ is a category variable, that splits the bonds based on their issuance amount into four subgroups: group 1 (<1st quartile); group 2 (1st to 2nd quartile); group 3 (2nd to 3rd quartile); and group 4 (>4th quartile). $\alpha_{i,t}$ and α_b are insurer × time and bond fixed effects, respectively. The sample spans from 2005 to 2011. NAIC 1 are AAA, AA, and A; NAIC 2 are BBB; and NAIC 3+ are BB or below rated bonds. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	All	AAA,AA,A	BBB	BB or below
	I	II	III	IV
$HDI_i \times Dist_t \times Size_{b=1}$	0.035**	0.011	0.090***	0.042**
	(0.016)	(0.033)	(0.025)	(0.018)
$HDI_i \times Dist_t \times Size_{b=2}$	0.004	0.008	0.004	-0.004
	(0.004)	(0.006)	(0.006)	(0.003)
$HDI_i \times Dist_t \times Size_{b=3}$	0.003	0.002	0.003	0.000
	(0.002)	(0.003)	(0.003)	(0.002)
$HDI_i \times Size_{b=1}$	-0.004	0.002	-0.003	-0.008
	(0.012)	(0.027)	(0.013)	(0.010)
$HDI_i \times Size_{b=2}$	0.004	-0.001	0.007	0.005
	(0.003)	(0.004)	(0.005)	(0.004)
$HDI_i \times Size_{b=3}$	0.001	0.002	0.001	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
Insurer × Year Fixed Effects	Yes	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes	Yes
Observations	30,219	12,005	11,393	6,635
R-squared	0.69	0.75	0.66	0.65

A. Additional Figures and Tables

Figure A.1: Evolution of Reported Market Values

The figure shows how reported market values changed during the financial crisis for bonds valued using internal models (IM), as compared to bonds valued using external sources (non-IM). We compute the cross-insurer average of the reported prices for each bond at each point in time and then compute the means for the IM and non-IM categories. A bond is classified as internal model if at least one insurer valued it using internal models in 2008. The sample includes all bonds held by insurers in 2008.

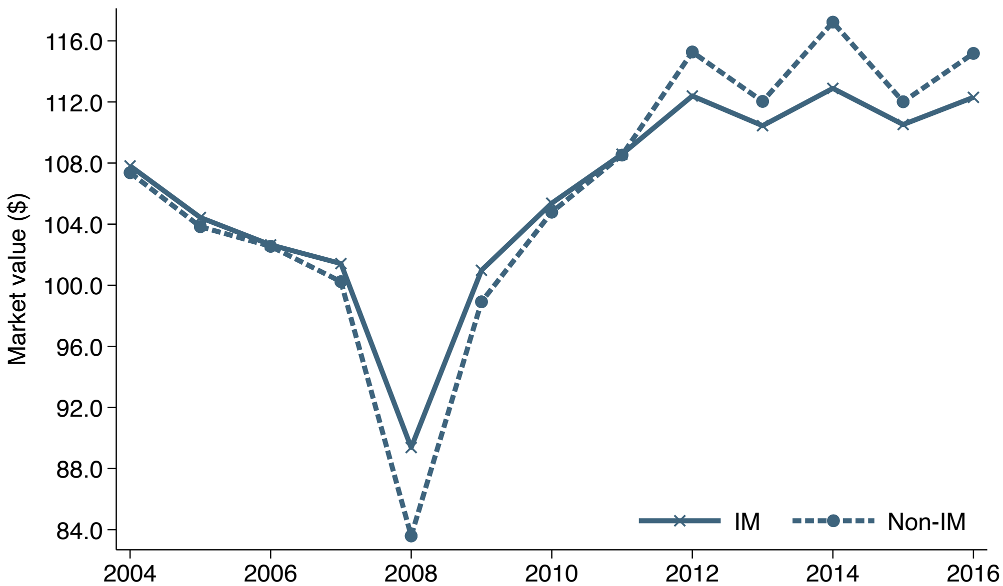
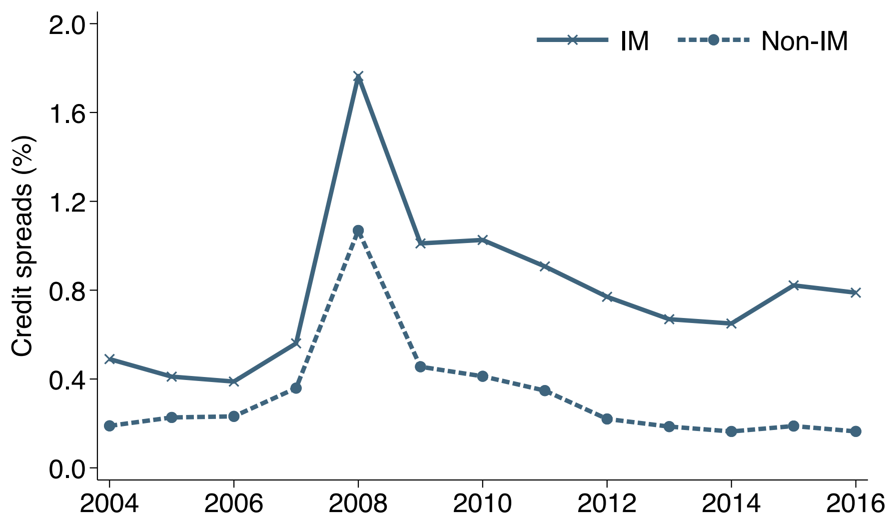
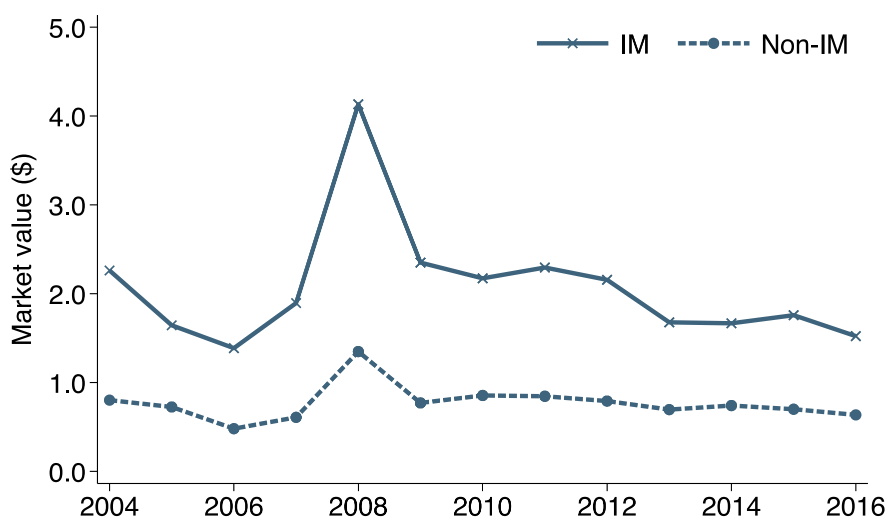


Figure A.2: Cross Insurer Dispersion in Reported Credit Spreads and Market Values

The figure shows the average cross-insurer standard deviation of reported credit spreads and market values for bonds valued using internal models (IM), as compared to bonds valued using external sources (non-IM). We compute the cross-insurer standard deviation for each bond at each point in time and then compute the means for the IM and non-IM categories. A bond is classified as internal model if at least one insurer valued it using internal models in 2008. The sample includes all bonds held by insurers in 2008.



(a) Credit spreads



(b) Market values

Figure A.3: Reported Credit Spreads by NAIC Rating Categories During the 2008 Crisis

The figure shows the average credit spreads in 2008 for internal model (IM) and non-internal model (non-IM) bonds, split by the NAIC rating categories. 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 internal models in 2008. The sample includes all bonds held by insurers in 2008.

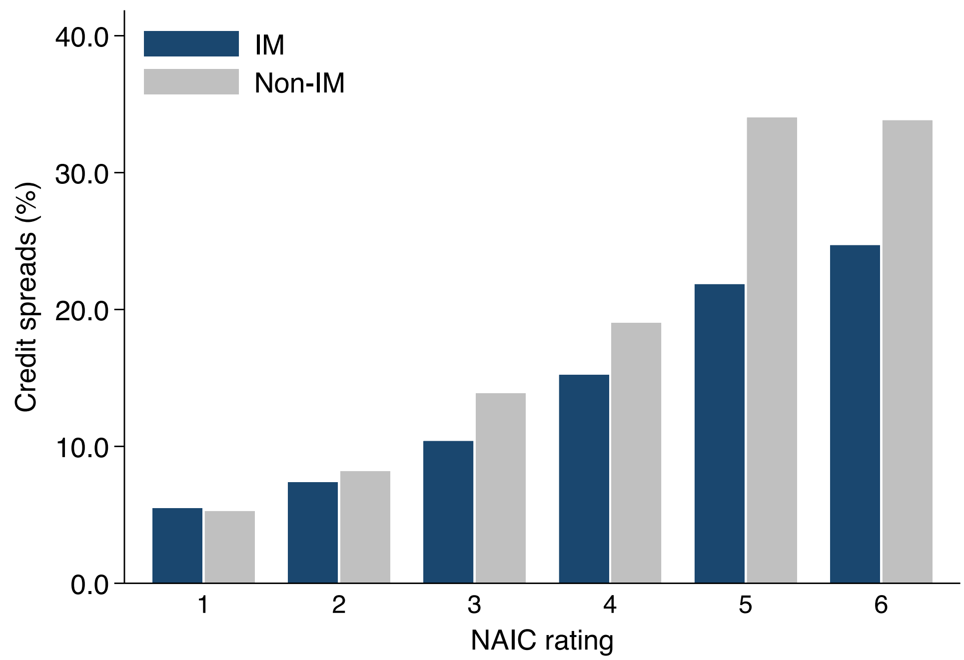
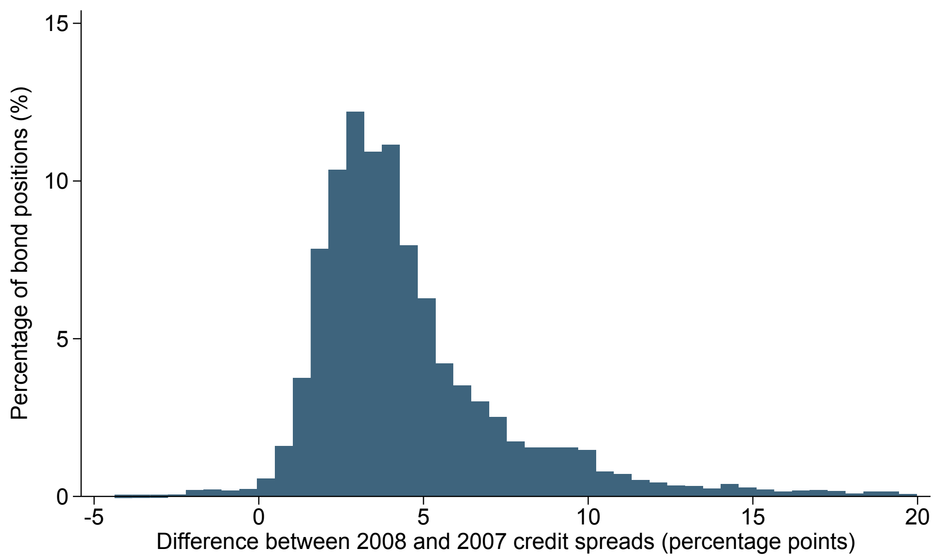
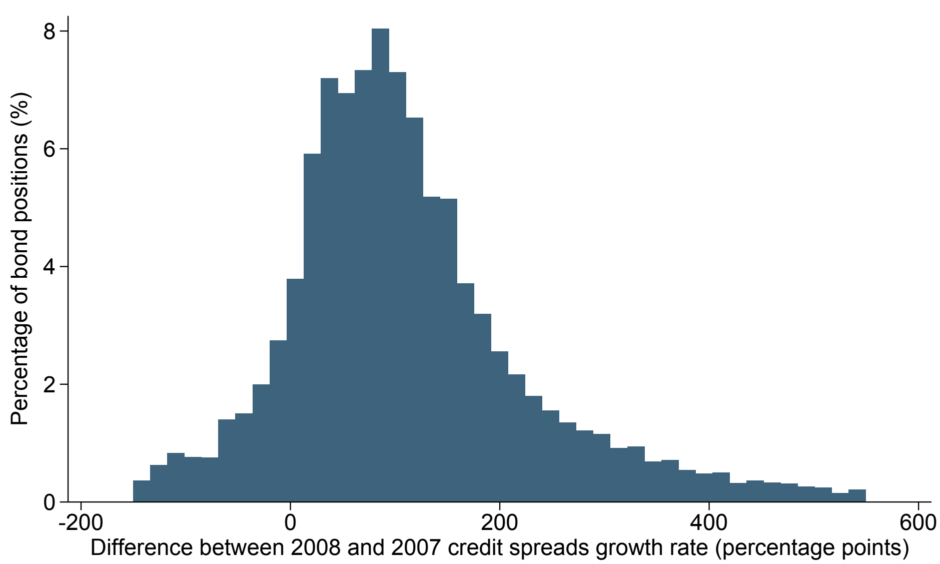


Figure A.4: Stale Prices and Extrapolation

The figure shows the existence of stale prices and extrapolation in the valuations of internal model bonds in 2008. Panel (a) shows the distribution of the difference in reported spreads between 2008 and 2007 at the insurer-bond level. Panel (b) 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 the insurer-bond level. The Y axes show percentage of positions.



(a) Stale prices



(b) Extrapolation

Table A.1: How do Insurance Companies Value Corporate Bonds?

The table shows the breakdown of the bond holdings by the valuation method in 2008. "Internal models only" are bonds that are valued using internal models by all insurers. "Non-internal models only" are bonds valued using external sources by all insurers. External sources include traded prices and quotes from brokers and pricing services.

Valuation method	Number of bonds	Total par value ($ billion)
Internal models only	5,149	119
Both internal and non-internal models	4,236	392
Non-internal models only	15,394	597
Total	24,779	1108

Table A.2: Bond and Holdings Characteristics

The table shows the descriptive statistics for internal model (panel a) and non-internal model bonds (panel b) for the year 2008. A bond is classified as internal model if at least one insurer valued it using internal models in 2008. The sample excludes bonds with maturities less than one year and greater than thirty years.

	Mean	StDev	P10	P25	Median	P75	P90
Panel a: Internal model							
NAIC rating	2.06	1.18	1.00	1.00	2.00	2.00	4.00
Remaining maturity	8.31	6.65	2.17	3.83	6.08	10.08	18.50
Credit spread (2008)(%)	8.64	8.85	3.10	4.60	6.26	9.29	15.20
Reported price (2008)	89.38	19.40	63.86	83.20	94.56	100.92	106.33
Credit spread (excl 2008)(%)	4.10	4.69	1.27	1.80	2.76	4.54	8.17
Reported price (excl 2008)	103.10	12.82	93.14	100.10	104.27	109.18	114.34
Credit spread (acquisition)(%)	2.69	3.32	0.28	1.23	2.06	3.45	5.40
Reported price (acquisition)	98.37	15.72	95.07	99.44	100.00	100.00	103.51
Holding Size (million)	14.93	31.02	1.00	3.20	7.67	15.00	28.63
Duration held (years)	4.35	3.76	0.59	1.48	3.45	5.90	9.62
Panel b: Non-internal model							
NAIC rating	2.12	1.33	1.00	1.00	2.00	3.00	4.00
Remaining maturity	9.02	7.57	2.25	3.83	6.08	11.17	22.58
Credit spread (2008)(%)	10.72	11.61	3.01	4.36	6.65	12.59	22.47
Reported price (2008)	83.59	22.57	50.41	70.00	89.00	100.21	105.70
Credit spread (excl 2008)(%)	3.99	4.61	1.10	1.68	2.78	4.68	7.67
Reported price (excl 2008)	102.29	13.46	90.19	97.79	102.60	108.64	115.82
Credit spread (acquisition)(%)	3.04	4.06	0.21	1.35	2.32	3.93	6.55
Reported price (acquisition)	98.51	16.69	91.83	97.89	100.00	100.75	107.10
Holding Size (million)	7.49	12.34	0.25	1.44	4.82	9.36	15.15
Duration held (years)	3.13	3.04	0.38	0.96	2.14	4.48	6.95

Table A.3: Correlation Between Reported and Acquisition Spreads: Placebo Tests

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

$$CS^{R}_{b,i} = \lambda_1 CS^{Acq}_{b,i} + \alpha_b + \alpha_i + \epsilon_{b,i},$$

where $CS^{R}_{b,i}$ is the reported credit spread of bond b held by insurer i. $CS^{Acq}_{b,i}$ is the prevailing spread for bond b at the time it was acquired by insurer i. α_b and α_i are bond and insurer fixed effects, respectively. The sample includes only 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
$CS^{Acq}_{b,i}$	0.129	0.191	0.171	0.424***	0.282*	0.107	-0.046
	(0.162)	(0.136)	(0.115)	(0.129)	(0.146)	(0.097)	(0.120)
Bond Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Insurer Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,318	7,272	8,518	9,161	7,742	6,206	4,200
R-squared	0.82	0.76	0.66	0.82	0.83	0.89	0.79

Table A.4: Internal Models and Future Asset Revisions

The table shows the relationship between future impairments and the valuation method used by insurers. We estimate:

$$\text{Asset Reversion}_{b,i}^{Year} = \gamma_1 IM_{b,i} + \alpha_b + \alpha_i + \epsilon_{b,i},$$

where Asset Reversion$_{b,i}^{Year}$ is the log of the impairment amount of bond b held by insurer i in years 2009, 2010, and 2011. $IM_{b,i}$ is a dummy variable for bond b that takes the value of 1 if insurer i valued the bond using an internal model. α_b and α_i are bond and insurer fixed effects, respectively. The sample includes all bonds that were held in 2008. Table shows standard errors in parentheses, clustered at the insurer level. Significance: * 10%; ** 5%; *** 1%.

	Investment Grade			High Yield		
	2009	2010	2011	2009	2010	2011
	I	II	III	IV	V	VI
$IM_{b,i}$	-0.009	0.002	0.026**	-0.003	0.142**	0.091
	(0.016)	(0.008)	(0.011)	(0.137)	(0.067)	(0.155)
Bond Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Insurer Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	31,263	25,645	18,868	2,751	1,739	1,074
R-squared	0.21	0.73	0.13	0.67	0.45	0.45

Table A.5: State Regulators' Characteristics

The table documents the summary statistics of state regulators' characteristics. The variables include (i) the total number of financial examiners and analysts in a state, (ii) the total budget, and (iii) the total number of financial exams (regular and discretionary) conducted by a state. Each variable is scaled 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. The table only includes the states for which the misreporting coefficient could be estimated using Equation (1).

	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

Table A.6: Transactions in TRACE

The table shows the difference in the propensity of finding a transaction in TRACE, depending on a bond's holding structure.

$$Dummy_b^{TiN} = \delta(CO_b) + \beta X_b + \alpha_k + \epsilon_b,$$

where $Dummy_b^{TiN}$ is a dummy variable for bond b that takes the value of 1 if the bond had at least one transaction in 2008. CO_b is a dummy variable for bond b that takes the value of 1 if a bond is held by up to two insurers in 2008. X_b are bond level controls, which include credit ratings and maturity. α_k are issuer fixed effects. The sample only includes the bonds that existed in our sample in 2008. As the transactions of private placement are not reported in TRACE, we exclude them from the sample. The variable of interest, δ, measures the difference in the probability of finding a transaction in TRACE for bonds with a more concentrated holding structure, as compared to bonds with a 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 a more concentrated holding structure 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. δ is now identified by comparing bonds of the same issuer. We find that the probability of finding a transaction is 24 percentage points lower for bonds with a more concentrated holding structure.

	$Dummy^{TiN}$	
	I	II
CO_b	-0.542***	-0.239***
	(0.016)	(0.015)
Constant	0.752***	0.667***
	(0.015)	(0.016)
Control	Yes	Yes
Issuer FE	No	Yes
Observations	16,476	11,980
R-squared	0.31	0.83

B. Computing Implied Credit Spreads from Reported Market Values

As impairment occurs due to changes in the credit risk of a bond, we compute implied credit spreads for each position. We proceed as follows. First, we compute the reported price by dividing the total reported market value 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 position.[47] In doing so, we assume that the bond is a straight bond. A very tiny proportion of our sample are putable or convertible bonds and roughly about 20% of the bonds are callable. However, the assumption is less problematic in our case as the main identification strategy compares the same bond across insurers.[48] We exclude positions where par value, market value, maturity date, or coupon rate are not populated. Finally, we subtract from the implied YTM of the bond, the YTM of a comparable maturity treasury, where the YTM of treasuries are from Datastream. 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).

C. Impairment Rule

Life insurers hold corporate bonds at book value. NAIC mandates that assets should be revised down from the existing book value (BV) to the prevailing market value (MV) when MV declines "sufficiently" below the BV due to a permanent decline in credit risk, i.e. when a bond is impaired. However, NAIC Statements of Statutory Accounting Principles (SSAP) does not specify an exact rule or a threshold at which impairments should take place. The NAIC guidelines state:

> *"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."* - SSAP number 26.

Absence of a specified threshold makes it difficult to ex-ante identify the bonds where

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

[48] Moreover, ignoring callable bonds do not change any of our main results and conclusions.

impairments would occur. To overcome this challenge, we uncover the historical impairment rule, i.e. we identify the thresholds below which impairments have occurred historically. As what constitutes a permanent decline depends on the volatility of credit spreads, which in turn varies across rating categories, we compute the impairment threshold separately for each rating category. Specifically, conditional on impairments, we compute:

$$\text{Threshold} = \text{Mean}\left(\frac{\text{BV}_{b,i,t} - \text{MV}_{b,t}}{\text{BV}_{b,i,t}}\right),$$

where the mean operates across all bonds b, and across all times t, for each rating category. The table below provides the thresholds computed for the entire sample from 2004 to 2016. The thresholds show on average how much was the MV below the BV for bonds within a rating category when an impairment took place. For example, on average the market values of BB bonds drop 15% below their book values when impairments take place.

Rating		Threshold
NAIC 1	AAA,AA,A	10%
NAIC 2	BBB	13%
NAIC 3	BB	15%
NAIC 4	B	18%
NAIC 5	CCC	32%
NAIC 6	CC or below	45%