Betting on Bond Ratings Disagreement

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Abstract

This paper examines, theoretically and empirically, the investment behavior of insurance companies in the corporate bond market when bond ratings are inconsistent. We find that insurers adjust bond holdings to reduce perceived credit quality uncertainty but increase holdings of bonds with low ratings and large rating dispersion. For the lowest-rated group of bonds, a one standard deviation increase in normalized bond rating dispersion increases insurer holdings by 1.7%, which accounts for more than 17% of its standard deviation, consistent with reaching for uncertainty behavior. This result is robust to various controls including bond yields, credit ratings, and high-order fixed effects.

Keywords: Corporate Bond, Ratings Dispersion, Ambiguity, Insurance Companies, Bond Holdings, Reaching for Uncertainty

JEL Classification: G11, G12, G14, G22, G24, D81

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1 Introduction

When uncertainty enters as a decision-making criterion, theories often posit that investors are ambiguity-averse as well as risk-averse. Ellsberg (1961) showed through a set of experiments that economic agents seek to avoid situations for which the probability of outcomes is unknown; that is, they dislike imperfect information regarding probability distributions. Later works formalize ambiguity aversion. For example, and among others, Gilboa and Schmeidler (1989) assume decision makers face a class of probability distributions and act to maximize utility in the most unfavorable scenario, and Epstein and Schneider (2003) expand this setup to axiomatize recursive multiple-priors utility. Recently, ambiguity aversion has also been empirically shown to play an important role in individual investors' stock market decisions (Dimmock et al., 2016; Bianchi and Tallon, 2019; Kostopoulos et al., 2021).

There is limited research, however, on whether and how ambiguity affects institutional investors' investment decisions. In this paper, we aim to provide both theoretical and empirical analysis on the investment behavior of insurance companies in the corporate bond market when they face ambiguous credit information. Insurance companies are the largest investor group in the U.S. corporate bond market, and corporate bonds account for more than half of their fixed income investment.[1] More importantly, the regulatory features of this industry make it an interesting case for our study. The National Association of Insurance Commissioners (NAIC) requires insurance companies to maintain capital levels commensurate with the size and riskiness of their investments (i.e., the risk-based capital (RBC) requirements). For bonds, credit ratings determine the risk categories. When ratings diverge for a given bond, NAIC has clear rules to designate risk groups.[2] Nevertheless, divergent ratings are

[1]Source: NAIC Capital Markets Bureau Special Reports - "U.S. Insurance Industry's Cash and Invested Assets Surpass $8 Trillion at Year-End 2021".

[2]If a bond is rated by two rating agencies, NAIC assigns it the lowest rating; if the bond is rated by

likely to signal uncertainty above and beyond risk, in that the disagreement between credit agencies potentially forces fund managers to reassess the perceived probability of default for bonds.

When credit evaluations differ among the major credit rating agencies, do fund managers change their investment in a bond because of the dispersion, or do they increase (decrease) their investment in anticipation of an improvement (deterioration) in the rating? To analyze the portfolio choice implications of credit rating dispersion, we construct a simple two-period model, where fund managers aim to maximize the total wealth by allocating a given initial amount between two credit-risky bonds. The model features a linear-quadratic preference function for the managers and two rating agencies. At the beginning of the first period, each bond receives a shock to its survival probability. Compared with the fund managers, rating agencies have better information about the shock, albeit with varying degrees of noise.

We first show that multiple ratings can improve the informativeness of the shock by reducing its posterior variance; yet how ratings affect the posterior probability of survival depends not only on the size and direction of the ratings realized, but also on the precision of the information possessed by each rating agency, which in turn affects the extent to which the managers want to update their information set upon observing the ratings.

In the case where fund managers know the distribution of the shock - when there is no credit information ambiguity from the managers' perspective - we show that disagreement in credit ratings yields no information update on the posterior probability of survival for each given bond. Moving to the case with information ambiguity, we assume that the managers only know the quality bounds of the information possessed by the credit rating agencies. If a given manager is ambiguity averse and acts based on the max-min principle, ambiguity

all three rating agencies, NAIC assigns it the middle rating (Purposes & Procedures Manual of the NAIC Investment Analysis Office, December 2021).

aversion prevails via disagreement in credit ratings. This is an important result as it provides a theoretical justification for the rating dispersion measure in our following empirical tests. In addition, we show that ambiguity aversion negatively affects the posterior probability of survival.

Provided that ambiguity aversion exists for a given proportion of fund managers, we provide closed-form solutions on the relation between a bond's credit rating disagreement and the proportion of its total outstanding amount held by these funds. On average, we show that aggregate fund holdings is decreasing in the credit rating disagreement of a bond. More interestingly, this relation varies with the bond's riskiness. As bond survival probabilities are bound between 0 and 1, asymmetric effects of uncertainty should prevail at the extremes, an intuition which Figure 1 illustrates. For a safe bond with survival probability close to 1, any uncertainty regarding its credit quality leans more toward adverse than favorable developments. The max-min principle leads to investors avoiding rating dispersion in highly-rated bonds, as is standard in the ambiguity aversion literature (e.g., Knight, 1921; Ellsberg, 1961). On the other hand, for risky bonds with limited downside, investor expectations of the worst-case stemming from rating dispersion is bounded. Thus, investors may actually lean toward uncertainty in this case.[3] Last but not least, if there were no ambiguity-averse fund managers, the average asset allocation effect of credit rating disagreement is zero, and there is no such asymmetry in the investment effect of rating disagreement for safe versus risky bonds, controlling for the mean rating.

[Insert Figure 1 About Here]

[3]Asymmetric price reactions in asset markets to good and bad news have been explained with the weights investors assign to signal precision (e.g. Kim et al. (2022a)). Our study adds a quantity channel in which uncertainty influences investor decisions, with contrasting effects caused by bounded probability distributions.

We test the quantity implication of asymmetric attitudes toward uncertainty for differing degrees of risk. According to the model, we quantify the degree of ambiguity regarding credit quality assessments as rating dispersion, which is constructed in the spirit of the Fano (1947) factor, a measure of dispersion of a probability distribution.[4] Even when ratings do not diverge, there still remain inherent uncertainties about the rating itself, therefore our measure is conservative compared with the true size of ambiguity.

We first document the relation between rating dispersion and rating changes in the following quarter. For safe bonds with zero or low dispersion measures, the possibility of downgrades is very similar to that of upgrades. Even in bonds with high dispersion, the likelihoods of receiving positive versus negative shocks to credit risk are not too disparate. In contrast, the differences are much larger in the subsample of risky bonds, where credit rating dispersion overwhelmingly predicts downgrades compared with upgrades. If insurers are concerned primarily with future rating changes, then they should avoid bonds with rating disagreement, especially in the risky group of bonds.

To test the portfolio choice decisions of insurance companies facing credit information ambiguity, we compute the fraction of a bond outstanding held by insurers using Lipper-eMAXX bond holdings data from 2002 to 2015.[5] Our analysis shows that after the average effect of rating dispersion on one-quarter-ahead fraction of insurers' bond holdings is negative, suggesting that insurance companies generally shy away from bonds with ratings disagreement. For the safest bonds (NAIC group 1), the negative relation between rating dispersion and fraction of a bond held by insurances in the following quarter is even stronger. In con-

[4]Other works which employ dispersion in forecasts or professional opinions include Diether et al. (2002), Epstein and Schneider (2008), Anderson et al. (2009a), Ilut and Schneider (2014), Kim (2016) and Kim et al. (2022a).

[5]eMAXX contains detailed fixed-income holdings for insurance companies, mutual funds, pension funds, and other investors at the quarterly level.

trast, the coefficient estimate of rating dispersion turns positive for the riskiest bonds (NAIC group 5).[6] A one standard deviation change in rating dispersion in the safest bonds decreases the proportion held by insurers by 2.2%, whereas for the riskiest bonds, the same change *increases* insurers' holdings by 1.7%. As we control for rating-by-quarter fixed effects, the findings are robust to any rating level shocks.

The results are robust to the inclusion of a host of bond-level control variables. In particular, our findings are robust to controlling for bond yield spread. That is, the "betting on disagreement" phenomenon we document is a distinct channel from "reaching for yield" behavior reported by Becker and Ivashina (2015). Whereas reaching for yield is unilateral and is explained in the framework of regulatory arbitrage, betting on disagreement is related to the asymmetric nature of uncertainty in safe versus risky investments. What is surprising in our result is that ambiguity-chasing behavior can occur, despite the existence of ambiguity aversion for conservative investors like insurance companies.

Observed and unobserved time-invariant bond- or industry-level characteristics may correlate with both ratings dispersion and funds' investment decision, thus driving our findings. We rule out this possibility by extending our specification and including bond fixed effects and industry-by-quarter fixed effects. Recall that our theoretical setup on credit information ambiguity arises from two rating agencies receiving default probability shock of a given bond with different levels of noise. The specification with bond fixed effect–relying on the within-issue changes of rating dispersion for identification–allows us to better capture these shocks and align with the theory, compared with the above cross-sectional specification.

The paper is organized as follows. Section 2 sets out the literature on insurance compa-

[6]We exclude NAIC risk category 6 because of paucity of the sample. However, it is logical to assume that the preference for rating dispersion shown in NAIC group 5 bonds will be similar, or even amplified, in group 6 bonds.

nies' corporate bond investments and uncertainty aversion. Section 3 presents the model and the hypothesis. Section 4 describes the data and documents the empirical results. Section 5 concludes.

2 Literature

The extant literature on determinants of insurers' bond investments highlights the role of regulation. Regulatory pressure imposed on insurance companies can induce fire sales of downgraded bonds in corporate bond markets (Ellul et al. (2011)), and their highly correlated strategies exacerbate fire sale risk (Nanda et al. (2019)). Conditional on regulatory risk classification, Becker and Ivashina (2015) find that insurers favor corporate bonds with higher issuance spreads - that is, there is "reaching for yield". Central to how regulators classify risk, credit ratings often act as a bar to investment for many types of funds. Using a Lehman Brothers 2005 index redefinition as a natural experiment, Chen et al. (2014) find that rating-based bond market segmentation exists, and it is distinct from that of reputation, regulation, indexation, and liquidity.[7]

Early works such as Knight (1921) and Ellsberg (1961) underscore the role of ambiguity aversion in financial decisions. Following these works, a strand of the literature relates asset prices to ambiguity or uncertainty. Gilboa and Schmeidler (1989) formalize a framework for ambiguity aversion, in which decision makers have a class of probability distributions and act according to a max-min rule—that is, maximization of utility in the worst-case scenario. In particular, their multiple-priors model illustrates how behavior in risky situations (in which objective probabilities are given) and ambiguous situations (in which odds are not

[7]Dass and Massa (2014) posit institutional investors favor issuers of various maturities due to lower information costs. Timmer (2018) finds disparate reactions to past holding returns by investor type.

given) can differ. Epstein and Wang (1994) formulate a dynamic version of the work by Gilboa and Schmeidler (1989) in discrete time, and Epstein and Schneider (2003) axiomatize recursive multiple-priors utility.[8] Whereas the mentioned studies focus on asset pricing implications and the unilateral effect of ambiguity aversion, our model differs by emphasizing the asymmetric effect of dispersion on quantity-related decisions for different levels of risk. Our analysis of rating dispersion and future rating changes show that a categorical scale (such as credit ratings or NAIC risk categories) can be relevant boundaries for the asymmetry.

Complementing the theoretical work, empirical studies employ various ways of measuring ambiguity and link them to asset prices. In relation to equity markets, Diether et al. (2002) use dispersion in analyst earnings forecasts; Anderson et al. (2009b), the degree of disagreement in professional forecasters; Hollstein and Prokopczuk (2018), option-implied volatility of the volatility index; Baltussen et al. (2018), the variance of a stock's implied volatility; and Brenner and Izhakian (2018), high-frequency data of the Exchange Traded Funds by the State Street Global Advisors (SPDR ETF). The results are mixed. While Anderson et al. (2009b) and Brenner and Izhakian (2018) find positive ambiguity premiums, the other studies find otherwise. Additionally, Jeong et al. (2015) estimate ambiguity from equity market return volatility and find a positive premium. In the fixed income space, Kim (2016) measures ambiguity from dispersions in forecasts of the short-term interest rate and finds that it is positively priced in treasury bonds.

Measuring ambiguity from dispersion in forecasts or opinions follows prior studies, such as Epstein and Schneider (2008), Ilut and Schneider (2014), and Kim (2016), which posit that when economic agents are ambiguity averse and information quality is obscure, dispersion

[8]Epstein and Schneider (2010) provide a comprehensive survey on ambiguity and related models. There are other families of ambiguity aversion models such as those with robust control (e.g., Hansen et al. (1999), Hansen and Sargent (2001)) or smooth ambiguity aversion (Klibanoff et al. (2005)). Epstein and Schneider (2010) and Guidolin and Rinaldi (2013) also provide comparisons of these models.

in professional forecasts can proxy for this type of uncertainty. In particular, our measure of rating dispersion follows prior studies (Morgan, 2002; Bonsall and Miller, 2017; Bonsall IV et al., 2017; Akins, 2018), all of which focus on the role of information quality in explaining disagreement between bond rating agencies. Regarding the potential implications of rating disagreement, Kim et al. (2022a) find evidence of positive credit information ambiguity premia in corporate bond, stock, and credit default swap (CDS) markets. Unlike these papers, our journey is on a road less taken, specifically, the one that lies between credit information ambiguity and quantity adjustment, and the asymmetric decisions across risk categories. In addition to rating dispersion, we also quantify credit-related uncertainty with dispersion in survival assessments, using historical survival probabilities associated with letter ratings from the "Big Three" credit rating agencies.

To our knowledge, a limited number of works explore the relation between ambiguity and quantity-related decisions in asset markets. Dimmock et al. (2016) measure individual investor ambiguity aversion via Ellsberg-urn type questions, documenting cross-sectional evidence that higher ambiguity aversion decreases household stock market participation, the proportion of financial assets held in stocks, and foreign stock ownership. In a study of French investors, Bianchi and Tallon (2019) document that ambiguity averse households tend to be underdiversified, and keep portfolio weights more stable over time. Also, using proprietary German data, Kostopoulos et al. (2021) find that individual investors respond to increases in aggregate ambiguity about volatility of the European stock market (i.e., volatility-of-volatility) by trading more and reducing their holdings of risky securities.[9] In a closely related work, Kim et al. (2022b) study holdings data to find that bond funds are

[9]Regarding corporate decisions, Johnson et al. (2021) find that when ambiguity about credit quality differs across the maturity spectrum, firms adjust their debt maturity structures away from the tenor with more ambiguity. Izhakian et al. (2021) relate historical equity return-based ambiguity to capital structure decisions.

averse to ambiguity in credit information, but learning can attenuate such behavior.

Unlike the prior works, our paper studies insurance companies' reaction to uncertainty about security-specific credit information quality, and highlights the contrasting behavior in the extreme risk categories. We contribute to the existing literature by investigating the causal effect of time-varying security-level credit information ambiguity on insurance holdings using comprehensive security-level holdings data in the U.S. As insurers are the largest holders of U.S. corporate bonds, this channel of adjustment will have important implications for portfolio choice decisions.

3 Motivation and Hypothesis

Suppose that there exist two periods, two credit-risky bonds denoted as A and B, and two credit rating agencies $k = 1, 2$. Risk-averse insurance companies in the interval of $[0, 1]$ are given an existing allocation and selects portfolio weights to purchase bonds. An insurer has a linear-quadratic preference function for the company wealth x, defined as $EU(x) = E(x) - \frac{\psi}{2} Var(x)$, where $\psi > 0$ is the degree of risk aversion. The survival probability of each bond type $i = A$, B is given as $\phi_i = \phi_i^* + \eta_i$, where $\eta_i \sim N(0, \sigma_i^2)$ describes the shocks to credit risk. σ_i^2 is sufficiently small such that the probability ϕ_i being outside the bound of $[0, 1]$ is negligible.[10] That is, $(1 - \phi_i)$ is the default probability for bond i.

The model assigns V_A and V_B with no default, and (δ_A, δ_B) for the case of default per unit of the bond. $V_i > \delta_i > 0$ holds for both types of debts. For simplicity, we normalize the total number of units of each bond to be 1. To introduce credit information and learning by the manager, we assume that in each period, the two rating agencies $k = 1$ and 2 provide

[10] Alternatively, we can assume $\phi_i = \mathcal{S}(\bar{\phi} + \eta_i)$, where $\mathcal{S}$ is a logistic function. Then, the survival probability is written in terms of a logarithmic odds ratio $(log(\phi/(1 - \phi)))$. Theoretical implications are identical.

new credit information $z_{k,i}$ about an issue's i's future default probability, and the manager updates that information. For example, rating agency k may have better information than the fund manager about each bond's default probability shock: $z_{k,i} = \eta_i + \varepsilon^z_{k,i}$, where $\varepsilon^z_{k,i} \sim N(0, (\sigma^z_{k,i})^2)$ measures the level of noise in information for the credit risk of bond issue i by rating agency k.[11] Then, the updated probability of a survival shock ($E\left(\eta_i | z_{1,i}, z_{2,i}\right)$) is derived as follows.

$$E\left(\eta_i | z_{1,i}, z_{2,i}\right) = \gamma_{1,i} z_{1,i} + \gamma_{2,i} z_{2,i},$$
$$\gamma_{k,i} = \frac{(\sigma^z_{k,i})^{-2}}{\sigma_i^{-2} + (\sigma^z_{1,i})^{-2} + (\sigma^z_{2,i})^{-2}}$$

Similarly, we can also compute the conditional variance $Var\left(\eta_i | z_i\right)$ as

$$Var\left(\eta_i | z_{1,i}, z_{2,i}\right) = \frac{1}{\sigma_i^{-2} + (\sigma^z_{1,i})^{-2} + (\sigma^z_{2,i})^{-2}}.$$

Multiple ratings (e.g., $\sigma_i^{-2} + (\sigma^z_{1,i})^{-2} + (\sigma^z_{2,i})^{-2}$ in lieu of $(\sigma^z_{1,i})^{-2}$) improve the informativeness of signals by lowering the posterior variance. However, the posterior mean, $E\left(\eta_i | z_{1,i}, z_{2,i}\right)$, depends upon both the sensitivities to the information ($\gamma_{k,i}$) and the size and direction of the shocks realized ($z_{k,i}$). Note that disagreement among credit rating agencies occur whenever $z_{1,i}$ and $z_{2,i}$ differ. In particular, when one news is good, and the other is bad with the same magnitude, say $z_{1,i} = \Delta_i > 0$ and $z_{2,i} = -\Delta_i$, the size of credit ratings disagreement amounts to $2\Delta_i$. In addition, the stylized fact that major credit rating agencies are comparable in their accuracy in predictions, leads to the assumption of $\sigma^z_{1,i} = \sigma^z_{2,i}$

[11] Alternatively, credit information ambiguity could come from the uncertainty in credit risk modelling, which should generate similar implications on the investment decisions as the current model. For instance, the more significant the misspecification in credit rating models, leading to deeper rating disagreements, the more likely it is that insurance companies may seek to hold bonds that offer greater robustness against this uncertainty.

(i.e., $\gamma_{1,i} = \gamma_{2,i}$). That is, we assume that disagreement in credit information is equally divided between good and bad news with the same magnitude. This is mainly for tractability, but out empirical analysis normalizes credit rating dispersion and control for ratings to be consistent with the model. Now, the following result prevails.

Claim 1 *The updated posterior probability shock of survival, $E(\eta_i|\Delta_i, -\Delta_i)$, is 0 if the decision maker knows the distribution, or no ambiguity exists. Disagreement in informative signals can yield no information update in the case of complete information.*

We now introduce ambiguity in credit information by assuming that the manager knows only the bounds of the information quality; $\sigma^z_{k,i} \in \left[\underline{\sigma}^z_{k,i}, \bar{\sigma}^z_{k,i}\right]$ holds for $k = 1, 2$, $i = A$, B, and $0 < \underline{\sigma}^z_{k,i} < \bar{\sigma}^z_{k,i}$. Denote $\bar{\gamma}_{k,i}$ for the case with $\sigma^z_{k,i} = \underline{\sigma}^z_{k,i}$ and $\underline{\gamma}_{k,i}$ for the case of $\sigma^z_{k,i} = \bar{\sigma}^z_{k,i}$ for $i = A$, B and $k = 1, 2$. Thus, $\underline{\gamma}_{k,i}$ refers to the case of highly uncertain quality, and $\bar{\gamma}_{k,i}$ is the information update with the most accurate signal. Similar to the case of no ambiguity, we assume that both credit rating agencies have the same degree of information uncertainty, or $\underline{\sigma}^z_{1,i} = \underline{\sigma}^z_{2,i}$, and $\bar{\sigma}^z_{1,i} = \bar{\sigma}^z_{2,i}$ for both $i = A, B$.

Suppose that a fraction $(0 < \lambda < 1)$ of the insurance companies dislike ambiguity and act based on the max-min principle. Intuitively, this means that the long-position managers choose $\underline{\gamma}_i$ when credit information is favorable $(z_i > 0)$, and $\bar{\gamma}_i$ when credit news is bad $(z_i \leq 0)$. That is, an ambiguity-averse manager perceives good (bad) news as noisy (accurate). Furthermore, in order to facilitate comparison, we assume that only bond A is subject to this credit information uncertainty in that $\sigma^2_{z,A} \in \left[\underline{\sigma}^2_{z,A}, \bar{\sigma}^2_{z,A}\right]$ with $0 < \underline{\sigma}^z_A < \bar{\sigma}^z_A$. The investor knows the value of σ^z_B for bond B. Rewriting the posterior of surivival probability with disagreement, $2\Delta_A$, we have

Claim 2 *Under the ambiguity in credit information described above and ambiguity aversion, the subjective posterior becomes*

$$E\left(\phi_A|\Delta_A, -\Delta_A\right) \quad = \quad \phi_i^* - (\bar{\gamma}_A - \underline{\gamma}_A)\Delta_A.$$

That is, when credit information ambiguity exists, ambiguity aversion prevails via disagreement in credit ratings and affects the investors' posterior probability of survival negatively.

In the beginning of period 0, the ambiguity-averse decision maker has a portfolio of bonds that is worth W_0 and makes a decision θ_A for bond A and $(1-\theta_A)$ for bond B after observing a signal. The bond values will be realized in the next period. We first compute the expected value of the fund W_1 in the following period, conditional upon the credit information $z = (z_A, z_B)$ as

$$\begin{aligned} E(W_1(\theta_A)|z) = &\left\{\left(\phi_A^* + \gamma_{1,A}z_{1,A} + \gamma_{2,A}z_{2,A}\right)V_A + \left(1 - \left(\phi_A^* + \gamma_{1,A}z_{1,A} + \gamma_{2,A}z_{2,A}\right)\right)\delta_A\right\}\theta_A \\ &+ \left\{\left(\phi_B^* + \gamma_{1,B}z_{1,B} + \gamma_{2,B}z_{2,B}\right)V_B + \left(1 - \left(\phi_B^* + \gamma_{1,B}z_{1,B} + \gamma_{2,B}z_{2,B}\right)\right)\delta_B\right\}\left(1-\theta_A\right). \end{aligned} \tag{1}$$

The conditional variance of W_1 is computed as

$$Var(W_1(\theta_A)|z) = \left(V_A - \delta_A\right)^2 \theta_A^2 \sum_{k=1}^{2} \gamma_{k,A}(\sigma_{k,A}^z)^2 + \left(V_B - \delta_B\right)^2 \left(1-\theta_A\right)^2 \sum_{k=1}^{2} \gamma_{k,B}(\sigma_{k,B}^z)^2. \tag{2}$$

A higher level of information precision (i.e., a lower value of $\sigma_{z,i}^2$) increases the learning sensitivity of the informative signal (γ_i) in equation (1) and lowers the posterior variance (2) by lowering $\gamma_i\sigma_{z,i}^2$ and vice versa. Thus, information ambiguity affects both (1) and (2).

Now, we consider the ambiguity-averse and risk-averse bond fund manager's problem after receiving new but noisy information,

$$\max_{\theta_A} \min_{\sigma^2_{z,i}\in\left[\underline{\sigma}^2_{z,i},\bar{\sigma}^2_{z,i}\right]_{i=A}} \left(E(W_1(\theta_A)|z) - \frac{\psi}{2} Var(W_1(\theta_A)|z) \right) \tag{3}$$

subject to equations (1) and (2). Given a choice of γ_i (or $\sigma^2_{z,i}$), the solution to problem (3) is readily available from the first-order condition.

Claim 3a *Portfolio weight for bonds with ambiguous signal (bond A) for an ambiguity-averse manager is given as*

$$\theta_A = \frac{\left(\phi^*_A + \sum_k \gamma_A z_A\right)(V_A - \delta_A) + \delta_A - \left(\phi^*_B + \sum_k \gamma_B z_B\right)(V_B - \delta_B) - \delta_B + \psi\,(V_B - \delta_B)^2 \sum_k \gamma_B \sigma^2_{z,B}}{\psi\left((V_A - \delta_A)^2 \sum_k \gamma_A \sigma^2_{z,A} + (V_B - \delta_B)^2 \sum_k \gamma_B \sigma^2_{z,B}\right)}. \tag{4}$$

To better identify the ambiguity channel, we make bonds differ only in term of credit information ambiguity. This can correspond to a stringent empirical specification tested.

Claim 3b *Assume that $\phi^*_A = \phi^*_B = \phi^*$, $V_A = V_B = V$, $\delta_A = \delta_B = \delta$, and $\sigma_A = \sigma_B = \sigma$. Then, equation (4) becomes*

$$\theta_A = \frac{\left(\sum_k \gamma_A z_A - \sum_k \gamma_B z_B\right)(V - \delta) + \psi\,(V - \delta)^2 \sum_k \gamma_B \sigma^2_{z,B}}{\psi\,(V - \delta)^2 \left(\sum_k \gamma_A \sigma^2_{z,A} + \sum_k \gamma_B \sigma^2_{z,B}\right)}. \tag{5}$$

To expound equation (5), we separately consider a case with only good news (i.e., $z_A = \Delta_A > 0$) and a case with only bad news (i.e., $z_A = -\Delta_A < 0$). Each case can represent a situation where

Claim 4a *When credit information ambiguity exists, with only good news ($z_A = \Delta_A > 0$), the manager chooses the most noisy case $\bar{\sigma}^2_{z,A}$:*

$$\theta_A^{z_A \geq 0} = \frac{\left(2\underline{\gamma}_A \Delta_A - \gamma_B z_B\right)(V-\delta) + \psi (V-\delta)^2 \gamma_B \sigma^2_{z,B}}{\psi (V-\delta)^2 \left(2\underline{\gamma}_A \bar{\sigma}^2_{z,A} + \gamma_B \sigma^2_{z,B}\right)}. \tag{6}$$

Note that if $\bar{\sigma}^2_{z,A}$ increases, $\underline{\gamma}_A$ decreases and $\underline{\gamma}_A \bar{\sigma}^2_{z,A}$ increases. This claim implies that the effect on good news is positive, though its effect becomes weaker due to ambiguity aversion.

Claim 4b With only negative news ((i.e., $z_A = -\Delta_A < 0$),

$$\theta_A^{z_A < 0} = \frac{\left(-2\bar{\gamma}_A \Delta_A - \gamma_B z_B\right)(V-\delta) + \psi (V-\delta)^2 \gamma_B \sigma^2_{z,B}}{\psi (V-\delta)^2 \left(2\bar{\gamma}_A \underline{\sigma}^2_{z,A} + \gamma_B \sigma^2_{z,B}\right)}. \tag{7}$$

In this case, an effective increase in ambiguity refers to a lower value of $\underline{\sigma}^2_{z,A}$. This in turn implies a higher value of $\bar{\gamma}_A$ (a lower value of $(-\bar{\gamma}_A)$) and a lower value of $\bar{\gamma}_A \underline{\sigma}^2_{z,A}$. In terms of interpretation for the above two cases, we can view that one rating agency does not change their ratings but the other agency modifies it. Therefore, ambiguity in signal affects portfolio decisions via disagreement, even if the direction of the shock is less uncertain. Now, the next result refers to the case where the signs of news differ as well.

Claim 4c When ratings disagree with different signs, we have the following.

$$\theta_A^{Disp} = \frac{\left(-(\bar{\gamma}_A - \underline{\gamma}_A)\Delta_A - \gamma_B z_B\right)(V-\delta) + \psi (V-\delta)^2 \gamma_B \sigma^2_{z,B}}{\psi (V-\delta)^2 \left(\bar{\gamma}_A \underline{\sigma}^2_{z,A} + \underline{\gamma}_A \bar{\sigma}^2_{z,A} + \gamma_B \sigma^2_{z,B}\right)} \tag{8}$$

Equation (8) states that the average effect of credit information ambiguity ($(\bar{\gamma}_A - \underline{\gamma}_A)\Delta_A$) on the bond holdings is negative. Multiple ratings may help investors update information but ambiguity aversion and rating dispersion lead to reduction in holdings. Claim 4 suggests that the average effect of ambiguity tends to negatively affect bond holdings, unless good news is dominant in frequency of rating dispersion.

One important implication of this model is that this result may be sensitive to the unconditional survival probability of the bond A. If the bond is very safe, i.e., $\phi^* \approx 1$, then disagreement in rating will be prevalent only to the downside direction. That is, within the current example, $\Delta_A > 0$ is virtually truncated and only the part of $-\Delta_A < 0$ prevails. Then, for an extreme case with complete truncation on upside, we can obtain

$$\theta_{Safe}^{Disp} = \frac{\left(-(\bar{\gamma}_A)\Delta_A - \gamma_B z_B\right)(V-\delta) + \psi (V-\delta)^2 \gamma_B \sigma_{z,B}^2}{\psi (V-\delta)^2 \left(\bar{\gamma}_A \underline{\sigma}_{z,A}^2 + \underline{\gamma}_A \bar{\sigma}_{z,A}^2 + \gamma_B \sigma_{z,B}^2\right)}. \tag{9}$$

Similarly, for a very risky bond with $\phi^* \approx 0$ where the downside disagreement disappears, we have the opposite result in that

$$\theta_{Risky}^{Disp} = \frac{\left((\underline{\gamma}_A)\Delta_A - \gamma_B z_B\right)(V-\delta) + \psi (V-\delta)^2 \gamma_B \sigma_{z,B}^2}{\psi (V-\delta)^2 \left(\bar{\gamma}_A \underline{\sigma}_{z,A}^2 + \underline{\gamma}_A \bar{\sigma}_{z,A}^2 + \gamma_B \sigma_{z,B}^2\right)}. \tag{10}$$

Equations (9) and (10) imply that the relations between ratings disagreement and bond holdings vary significantly depending on how safe (or risky) the bonds are. For very safe bonds, credit information uncertainty works mostly on the downside, hence conservative investors tend to reduce their holdings, whereas in highly risky bonds, split ratings can lead to increase in holdings because the good news aspect of credit information uncertainty prevails. Note that the above results do not arise without ambiguity aversion. The remaining

$(1-\lambda)$ fraction of insurance companies have $\bar{\gamma}_A = \underline{\gamma}_A \equiv \gamma_A^*$, and denoting the total insurance company holdings for bond A with ratings disagreement by Θ_A^{Disp}, we obtain the following testable implications.

Claim 5 *For each group of assets, the total insurers' holdings are computed as:*

$$\begin{aligned}
\Theta_A^{Disp} &= \frac{-\lambda(\bar{\gamma}_A - \underline{\gamma}_A)\Delta_A (V-\delta) + \psi (V-\delta)\left(\gamma_B \sigma_{z,B}^2 (V-\delta) - \gamma_B z_B\right)}{\psi (V-\delta)^2 \left(\bar{\gamma}_A \underline{\sigma}_{z,A}^2 + \underline{\gamma}_A \bar{\sigma}_{z,A}^2 + \gamma_B \sigma_{z,B}^2\right)} \\
\Theta_{Safe}^{Disp} &= \frac{-(\lambda\bar{\gamma}_A + (1-\lambda)\gamma_A^*)\Delta_A (V-\delta) + \psi (V-\delta)\left(\gamma_B \sigma_{z,B}^2 (V-\delta) - \gamma_B z_B\right)}{\psi (V-\delta)^2 \left(\bar{\gamma}_A \underline{\sigma}_{z,A}^2 + \underline{\gamma}_A \bar{\sigma}_{z,A}^2 + \gamma_B \sigma_{z,B}^2\right)} \qquad (11) \\
\Theta_{Risky}^{Disp} &= \frac{(\lambda\underline{\gamma}_A + (1-\lambda)\gamma_A^*)\Delta_A (V-\delta) + \psi (V-\delta)\left(\gamma_B \sigma_{z,B}^2 (V-\delta) - \gamma_B z_B\right)}{\psi (V-\delta)^2 \left(\bar{\gamma}_A \underline{\sigma}_{z,A}^2 + \underline{\gamma}_A \bar{\sigma}_{z,A}^2 + \gamma_B \sigma_{z,B}^2\right)}.
\end{aligned}$$

Equations (11) imply that interactions between risk and uncertainty help identify the channels of ambiguous credit information onto bond holdings, provided that there exist ambiguity-averse asset managers. The first equation shows that insurers will reduce bonds with increases in credit rating disagreement, and the effect is bigger with larger ambiguity in credit rating. Furthermore, this uncertainty channel strengthens for safer bonds (Θ_{Safe}^{Disp}), for riskier bonds, increases in investment (Θ_{Risky}^{Disp}) prevail with rating disagreement, and $\left|\Theta_{Safe}^{Disp}\right| > \left|\Theta_{Risky}^{Disp}\right|$ holds under ambiguity aversion. Now, if there is no ambiguity-averse insurer ($\lambda = 0$), the average effect of credit rating dispersion on portfolio holdings should be zero. An important assumption for the results is that changes in credit rating dispersion are equally likely to occur from rating upgrades and downgrades. As discussed in the next section, we normalize our rating dispersion measures by the average consensus across rating agencies, which addresses this assumption because the average consensus is controlled for in the empirical analysis. Thus, our empirical dispersion measure is consistent with the assumption.

4 Empirical Analysis

This section describes the data, followed by the main empirical results.

4.1 Data and Variables

Our sample consists of U.S. corporate debentures and medium-term notes from Mergent's Fixed Income Securities Database (FISD). We require the sample bonds to be denominated in U.S. dollars, pay fixed or zero coupons, be non-convertible, non-exchangeable, and non-putable. Bonds that mature within one year, or those without ratings are excluded. Bond holdings data is from Lipper-eMAXX, and secondary market transactions data from Enhanced TRACE provided by Wharton Research Data Services (WRDS). The data period is from Q3 of 2002 to Q1 of 2015.

4.1.1 Insurers' Holdings

The insurance sector is a major holder of corporate bonds, therefore any factor that affects their quantity decision deserves due attention.[12] The dependent variable in our study is the fraction of bonds held by insurers on issue level, or the total holdings by insurance companies for each bond scaled by its amount outstanding. For each bond in our sample, we extract its institutional holdings data from the Lipper eMAXX fixed-income database of Thomson Reuters from Q3 of 2002 to Q1 of 2015 and add up all holdings by insurance companies at quarterly intervals. eMAXX contains detailed fixed-income holdings for insurance companies, mutual funds, pension funds, and other investors at the quarterly level.[13]

[12] As of 2021 year-end, insurers held over $4.9 trillion dollars in bond investments (source: NAIC). Of this amount, $2.8 trillion was in corporate bonds, which is about 28% of the total corporate bond market outstanding of $10 trillion reported by the Securities Industry and Financial Markets Association (SIFMA).

[13] As noted in previous studies (see, for example, Dass and Massa (2014), Becker and Ivashina (2015)), the holdings information come from regulatory disclosure to the National Association of Insurance Commissioners

We study the effects of bond ratings dispersion, or uncertainty regarding credit quality assessments, on the investment decision of insurance companies, controlling for other relevant bond characteristics including yield spreads and returns.

4.1.2 NAIC Score and Group

The National Association of Insurance Commissioners (NAIC), comprising of insurance regulators from the 50 states, the District of Columbia, and the five U.S. territories, was founded in 1871. The regulatory body sets the standards for the U.S. insurance industry, and incorporation of NAIC rules in any study of the insurance sector is essential. Relevant to our study is the way NAIC classifies the riskiness of corporate bonds and sets risk-based capital (RBC) requirements.

NAIC specifies how to report indicators of credit ratings. While the conversion of credit ratings into numerical scores - discrete numbers starting with 1 for bonds of the highest credit quality (Aaa for Moody's, AAA for S&P and Fitch) and increasing ordinally as ratings move down the alphanumeric credit rating scale - is standard in corporate bond studies, the credit indicators used are usually averages of the ratings. However, the standards set for insurers are different - when there are two ratings, the lower rating is used, and when there are three ratings, the second lowest rating is used. The second lowest rating rule applies even if the bottom two ratings are equivalent. Our $NAIC\_score$ variable is the numerical equivalent of the NAIC definition of credit quality.

The NAIC scores are further grouped into $NAIC\_group$, again following the association's rules and guidelines. NAIC group 1 consists of the highest quality bonds, or those with AAA,

(NAIC) for insurance companies; the Securities and Exchange Commission (SEC) for mutual funds, asset managers, and public pension funds; and voluntary disclosures by the major private pension funds. Yet, the coverage of eMAXX for banks and hedge funds is quite limited.

AA, or A ratings. BBB bonds belong to NAIC group 2, and BB bonds to group 3. Single-B bonds are placed into NAIC group 4, and CCC bonds into group 5. Bonds with CC ratings or lower belong to NAIC group 6. NAIC groups 1 and 2 are Investment Grade bonds, and the others are Non-Investment Grade. For our analysis, we only include bonds with NAIC scores of 1 to 19, or equivalently, NAIC groups of 1 to 5, since the number of observations in NAIC group 6 is very small.

NAIC groups are important since they are relevant for calculating risk-based capital (RBC) requirements. RBC requirements are imposed to ensure that insurance companies fulfill their obligations to policyholders - it is a statutory minimum level of capital, based on the insurance company's size and the riskiness of its assets and operations. Before the implementation of the RBC standard in 1993, regulators used fixed capital standards which imposed the same amount of minimum capital requirement for each insurance company regardless of its size or risk profile. The fixed capital requirement also varied widely among the states. The inherent shortcomings of the fixed capital standard led to many insurance company insolvencies in the 1980's, to which the RBC standard was a response. If an insurer's capital ratio falls beneath statutory minimum requirements, regulators have the authority to take actions ranging from requiring submission of action plans to obligatory management takeover. High quality bonds require low capital charges in computing RBC, but as ratings deteriorate, the capital charges to the insurer increase. Risk aversion is therefore both implicit and explicit in insurers' investment decisions.

4.1.3 Rating Dispersion

Rating dispersion, our proxy for uncertainty regarding credit ratings, is calculated as the standard deviation of a bond's credit rating scores scaled by the square root of its NAIC score. It is constructed in the spirit of the Fano factor (Fano (1947)), which is a measure of the dispersion of probability distribution in electronic particle detection. Other works which employ dispersion in professional opinions or forecasts include Diether et al. (2002), Epstein and Schneider (2008), Ilut and Schneider (2014), Kim (2016), and Kim et al. (2022a).

Using credit rating scores may raise concerns regarding the equivalence of alphanumeric ratings across time. The probability-based dispersion measure addresses this issue. As the three major credit rating agencies publish annual default studies around February to March, we match the historical survival probabilities corresponding to each rating, rolling the probability curves as of March in each year to avoid look-ahead bias.[14] For example, rating dispersion measures constructed in December 2013 use the 2012 survival probability curve, and measurements in March of 2014 use the (updated) 2013 curve. Both rating-based and probability-based dispersion is set to zero if there is only one rating agency assessing the bond's credit quality. In this case, the single rating dummy takes a value of 1.

Due to normalization, a riskier bond will have a higher measure of uncertainty if the raw probability dispersion is identical to that of a safer bond. While intuitively appealing in the sense that uncertainty regarding credit quality grows more important as that quality deteriorates, there may be concerns about intentionally inflating uncertainty in the lower quality bonds to show empirical results. The credit rating score-based measure penalizes the size of uncertainty in the other way (the denominator being larger in riskier bonds), and our results are robust to both ways of measuring uncertainty, showing that our findings do not depend on normalization of rating dispersion. Moreover, we include controls for ratings and show results by risk category, which further alleviates the concern regarding differing sizes

[14]We average the 3-year cumulative default rates from the 3 credit rating agencies in constructing the survival probability curve. Because we use historical rates, some ratings may have higher default rates than their adjacent inferior rating. In this case, we remove those observations and fit the curve with a piece-wise linear interpolation method.

of uncertainty for varying degrees of risk.

4.1.4 Other Characteristics

Recent works document "reaching for yield" behavior in corporate bond investors (e.g. Becker and Ivashina (2015), Choi and Kronlund (2017)). Thus, it is imperative that we include the variable and check our *Rating dispersion* effects are distinct from those caused by investors simply seeking bonds with higher yields within a risk category. We accordingly control for the yield spread, which is the corporate bond yield minus its maturity-matched treasury yield.[15] Basic bond controls include the size of the bond offering ($ln(Offering$ $amount)$) and the bond's duration ($Duration$).

We employ several bond-specific variables that may affect insurances' investment behavior, using secondary market transactions data from the Enhanced TRACE database provided by WRDS. First, to control for potential investment cyclicality in bonds (Timmer, 2018), we include monthly returns. Second, we use the bid-ask spreads to proxy for bond liquidity, and also include trading volume as the log of a bonds' total trading volume in the previous quarter scaled by its amount outstanding. Since the number of trades does not necessarily have a linear relation to trading volume, it enters our set of control variables as well. We compute bond volatility as the standard deviation of monthly bond returns over the past 36 months, requiring at least three return observations.

4.1.5 Descriptive Statistics

Descriptive statistics for the main variables used in this study are presented in Table 1. For the average bond in our sample, insurance companies own more than 35% of total amount

[15]Treasury yield data is from Liu and Wu (2021): https://sites.google.com/view/jingcynthiawu/yield-data?pli=1.

outstanding. The average size of uncertainty regarding credit ratings quality is 0.2 for the rating-based measure, and 0.009 for the probability-based. The standard deviations are 0.197 and 0.02, respectively. The mean credit rating score of our sample bonds is close to 9, which is in line with most insurance bond holdings being Investment Grade (a numerical score of 10 is the threshold). Multiple credit ratings is the norm, with only 1.2% of sample bonds having a single rating. The average score translates into a historical survival probability of 95.9%. The mean yield spread is 3%, and the average bond duration is 5.9 years. Our data covers the period from Q3 2002 to Q1 2015.

[Insert Table 1 About Here]

Table 2 further tabulates representative characteristics of the data by NAIC group, the indicator for regulatory risk classification. The numbers reported are medians, with standard deviations reported in parentheses below. Apart from obvious patterns regarding credit ratings/survival probability and yield spread, the majority of our sample bonds are in the NAIC1 or NAIC2 categories, or the market's definition of Investment Grade. To note, rating-based ambiguity does not show a monotonic pattern with NAIC group, but probability-based ambiguity increases as credit quality deteriorates. Bond returns in our sample period are highest for NAIC group 5 bonds, in line with risk compensation.

[Insert Table 2 About Here]

Pairwise correlations between the main variables of interest are presented in Table 3. Both rating- and probability-based dispersion are negatively and significantly correlated with insurers' holdings, supporting our conjecture that the overall effect of credit rating disagreement is to decrease the proportion of a bond held by insurance companies. Moreover, the degree of correlation between the two measures of dispersion is not very high, showing that it is a worthwhile exercise to check the results according to each measurement type. Consistent results with the two alternative measures of dispersion will add robustness to the study. Additionally, our dispersion measures are not highly correlated with yield spreads, lending support to our case that rating disagreement is not mechanically related to higher spreads.

[Insert Table 3 About Here]

4.2 Empirical Results

This section tests the theory by verifying whether disagreement in perceived credit quality, or credit rating dispersion, affects insurers' bond investment behavior and discusses the results.

4.2.1 Identification Strategy

We use the following specification to identify the rating dispersion channel:

$$\begin{aligned}\theta_{i,t} &= \beta_1 * RatingDispersion_{i,t-1} + \beta_2 * RatingDispersion_{i,t-1} * NAIC\_group_{i,t-1} \\ &+ \beta_3 * YieldSpread_{i,t-1} + Controls + FixedEffects + \epsilon_{i,t}, \end{aligned} \tag{12}$$

where $\theta_{i,t}$ is the fraction of a bond outstanding held by insurers at time t, and *Rating* $Dispersion_{i,t-1}$ denotes bond i's rating dispersion, gauged by either the credit rating-based or survival probability-based dispersion measure in the previous quarter. Recall that our rating dispersion measures are normalized by either the NAIC credit score or the corresponding average survival probability (i.e., credit risk). We lag dispersion and NAIC categories by one quarter, to prevent the results from being contaminated by the possibility of contemporaneous trading decisions affecting ratings and rating dispersion. As trades can be executed at any time during a given quarter t, the use of lagged dispersion measures also rules out the possibility of trades executed before the investor observes the magnitude of credit rating dispersion across the rating agencies. β_1 estimates the predictive power of rating dispersion on one-quarter ahead fraction of bonds held by insurers, and β_2 the differential effects of rating dispersion pertaining to distinct NAIC risk categories.

β_3 measures the effect of yield spreads over treasuries on insurers' bond holding decisions. Ceteris paribus, the natural assumption is that investors prefer bonds with higher yields. If rating dispersion simply translates into higher yields either due to investor's attention to the worst rating or as compensation for disagreement in credit assessments, the measure becomes redundant. It is extremely important that we check the validity of our measure against this case and separate the consequences of yield spread from those of rating dispersion. As shown in Table 3, the correlation between rating-based dispersion and yield spread is only 0.026 (0.484 for probability-based dispersion and yield spread), and we further check the disparate effects of the variables in a regression setup.

Controls include the bond bid-ask spread (i.e., bond liquidity) and monthly return, which are time-varying and can affect the investment decision of insurers. Trading volume and number of trades further control for liquidity effects, and volatility of returns account for any risk-return related preferences. Basic bond characteristics - offering size and duration - also enter the equation. We lag these variables also by one quarter, and winsorize all independent variables at the 1% and 99% levels. Ratings do not enter the set of controls because we include rating-by-quarter fixed effects in all our regressions. Standard errors are clustered by both issuer and quarter, ensuring robustness to heteroscedasticity and arbitrary serial and contemporaneous cross-sectional correlation in $\epsilon_{i,t}$.

For further identification, we employ several sets of high-dimensional fixed effects. The requisite rating-by-quarter fixed effects mentioned ensures that any qualitative differences across credit ratings or their time-varying characteristics do not drive the effect of dispersion. Then, we incrementally add bond fixed effects to efface the impact of observed and unobserved bond-level heterogeneities, and industry-by-quarter fixed effects to remove the influence of any industry characteristics or changes to them that may be correlated with rating dispersion. With the full set of fixed effects, we are able to observe how within-bond changes in credit-rating related uncertainty affect insurers' bond holdings, netting out any static and/or time-varying effects of credit ratings and industry features that may affect the degree of disagreement in credit quality assessments.

4.2.2 Rating Dispersion and Rating Changes

Our main goal is to understand how rating dispersion affects insurers' bond holdings. But first, we need to examine what rating dispersion means for credit ratings. Two questions follow: How does rating dispersion relate to future rating changes? And how does rating dispersion affect the perception of uncertainty for different types of bonds, especially with respect to credit risk? These questions are critical to our study because they can rule out an alternative explanation that rating inconsistencies signal upcoming rating downgrades and that insurers avoid some split-rated bonds not because of ambiguity aversion but because of changing risk profiles. They can also help us identify the situations in which uncertainty has different effects. Our theory suggests that perceived uncertainty is not the same for a bond with substantial credit risk and a safe bond, even if they have the same degree of rating dispersion and the same likelihood of upgrades and downgrades.

We test if rating dispersion is a predictor of credit rating changes in the following quarter in the whole sample, the subsample of safe bonds (NAIC group<3), and the subsample of risky bonds (NAIC group>3). We create two indicator variables, one capturing credit rating downgrades and the other upgrades, and present the model-free statistics in Table 4. Within each risk group (safe or risky), bonds are classified into three categories according to the size of rating disagreement: zero, low, and high, where the low and high subgroups are defined relative to the median rating dispersion of bonds with positive dispersion in each risk group. The mean probabilities of downgrades and upgrades for each subgroup are then examined separately. Panel A shows results with rating dispersion based on credit rating scores, and Panel B with measures based on survival probability.

Results show that for safe bonds with zero or low dispersion measures, the possibility of downgrades is very similar to that of upgrades. Even in bonds with high dispersion, the likelihoods of receiving positive versus negative shocks to credit risk are not too disparate. In fact, the differences are much larger in the subsample of risky bonds, where credit rating dispersion overwhelmingly predicts downgrades compared to upgrades. If insurers are concerned primarily with future rating changes, then they should avoid bonds with rating disagreement, especially in the risky group of bonds. If we are to observe "betting on bond ratings disagreement" for these risky bonds, it would strongly indicate that underlying our rating dispersion measures, uncertainty has impact on investors' investment decision in the corporate bond market over and above their predictive effect of possible upcoming rating changes.

[Insert Table 4 About Here]

To add robustness to the findings, we further present regression results to control for other bond characteristics that may contain information on a given bond's future rating changes, also including rating-by-quarter fixed effects. Panel A of Table A.1 shows results with rating dispersion based on credit rating scores, and Panel B with rating dispersion based on survival probability. From the full sample results (columns (1) and (2)), it is evident that the relation of rating dispersion to subsequent rating changes is not unilateral. Rating dispersion predicts *both* downgrades and upgrades positively and significantly, although the coefficient on rating dispersion for downgrades is about three to four times as large as that for upgrades.

For the subsample of 'safe' or Investment Grade bonds, split ratings still positively and significantly predict future rating changes in both directions. What is striking is that between the two dispersion measures, the prediction power of rating dispersion is not unambiguously stronger for downgrades than for upgrades (columns (3) and (4)). Panel A reports that the coefficient on rating-based dispersion for upgrades is half of the size of the counterpart for downgrades. In contrast, Panel B documents the opposite: the coefficient on probability-based dispersion for upgrades is two times as large as that for downgrades. Thus, the evidence opposes the alternative reasoning that investors avoid safe bonds with split ratings simply because it dominantly predicts imminent downgrades.

Deserving more attention are the results for the 'risky' bond subsample (i.e., bonds in NAIC groups 4 and 5). Columns (5) and (6) show that while both rating dispersion measures are positively and significantly related to future downgrades, rating dispersion either *negatively* predicts (rating-based measure) or has little prediction power (probability-based measure) on upgrades. This result has further implications when we test the relation between rating dispersion and quantity decisions in later regressions, especially regarding categorical extremes being the relevant margin for asymmetric effects of uncertainty.[16] The model is extended by adding bond fixed effects and industry-by-quarter fixed effects in Table

[16]For example, the average 3-year cumulative default rate for Caa grade bonds (NAIC group 5) during 1983 to 2014 reported by Moody's was 31.429%.

A.2, and the above cross-sectional relations between rating dispersion and future rating changes still hold in the within-issue regression analysis.

4.2.3 Rating Dispersion and Fraction of Bonds Held by Insurance Companies

We move on to present the relations between rating dispersion, both stand-alone and interacted with differing degrees of credit risk, and insurers' bond holdings in Table 5. Column (1) starts with a parsimonious specification that includes *Rating-based dispersion* and *Single rating dummy*. We also control for rating-by-quarter fixed effects, which preclude the possibility of regression results being contaminated by observed and unobserved heterogeneity across credit ratings in each quarter. The single rating dummy allows us to differentiate between cases when dispersion is zero because multiple ratings concur, or simply because there is only one opinion. When it equals 1, rating dispersion is zero by construction, but the opposite does not hold.

The effect of *Rating-based dispersion* on one-quarter-ahead fraction of insurers' bond holdings is negative, suggesting that insurance companies generally shy away from bonds with ratings disagreement. The results tie well with Claim 4, which posits that the average effect of ambiguity on bond holdings should be negative, unless good news is dominant. Insurers are also likely to decrease holdings of bonds with only one rating, because the number of ratings is related to bond credit quality. In regard to the possibility that split ratings signal an imminent rating downgrade and therefore investors reduce their holdings, we have already shown in Table A.1 that rating dispersion predicts downgrades and upgrades to almost equal degrees. Moreover, Livingston et al. (2008) find that rating splits are quite persistent, with 70% of rating splits being maintained 4 years after bond issuance. If insurers are purely betting on future rating changes, the average effect of rating dispersion on their next-quarter bond holdings should be statistically indiscernible from zero. The negative coefficient of rating dispersion on insurers' holdings provides empirical support for our theory that such disagreement can proxy for credit information ambiguity, and investors are averse to it.

Column (2) expands the regression setup to include various control variables, to segregate the effect of rating dispersion from other sources of risk. The yield spread, which is the difference between the corporate bond's traded yield and its maturity-matched treasury yield, enters the regression to check for the effects of differing yields within a rating group on bond holdings. If split ratings simply result in investors' credit assessments being tilted toward the inferior rating(s), this should manifest itself in higher yields, which will subsume the effect of rating dispersion. In addition, if insurers are involved in risk-seeking activity within the regulatory requirements set by the NAIC, they should lean toward the higher yielding bonds, conditional on risk indicators. This is the "reaching for yield" behavior documented in insurance companies by Becker and Ivashina (2015), which should be diametric to the effects of ambiguity aversion on bond holdings.[17] Column (3) incrementally adds the interaction term between yield spread and duration. The yield spread has the expected positive effect on insurance bond holdings, and the economic and statistical significance of our rating dispersion measure is robust to the addition of the strong proxy for risk and profit. Attention is drawn to the *opposite* signs of the coefficients on rating dispersion and yield spread in column (3), showing that they are distinct factors in insurers' portfolio decisions.

Larger issuances result in smaller proportions held by insurance companies, who lean toward bonds with longer duration.[18] Bond return accounts for momentum-trading behavior,

[17]The reaching for yield behavior has been observed in mutual funds as well (Choi and Kronlund (2017)), but mutual funds are not subject to NAIC regulations.

[18]We interpret the negative sign on the interaction of yield spread and duration as insurers being willing to accept lower yields for investments with longer duration. Also, the effect of yield spread becomes negative

and our results echo extant findings that insurances act counter-cyclically to past return (e.g. Timmer (2018)). The effects of liquidity are included with the bid-ask spread, trading volume, and number of trades. The negative coefficients of the liquidity variables show that insurance companies are generally tolerant toward illiquidity. The positive relation of bond return volatility to holdings may be additional evidence of risk-seeking behavior within regulatory risk categories.

In the data section, we described the importance of NAIC group classifications in calculating an insurer's risk-based capital (RBC) requirement. Simply put, the riskier the bond (higher NAIC group number), the more burdensome it becomes in the RBC calculation, making the bond costlier for an insurer to hold. To check for effects of the explicit regulatory costs, we include the interaction between the NAIC group number and rating dispersion in columns (4) to (6) of Table 5. The NAIC group itself does not need to be included because we already control for rating-by-quarter fixed effects. The economic magnitude and statistical significance of coefficients for other control variables remain qualitatively similar, with or without NAIC group interactions.

The coefficients of the interaction term of rating dispersion with NAIC group have interesting implications. *Rating-based dispersion* retains its stand-alone negative significance, but the interaction of dispersion and NAIC group loads significantly positive. suggesting that the effect of dispersion differs significantly across the NAIC groups. Taking figures from the full specification of column (6), a one standard deviation change in rating dispersion in a bond belonging to NAIC group 1 category *decreases* the fraction of insurers' holdings by 2.2% ((-0.160 + 0.049×1)×0.197) on average. However, for a bond in NAIC group 5, an equivalent change in rating dispersion leads to an *increase* in insurer's bond holdings

without this interaction term.

by 1.7% ((-0.160 + 0.049×5)×0.197) in the following quarter. That is, there is an asymmetric reaction to rating dispersion across different bond risk categories - in safe bonds, insurers move away from disagreements in credit quality assessments, but in risky bonds the opposite is true. This is in line with our conjecture that any uncertainty ensuing from rating dispersion is asymmetric. For safe bonds, the subjective assessment of upside potential from disagreement in credit information is limited, and downside events are considered much more likely. Conversely, downside potential is limited for the most risky bonds, and any uncertainty favors upside possibilities. The average effect of rating dispersion on bond holdings is negative because the majority of bonds held by insurers are investment grade bonds. Including the interaction term with risk amplifies the negative effect of standalone rating dispersion on bond holdings, more clearly identifying the impact of credit information ambiguity in insurers' decisions.

[Insert Table 5 About Here]

The next set of tests addresses the integrity of credit rating agencies and the equivalence of ratings through time.[19] To do this, we re-construct rating dispersion from historical survival probabilities. The probability curves are updated each year from annual default studies from the three major agencies, and thus we control for the possibility of credit ratings quality varying through time and the non-linearity in default probabilities represented by alphanumeric ratings. Table 6 shows that the results discussed in Table 5 hold, regardless of whether rating dispersion is measured from credit rating scores or survival probabilities.

[19]Credit rating agencies have been associated with financial crises, for not providing credit rating information in a timely manner (e.g. White (2010)). There are also empirical works that support the view that credit rating agencies inflate their assessments of credit quality (e.g. Jiang et al. (2012); Cornaggia and Cornaggia (2013)).

The magnitude of coefficients differ because the mean of probability-based dispersion is only about 5 percent of rating-based dispersion. Again, for safe bonds, the effect of increases in credit rating dispersion on insurers' holdings is negative, but for risky bonds it is positive.

[Insert Table 6 About Here]

4.2.4 Bond Fixed Effects

We test our setup more stringently in Table 7, by adding bond fixed effects. This controls for observed and unobserved time-invariant bond characteristics that may be correlated with both ratings dispersion and investment decision by insurance funds. In this setting, the identification relies on the within-issue changes of rating dispersion, which is caused by the varying magnitudes of rating changes across rating agencies. Provided that rating changes are mainly determined by the arrival of shocks about default probability,[20] the specification with bond fixed effects is better aligning than the above cross-sectional model with our theoretical setup in Section 3 about credit information ambiguity: the two rating agencies receive default probability shock of a given bond with different levels of noise.

Columns (1), (2), (4) and (5) are replications of Table 6 with bond fixed effects added, and columns (3) and (6) further include industry-by-quarter fixed effects to remove the effects of any industry characteristics correlated with rating dispersion. The coefficient estimates for rating dispersion with bond fixed effects are around a quarter the size of those without (half in the case of probability-based dispersion), but the statistical significance remains strong. The same holds for the interaction term of dispersion and NAIC group, showing that our

[20]The alternative source of rating changes could be the change in credit risk modelling by rating agencies. To the extent that such modifications are done at each rating or industry level, the rating-by-quarter and industry-by-quarter fixed effects could at least account for the average impact of these changes across rating agencies.

results are not caused by heterogeneity in rating dispersion across different issues. The effect of yield spread, on the other hand, becomes much weaker both economically and statistically with the inclusion of bond fixed effects.

[Insert Table 7 About Here]

4.2.5 Asymmetric Reaction to Rating Dispersion by Risk Category

We have already highlighted the differences in attitudes of insurers toward rating dispersion for different NAIC risk categories with the interaction of rating dispersion and NAIC group. Using the interaction term, however, does not allow for a clear picture on the contrasting investment effect of rating dispersion when rating moves from one bounded extreme to the other end. It could be that issues with rating in particular groups (e.g., NAIC2 vs. NAIC3) are the only ones to experience the effects of rating dispersion. Thus we analyze results of the regressions with the stringent set of fixed effects estimated as in the previous section, but with a specification that allows the coefficient on rating dispersion to change across NAIC groups. I do this by interacting the rating dispersion with each NAIC group dummy. $Rating\ dispersion\ NAICn$ equals the rating dispersion for a bond belonging to NAIC group n, and zero for those belonging to all other risk categories. For example, a bond in NAIC group 1 will have $Rating\ dispersion\ NAIC1$ equal its rating dispersion, and $Rating\ dispersion\ NAIC2{\sim}5$ of zero. Note that instead of producing coefficients that measure differences between the slopes, this specification estimates the slopes themselves. Thus, the analysis illustrates clearly the asymmetry in quantity decisions made by insurers with regard to rating dispersion for differing risk categories.

Table 8 reports the results. For the safest bonds belonging in NAIC groups 1 and 2 (which coincide with the Investment Grade definition), rating dispersion is negatively related to future bond holdings. However, in NAIC group 3, the effect of rating dispersion is unclear, and in the riskiest bonds (NAIC groups 4 and 5), the relation becomes *positive*. In particular, the positive effect of rating dispersion on bond holdings is strongest for NAIC group 5 bonds, the riskiest in our sample. The results are consistent with Claim 5, which states that insurers will decrease holdings of safe bonds with credit rating ambiguity, but increase investment of risky bonds with rating disagreement. Again, we stress the bounded nature of uncertainty at each extreme as the source of this phenomenon. In the middle ratings, both up- and down-sides are open, and ratings dispersion in this region can result in inaction. For the safest bonds, the positive area of the probability distribution is truncated, leaving the negative area only. For the riskiest bonds it is vice-versa, and investors may prefer the distribution with larger positive potential despite ambiguity aversion. The empirical results presented support this conjecture, that insurers 'bet on bond ratings disagreement' in bonds with high risk.

[Insert Table 8 About Here]

4.2.6 Capital Surplus and Leverage

We explore whether capital surplus related and leverage-related pressures faced by insurance funds have implications with regard to their investment behavior in bonds with rating dispersion. Maintaining regulatory capital requirements is of utmost importance to insurance companies. Thus, capital-constrained insurance funds may become conservative in their investment decisions, reducing their holdings of bonds with high rating dispersion. For a safe (risky) bond, we would expect the negative (positive) relation between rating dispersion and bond holding is stronger (weaker) when the bond is held more by capital-constrained funds.

For risky bonds, however, these funds may increase their holding to gamble for resurrection. Regarding the leverage-related pressure, on the one hand, high leverage may result in asset substitution by funds, increasing their investment in risky bonds with high rating dispersion. On the other hand, funds with high leverage are likely to be closely monitored by their creditors, leading to their reduced holdings of bonds with high rating dispersion. That is, the negative (positive) relation between rating dispersion and bond holding is stronger (weaker) when the bond is held more by high leverage funds.

Information on regulatory capital surplus and leverage for insurance companies is extracted from S&P's Capital IQ. The former measures the difference between required capital and reported capital, normalized by book value of assets; the latter is defined as the ratio of assets to equity. First, at the beginning of each quarter, we sort the sample by capital surplus and classify funds in the bottom 33% as low capital surplus funds. We also sort the sample each quarter by leverage, and classify funds in the top 33% as high leverage funds. Next, we calculate the amount of each bond held by the low capital surplus funds as a proportion of the total insurance holdings of the bond. If the proportion is above the median of each NAIC group in a given quarter, we consider this bond to have high exposure to capital surplus related pressure, and low exposure otherwise. Third, within the subsamples of bonds with high and low exposure to capital surplus related pressure, respectively, we compute the amount of each bond held by high leverage funds as a proportion to the total insurance holdings of the bond. If the proportion is above the median of each NAIC group in a given quarter, the bond is considered to have high exposure to leverage related pressure, and low exposure otherwise. We run Eqn. (12) for each subsample, controlling for bond, rating-by-quarter, and industry-by-quarter fixed effects. The results are reported in Table

9, using rating-based dispersion in Panel A and probability-based dispersion in Panel B.[21]

The results show that for safe bonds, the negative relation between rating dispersion and insurance funds' holding varies little across the four subsamples. This suggests that ambiguity aversion effect is little affected by bonds' different exposures to capital surplus pressure and leverage pressure. For risky bonds, reaching for ratings disagreement is only statistically significant and economically large for the ones with high exposure to low capital surplus pressure, but low exposure to high leverage pressure. It is consistent with the view that funds with little to draw upon bet on ratings disagreement, but leverage-related pressure works as a constraint and limits such betting behavior.

[Insert Table 9 About Here]

5 Conclusion

Proxying for the size of ambiguity by the degree of rating dispersion from the multiple credit rating companies, we find 'betting on bond ratings disagreement' in risky bonds by insurance funds. On average, the average effect of rating disagreement is to reduce the holdings of bonds with greater degree of rating dispersion, in line with the ambiguity aversion literature. However, insurers reduce their holdings of safe bonds with increases in dispersion, but the opposite is true for risky bonds despite higher probability of posterior downgrades.

We explain the 'betting on dispersion' behavior with bond survival probability assessments being bounded. At the lower and upper ends of the probability boundary, uncertainty can only point in opposite directions. Categorical risk classifications (NAIC groups) can act

[21] Results on single-sorting by capital surplus or leverage are presented in Tables A.4 and A.5 of the Online Appendix. Insurance companies seem to differ in their bond holding decisions regarding rating dispersion according to their level of capital surplus (only for risky bonds), but not according to leverage.

as defining regions for this asymmetry as well. In safe bonds, rating dispersion portends unfavorable developments, and investors adjust their bond holdings away from such uncertainty. However, in bonds with very low credit quality, such disagreement suggests upside potential with limited downside, and insurance companies tilt their investments toward bonds with rating dispersion. With ambiguity aversion, the average effect of credit rating dispersion on holdings of the affected bonds should be negative, and the absolute size of adjustment in risky bonds will be smaller than that in safe bonds.

This novel finding of asymmetric reaction to credit rating disagreement depending on the level of risk is robust to the inclusion of bond fixed effects, and both time-invariant and variant credit rating and industry characteristics. Whereas the preference for bonds with higher yields within a rating category is attributed to imperfect risk classification and regulatory arbitrage, the empirical results suggest that betting on ratings disagreement stems from uncertainty regarding credit quality assessments and the nature of probability distributions that are truncated at the extremes.

Appendix A: Variable Definitions

Variable	Definition (Source)
Insurers' holdings	Total holdings of a bond by insurance company funds scaled by amount outstanding (eMAXX and FISD). Quarterly.
Rating-based dispersion	Bond ratings dispersion based on credit rating scores, defined as *std_score* scaled by $\sqrt{NAIC\_score}$. $NAIC\_score$ is the numeric credit rating of a bond following NAIC rules: if the bond is rated by two rating agencies, use the lowest rating; if the bond is rated by all three rating agencies, use the middle rating. Credit rating scores range from 1 (AAA) to 19(CCC-) in our sample. *std_score* is the standard deviation of rating scores for a bond and is set to zero if there is only one rating (FISD).
Probability-based dispersion	Bond ratings dispersion based on historical survival probabilities, defined as *std_sp* scaled by $\sqrt{NAIC\_sp}$. $NAIC\_sp$ is the historical survival probability for a bond corresponding to $NAIC\_score$, and the survival probability curves are updated as of March each year. *std_sp* is the standard deviation of survival probabilities and is set to zero if there is only one rating (Annual default studies are from S&P, Moody's and Fitch).
NAIC_group	A bond's NAIC risk category based on NAIC_score: 1 for bonds with scores from 1 to 7, 2 for bonds with scores from 8 to 10, 3 for bonds with scores from 11 to 13, 4 for bonds with scores from 14 to 16, 5 for bonds with scores from 17 to 19.
Single rating dummy	1 if an issue is only covered by one rating agency, zero otherwise.
Offering amount	The par value of debt initially issued (FISD).
Duration	Bond duration (FISD).
Bid-ask spread	Average trade-weighted bid-ask spread in the month prior to the quarter (TRACE).
Bond return	Monthly bond return prior to the quarter, calculated as $\frac{(P_t+AI_t)+C_t-(P_{t-1}+AI_{t-1})}{(P_{t-1}+AI_{t-1})}$ (TRACE).
Bond volatility	SD of monthly bond return over the past 36 months. Three nonmissing monthly returns are required (TRACE).
Yield spread	A bond's yield minus duration-matched treasury yield (TRACE).
Trading volume	$\frac{bond\_volume}{amount\_outstanding}$, where *bond_volume* is total bond trading volume in the previous quarter (TRACE).
Number of trades	The number of investors reporting a changed position in a quarter (eMAXX)

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Figure 1: **Asymmetric Uncertainty Associated With Rating Dispersion**

This figure shows the asymmetric nature of uncertainty associated with rating dispersion. Survival probability (1 - default probability) is denoted by ϕ_i for bond i, which is bounded between 0 and 1. For very safe bonds, uncertainty associated with rating dispersion is likely to be more negative, making investors avoid it. Conversely, for very risky bonds, uncertainty associated with rating dispersion is likely to be more positive, causing investors to lean toward such uncertainty. In the middle region, uncertainty does not point in a certain way, and may lead to inaction on the part of investors.

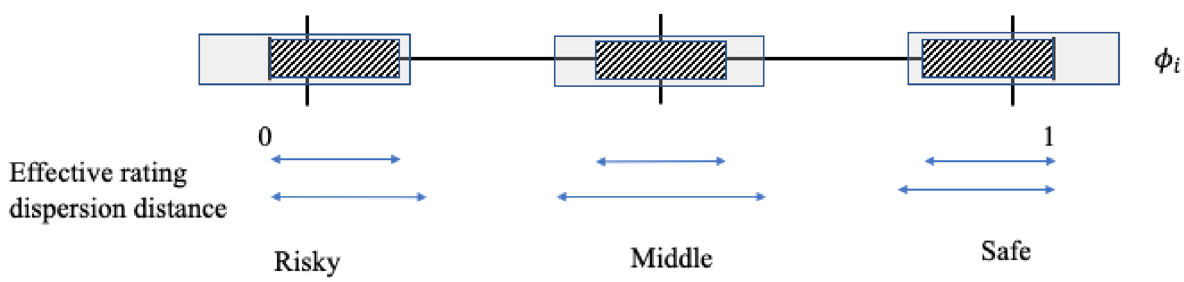

Table 1: **Descriptive statistics**

This table reports descriptive statistics of main variables used in this study. $Number\ of\ bonds$ refers to the unique number of issues per quarter. $Insurers'\ holdings$, the dependent variable of this study, are the fraction of each bond held by insurers scaled by its total amount outstanding as of each quarter. $Rating-based\ dispersion$ is the standard deviation in credit ratings scores of a bond, scaled by the square root of its NAIC score. $Probability-based\ dispersion$ is measured in the same way as its rating-based counterpart, with historical survival probabilities matched to the relevant credit rating scores. Other variable definitions are as in Appendix A. The sample period is from Q3 of 2002 to Q1 of 2015.

	Mean	P25	Median	P75	Std.Dev.	N
Number of bonds	4,526	4,137	4,405	4,876	519	223,526
Insurers' holdings	0.356	0.145	0.330	0.538	0.240	223,526
Rating-based dispersion	0.200	0.000	0.192	0.277	0.197	223,526
Probability-based dispersion	0.009	0.000	0.001	0.008	0.020	223,526
Credit rating	8.896	6	8	10	3.739	223,526
Survival probability	0.959	0.969	0.990	0.996	0.070	223,526
Single rating dummy	0.012	0	0	0	0.110	223,526
Offering amount ($ Mil)	503	210	337	600	522	223,526
Yield spread	0.029	0.011	0.019	0.035	0.032	223,526
Duration	5.911	3.134	4.966	7.581	3.706	223,526
Bond return	0.004	-0.007	0.003	0.015	0.031	223,526
Bid-ask spread	0.007	0.002	0.005	0.010	0.008	223,526
Bond volatility	0.032	0.016	0.025	0.038	0.028	223,526
ln(Trading volume)	4.581	3.871	4.830	5.558	1.484	223,526
ln(Number of trades)	2.227	1.386	2.303	3.135	1.203	223,526

Table 2: **Descriptive statistics by NAIC Group**

This table reports descriptive statistics of main variables used in this study by NAIC group. NAIC group 1 is the group of safest bonds, and group 5 the riskiest in our sample. Variable definitions are as in Table 1. The numbers reported are medians, with standard deviations below in parentheses. The sample period is from Q3 of 2002 to Q1 of 2015.

	NAIC 1	NAIC 2	NAIC 3	NAIC 4	NAIC 5
Number of bonds	1,779	1,638	444	482	190
	(169)	(374)	(39)	(71)	(37)
Insurers' holdings	0.402	0.453	0.213	0.106	0.062
	(0.225)	(0.218)	(0.164)	(0.109)	(0.095)
Rating-based dispersion	0.238	0.156	0.208	0.200	0.212
	(0.223)	(0.163)	(0.172)	(0.187)	(0.207)
Probability-based dispersion	0.001	0.004	0.015	0.030	0.057
	(0.002)	(0.005)	(0.014)	(0.029)	(0.045)
Credit rating	5	9	12	15	17
	(1.491)	(0.768)	(0.820)	(0.816)	(0.654)
Survival probability	0.997	0.985	0.940	0.851	0.712
	(0.002)	(0.007)	(0.018)	(0.039)	(0.043)
Single rating dummy	0	0	0	0	0
	(0.082)	(0.100)	(0.123)	(0.173)	(0.168)
Yield spread	0.015	0.023	0.043	0.060	0.100
	(0.014)	(0.019)	(0.028)	(0.038)	(0.060)
Offering amount ($ Mil)	612	450	430	392	402
	(644)	(427)	(380)	(385)	(401)
Duration	6.400	6.193	5.087	4.671	4.052
	(4.289)	(3.689)	(2.497)	(1.891)	(1.779)
Bond return	0.004	0.004	0.005	0.006	0.009
	(0.027)	(0.029)	(0.033)	(0.036)	(0.055)
Bid-ask spread	0.007	0.007	0.008	0.007	0.009
	(0.008)	(0.008)	(0.008)	(0.007)	(0.010)
Bond volatility	0.026	0.031	0.038	0.041	0.071
	(0.019)	(0.022)	(0.030)	(0.036)	(0.052)
ln(Trading volume)	4.316	4.414	5.104	5.252	5.540
	(1.465)	(1.541)	(1.269)	(1.121)	(1.185)
ln(Number of trades)	2.046	2.128	2.554	2.791	2.560
	(1.192)	(1.166)	(1.253)	(1.076)	(1.170)

Table 3: **Correlation Table**

This table reports pairwise correlations of main variables used in this study. *Insurers′ holdings*, the dependent variable of this study, are the fraction of each bond held by insurers scaled by its total amount outstanding as of each quarter. *Rating − based dispersion* is the standard deviation in credit ratings scores of a bond, scaled by the square root of its NAIC score. *Probability − based dispersion* is measured in the same way as its rating-based counterpart, with historical survival probabilities matched to the relevant credit rating scores. Other variable definitions are as in Appendix A. The sample period is from Q3 of 2002 to Q1 of 2015.

	Pairwise Correlations						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Insurers' holdings	1.000						
(2) Rating-based dispersion	-0.091***	1.000					
(3) Probability-based dispersion	-0.338***	0.338***	1.000				
(4) Credit rating	-0.391***	-0.080***	0.619***	1.000			
(5) Survival probability	0.468***	0.005*	-0.707***	-0.854***	1.000		
(6) Yield spread	-0.334***	0.026***	0.484***	0.611***	-0.641***	1.000	
(7) Duration	0.275***	-0.012***	-0.126***	-0.166***	0.178***	-0.120***	1.000

Table 4: **Rating Dispersion and Rating Changes**

This table reports the mean likelihood of one-quarter ahead rating changes in bond subsamples with different magnitudes of credit rating dispersion. $Rating - based\ dispersion$ is the standard deviation of credit rating scores for a bond issue scaled by the square root of its NAIC score, and $Probability - based\ dispersion$ is the standard deviation of historical survival-probabilities matched to alphanumeric ratings scaled by the square root of the NAIC score equivalent survival probability. Historical survival probability curves are rolled each year wthout look-ahead bias. Rating dispersion is measured at the end of the prior quarter, and rating changes happen in the current quarter. Zero dispersion bonds are those for which all available ratings concur, and bonds with discordant ratings are placed into low and high groups by the relevant group's median credit rating dispersion. The sample period is from Q3 of 2002 to Q1 of 2015.

Panel A: Rating-based dispersion	Downgrade	Upgrade
NAIC group $<$ 3 (Safe)		
Zero dispersion	0.009	0.011
Low dispersion	0.038	0.035
High dispersion	0.051	0.032
NAIC group $>$ 3 (Risky)		
Zero dispersion	0.032	0.052
Low dispersion	0.081	0.037
High dispersion	0.138	0.051

Panel B: Probability-based dispersion	Downgrade	Upgrade
NAIC group $<$ 3 (Safe)		
Zero dispersion	0.009	0.011
Low dispersion	0.040	0.030
High dispersion	0.049	0.038
NAIC group $>$ 3 (Risky)		
Zero dispersion	0.032	0.052
Low dispersion	0.079	0.046
High dispersion	0.134	0.041

Table 5: **Rating Dispersion and Insurers' Holdings - With and Without NAIC Group**

This table reports estimates of panel regression results of the fraction of corporate bonds held by insurance companies on measures of rating dispersion and various control variables, with rating-by-quarter fixed effects. $Rating - based\ dispersion$ is the standard deviation of credit rating scores for a bond issue scaled by the square root of its NAIC score, and $NAIC\_group$ is the credit rating category defined by NAIC. Other variable definitions are as in Appendix A. Rating dispersion and other control variables are measured in the prior quarter. Rating-by-quarter fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

Dependent Variable:	Without NAIC group			With NAIC group		
Insurer's Holdings	(1)	(2)	(3)	(4)	(5)	(6)
Rating-based dispersion	-0.071***	-0.070***	-0.066***	-0.176***	-0.164***	-0.160***
	(0.019)	(0.015)	(0.014)	(0.034)	(0.026)	(0.025)
Dispersion × NAIC_group				0.055***	0.049***	0.049***
				(0.010)	(0.008)	(0.008)
Single rating dummy	-0.016	-0.040**	-0.038**	-0.007	-0.033*	-0.030*
	(0.015)	(0.017)	(0.017)	(0.015)	(0.017)	(0.017)
Yield spread		-0.608***	0.422***		-0.567***	0.462***
		(0.120)	(0.133)		(0.113)	(0.141)
Yield spread × Duration			-0.390***			-0.390***
			(0.048)			(0.049)
ln(Offering amount)		-0.040***	-0.040***		-0.040***	-0.040***
		(0.006)	(0.006)		(0.006)	(0.006)
Duration		0.011***	0.019***		0.011***	0.019***
		(0.001)	(0.001)		(0.001)	(0.001)
Bond return		-0.032	-0.101**		-0.024	-0.093**
		(0.047)	(0.042)		(0.047)	(0.042)
Bid-ask spread		-1.633***	-1.320***		-1.672***	-1.360***
		(0.261)	(0.243)		(0.259)	(0.241)
ln(Trading volume)		-0.038***	-0.038***		-0.038***	-0.039***
		(0.003)	(0.003)		(0.003)	(0.003)
ln(Number of trades)		-0.005	-0.007**		-0.004	-0.006*
		(0.003)	(0.003)		(0.003)	(0.003)
Bond volatility		0.068	0.208*		0.033	0.174
		(0.125)	(0.124)		(0.122)	(0.121)
Rating-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	223,526	223,526	223,526	223,526	223,526	223,526
Adj. R^2	0.354	0.489	0.498	0.356	0.491	0.500

Table 6: **Rating Dispersion and Insurers' Holdings - Rating- and Probability-Based Dispersion Measures**

This table reports estimates of panel regression results of the fraction of corporate bonds held by insurance companies on measures of rating dispersion and various control variables, with rating-by-quarter fixed effects. *Rating dispersion* is the standard deviation of credit rating scores for a bond issue scaled by the square root of its NAIC score, or its equivalent measured with historical survival probabilities. $NAIC\_group$ is the credit rating category defined by NAIC. Other variable definitions are as in Appendix A. Rating dispersion and other control variables are measured in the prior quarter. Rating-by-quarter fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

Dependent Variable:	Rating-based		Probability-based	
Insurers' Holdings	(1)	(2)	(3)	(4)
Rating dispersion	-0.176***	-0.164***	-3.436***	-3.055***
	(0.034)	(0.026)	(0.682)	(0.556)
Dispersion × NAIC_group	0.055***	0.049***	0.817***	0.742***
	(0.010)	(0.008)	(0.150)	(0.122)
Single rating dummy	-0.007	-0.033*	-0.004	-0.028
	(0.015)	(0.017)	(0.015)	(0.017)
Yield spread		-0.564***		-0.572***
		(0.113)		(0.115)
ln(Offering amount)		-0.040***		-0.040***
		(0.006)		(0.006)
Duration		0.011***		0.012***
		(0.001)		(0.001)
Bond return		-0.023		-0.027
		(0.047)		(0.048)
Bid-ask spread		-1.675***		-1.719***
		(0.260)		(0.264)
ln(Trading volume)		-0.039***		-0.038***
		(0.003)		(0.003)
ln(Number of trades)		-0.004		-0.004
		(0.003)		(0.003)
Bond volatility		0.034		0.043
		(0.122)		(0.125)
Rating-Quarter FE	Yes	Yes	Yes	Yes
Observations	223,526	223,526	223,526	223,526
Adj. R^2	0.356	0.491	0.352	0.487

Table 7: **Within-Issue Relation Between Rating Dispersion and Insurers' Holdings**

This table reports estimates of panel regression results of the fraction of corporate bonds held by insurance companies on measures of rating dispersion and various control variables, with bond fixed effects. *Rating dispersion* is the standard deviation of credit rating scores for a bond issue scaled by the square root of its NAIC score, or its equivalent measured with historical survival probabilities. $NAIC\_group$ is the credit rating category defined by NAIC. Other variable definitions are as in Appendix A. Rating dispersion and other control variables are measured in the prior quarter. Various fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

Dependent Variable:	Rating-based			Probability-based		
Insurers' Holdings	(1)	(2)	(3)	(4)	(5)	(6)
Rating dispersion	-0.040***	-0.035***	-0.035***	-1.665***	-1.505***	-1.321***
	(0.010)	(0.010)	(0.009)	(0.286)	(0.278)	(0.234)
Dispersion × NAIC_group	0.015***	0.014***	0.013***	0.384***	0.354***	0.310***
	(0.004)	(0.004)	(0.003)	(0.063)	(0.061)	(0.051)
Single rating dummy	-0.006	-0.007	-0.006	-0.008	-0.008	-0.007
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Yield spread		0.092**	0.061		0.106**	0.074*
		(0.042)	(0.043)		(0.041)	(0.043)
Duration		0.017***	0.016***		0.017***	0.016***
		(0.001)	(0.001)		(0.001)	(0.001)
Bond return		-0.011	-0.008		-0.010	-0.007
		(0.010)	(0.009)		(0.010)	(0.009)
Bid-ask spread		-0.047	-0.073*		-0.047	-0.073*
		(0.047)	(0.042)		(0.047)	(0.042)
ln(Trading volume)		-0.005***	-0.004***		-0.005***	-0.004***
		(0.000)	(0.000)		(0.000)	(0.000)
ln(Number of trades)		-0.001	-0.001		-0.001	-0.001
		(0.001)	(0.001)		(0.001)	(0.001)
Bond volatility		0.013	0.030		0.022	0.038
		(0.044)	(0.040)		(0.045)	(0.040)
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Rating-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Quarter FE			Yes			Yes
Observations	222,817	222,817	222,800	222,817	222,817	222,800
Adj. R^2	0.916	0.919	0.923	0.917	0.919	0.923

Table 8: **Block-Diagonal Specification**

This table reports estimates of panel regression results of the fraction of corporate bonds held by insurance companies on measures of rating dispersion and various control variables, with a block-diagonal specification. *Rating dispersion NAIC N* equals a bond's *Rating dispersion* if the bond belongs to *NAIC_group N* and zero otherwise, where $N = 1$ (safest),...,5 (most risky). Other variable definitions are as in Appendix A. Rating dispersion and other control variables are measured in the prior quarter. Various fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

Dependent Variable:	Rating-based		Probability-based	
Insurers' Holdings	(1)	(2)	(3)	(4)
Rating dispersion NAIC1	-0.018**	-0.018**	-1.634***	-1.070***
	(0.007)	(0.007)	(0.433)	(0.337)
Rating dispersion NAIC2	-0.011	-0.017	-1.480***	-1.386***
	(0.013)	(0.011)	(0.305)	(0.268)
Rating dispersion NAIC3	0.002	-0.001	-0.274	-0.267
	(0.017)	(0.015)	(0.173)	(0.160)
Rating dispersion NAIC4	0.028**	0.028**	0.120	0.115*
	(0.013)	(0.011)	(0.073)	(0.065)
Rating dispersion NAIC5	0.038**	0.028**	0.136**	0.110**
	(0.014)	(0.013)	(0.053)	(0.049)
Single rating dummy	-0.006	-0.006	-0.008	-0.006
	(0.010)	(0.010)	(0.010)	(0.010)
Yield spread	0.091**	0.060	0.106**	0.071
	(0.042)	(0.043)	(0.041)	(0.043)
Duration	0.017***	0.016***	0.017***	0.016***
	(0.001)	(0.001)	(0.001)	(0.001)
Bond return	-0.011	-0.008	-0.010	-0.007
	(0.010)	(0.009)	(0.010)	(0.009)
Bid-ask spread	-0.046	-0.073*	-0.046	-0.073*
	(0.047)	(0.042)	(0.047)	(0.041)
ln(Trading volume)	-0.005***	-0.004***	-0.005***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
ln(Number of trades)	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Bond volatility	0.014	0.031	0.022	0.038
	(0.045)	(0.040)	(0.045)	(0.040)
Bond FE	Yes	Yes	Yes	Yes
Rating-Quarter FE	Yes	Yes	Yes	Yes
Industry-Quarter FE		Yes		Yes
Observations	222,817	222,800	222,817	222,800
Adj. R^2	0.919	0.923	0.919	0.923

Table 9: **Capital Surplus and Leverage Exposure**

This table reports estimates of panel regression results of the fraction of corporate bonds held by insurance companies on measures of rating dispersion and various control variables, double sorted by exposures to low capital surplus funds and high leverage funds. Low surplus funds are defined as those in the bottom 33% of the total sample sorted by capital surplus. High leverage funds are defined as those in the top 66% of the total sample sorted by leverage. *High Exposure* are bonds with above-median holdings by each type of funds by NAIC group and quarter, therefore with higher related pressure; *Low Exposure* is the subsample of bonds with below-median holdings. *Rating dispersion NAIC N* equals a bond's *Rating dispersion* if the bond belongs to *NAIC_group N* and zero otherwise, where $N = 1$ (safest),...,5 (most risky). Other variable definitions are as in Appendix A. Rating dispersion and other control variables are measured in the prior quarter. Various fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

Panel A: Rating-based dispersion

Exposure to Capital Surplus Pressure	Low		High	
	(1)	(2)	(3)	(4)
Exposure to Leverage Pressure	Low	High	Low	High
Rating dispersion NAIC1 & 2	-0.022***	-0.017**	-0.018**	-0.014
	(0.006)	(0.006)	(0.007)	(0.009)
Rating dispersion NAIC3	0.006	0.027*	0.010	-0.031
	(0.013)	(0.015)	(0.020)	(0.024)
Rating dispersion NAIC4 & 5	-0.001	0.018	0.034***	-0.009
	(0.012)	(0.013)	(0.012)	(0.014)
Controls	Yes	Yes	Yes	Yes
Bond, Rating-Quarter, Industry-Quarter FE	Yes	Yes	Yes	Yes
Observations	54,796	53,713	54,132	54,477
Adj. R^2	0.936	0.931	0.931	0.923

Panel B: Probability-based dispersion

Exposure to Capital Surplus Pressure	Low		High	
	(5)	(6)	(7)	(8)
Exposure to Leverage Pressure	Low	High	Low	High
Rating dispersion NAIC1 & 2	-0.772***	-1.083***	-1.331***	-1.233***
	(0.236)	(0.320)	(0.298)	(0.377)
Rating dispersion NAIC3	-0.088	0.098	-0.202	-0.590***
	(0.153)	(0.197)	(0.215)	(0.196)
Rating dispersion NAIC4 & 5	-0.031	0.078	0.123**	-0.069
	(0.047)	(0.072)	(0.057)	(0.053)
Controls	Yes	Yes	Yes	Yes
Bond, Rating-Quarter, Industry-Quarter FE	Yes	Yes	Yes	Yes
Observations	54,796	53,713	54,132	54,477
Adj. R^2	0.936	0.931	0.931	0.924

Internet Appendix to
"Betting on Bond Ratings Disagreement"

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A.1 Rating Dispersion and Yield Spreads With NAIC Group

We further analyze the differential effects of rating dispersion and yield spreads on insurer's bond holdings by including interaction of yield spread and NAIC group. Table A.3 presents the results for both rating-based and probability-based dispersion measures, with stringent sets of fixed effects. As in prior analyses, the average effect of rating dispersion is to decrease insurer's holdings of a bond, but there is betting on rating disagreement in the riskier bonds. As for yield spread, the stand-alone term is statistically insignificant, and the interaction term shows that reaching for yield is stronger in riskier bonds as well, albeit the weaker statistical power. In the parsimonious setups (columns (1) and (4)), even the interaction between yield spread and NAIC group is insignificant (and also of the unexpected sign), whereas the rating dispersion measure performs well regardless.[22] This is evidence that betting on credit rating disagreement is independent of, and is stronger than, reaching for yield in corporate bond investments by insurers.

[Insert Table A.3 About Here]

A.2 Single Sorts on Capital Surplus or Leverage

Table A.4 reports the results by exposure to low capital surplus funds, with the most stringent set of fixed effects in our setup.[23] Both rating-based and probability-based dispersion measures show that insurers reduce holdings in investment-grade bonds (NAIC groups 1 & 2) with divergent ratings, as expected. More interestingly, the 'betting on bond ratings

[22]We also test a specification with additional interaction of rating dispersion and yield spread. The term itself is statistically insignificant, and the explanatory power of other variables remain similar to those shown in Table A.3. For brevity, the table is not presented.

[23]We group NAIC groups 1 & 2 and NAIC groups 4 & 5 together for reporting, as Table 8 shows that they are similar in regard to rating dispersion behavior.

disagreement' behavior in lower-quality bonds is evident only in those with high exposure to capital related pressure. We surmise that insurance companies with low capital surplus (and therefore higher risk) bet more heavily on ratings disagreement compared to their counterparts with high capital surplus, with hopes for a favorable turn of the tide.

[Insert Table A.4 About Here]

Next, the role of leverage related pressure is examined. Table A.5 presents the results of single sorting on exposure to leverage, and shows that betting on ratings disagreement is not materially affected by exposure to high leverage funds. Unlike capital surplus, leverage is not a metric directly regulated, which we believe leads to the qualitative differences between effects of the two possible measures of constraints on the relation between rating dispersion and bond holdings.

[Insert Table A.5 About Here]

Table A.1: **Relation Between Rating Dispersion and Rating Changes**

This table reports estimates of panel regression results of rating downgrades and upgrades on measures of rating dispersion and various control variables. Rating dispersion and other control variables are measured at the end of the prior quarter, and rating changes happen in the current quarter. Other variable definitions are as in Appendix A. Rating-by-quarter fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

	Panel A: Rating-based Dispersion					
	Full sample		NAIC<3 (Safe)		NAIC>3 (Risky)	
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
Rating Change	Downgrade	Upgrade	Downgrade	Upgrade	Downgrade	Upgrade
Rating dispersion	0.112***	0.032***	0.087***	0.042***	0.197***	-0.037***
	(0.013)	(0.006)	(0.013)	(0.008)	(0.024)	(0.010)
Single rating dummy	-0.017***	0.014***	-0.016***	0.010*	-0.001	0.004
	(0.005)	(0.005)	(0.005)	(0.006)	(0.011)	(0.007)
Yield spread	1.873***	-0.213***	2.204***	-0.037	1.391***	-0.374***
	(0.147)	(0.046)	(0.197)	(0.052)	(0.130)	(0.066)
Duration	-0.001***	-0.000	-0.002***	0.000	0.005***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Bond return	-0.002	0.016	0.098	0.031	-0.187*	-0.030
	(0.067)	(0.016)	(0.065)	(0.019)	(0.095)	(0.038)
Bid-ask spread	1.302***	-0.395***	0.948***	-0.310***	2.500***	-0.535***
	(0.138)	(0.080)	(0.153)	(0.085)	(0.376)	(0.155)
ln(Trading volume)	0.011***	0.001***	0.007***	0.002***	0.026***	0.004***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.003)	(0.001)
ln(Number of trades)	-0.006***	0.004***	-0.004***	0.004***	-0.003	-0.003*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.002)
Bond volatility	-0.003	0.280***	-0.054	0.083	-0.219*	0.518***
	(0.075)	(0.062)	(0.093)	(0.053)	(0.126)	(0.110)
Rating-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	223,375	223,375	168,077	168,077	33,067	33,067
Adj. R^2	0.119	0.039	0.091	0.030	0.144	0.051

Table A.1: **Relation Between Rating Dispersion and Rating Changes - Continued**

	Panel B: Probability-based Dispersion					
	Full sample		NAIC<3 (Safe)		NAIC>3 (Risky)	
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
Rating Change	Downgrade	Upgrade	Downgrade	Upgrade	Downgrade	Upgrade
Rating dispersion	1.136***	0.315***	2.300***	4.320***	1.021***	0.021
	(0.127)	(0.068)	(0.525)	(0.545)	(0.130)	(0.057)
Single rating dummy	-0.020***	0.013***	-0.027***	0.014**	-0.001	0.012
	(0.005)	(0.005)	(0.005)	(0.006)	(0.010)	(0.007)
Yield spread	1.933***	-0.196***	2.261***	-0.080	1.396***	-0.356***
	(0.147)	(0.045)	(0.200)	(0.054)	(0.133)	(0.064)
Duration	-0.001***	-0.000	-0.002***	0.000	0.006***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Bond return	0.010	0.020	0.107	0.026	-0.188*	-0.024
	(0.065)	(0.016)	(0.065)	(0.019)	(0.098)	(0.037)
Bid-ask spread	1.334***	-0.386***	1.003***	-0.310***	2.506***	-0.617***
	(0.142)	(0.080)	(0.158)	(0.086)	(0.383)	(0.155)
ln(Trading volume)	0.011***	0.001***	0.007***	0.001***	0.026***	0.004**
	(0.001)	(0.000)	(0.001)	(0.001)	(0.003)	(0.001)
ln(Number of trades)	-0.006***	0.004***	-0.004***	0.004***	-0.004	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.002)
Bond volatility	-0.006	0.279***	-0.036	0.059	-0.205	0.498***
	(0.075)	(0.060)	(0.094)	(0.052)	(0.124)	(0.109)
Rating-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	223,375	223,375	168,077	168,077	33,067	33,067
Adj. R^2	0.114	0.038	0.084	0.033	0.141	0.050

Table A.2: **Within-Issue Relation Between Rating Dispersion and Rating Changes**

This table reports estimates of panel regression results of rating downgrades and upgrades on measures of rating dispersion and various control variables. Rating dispersion and other control variables are measured at the end of the prior quarter, and rating changes happen in the current quarter. Other variable definitions are as in Appendix A. Various fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

	Panel A: Rating-based Dispersion					
	Full sample		NAIC<3 (Safe)		NAIC>3 (Risky)	
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
Rating Change	Downgrade	Upgrade	Downgrade	Upgrade	Downgrade	Upgrade
Rating dispersion	0.147***	0.050***	0.121***	0.088***	0.213***	-0.107***
	(0.017)	(0.012)	(0.018)	(0.014)	(0.038)	(0.022)
Single rating dummy	-0.034**	0.040***	0.007	0.031**	-0.036**	0.011
	(0.014)	(0.011)	(0.017)	(0.014)	(0.015)	(0.018)
Yield spread	1.664***	0.007	1.621***	0.247***	1.059***	-0.230***
	(0.163)	(0.060)	(0.317)	(0.082)	(0.175)	(0.085)
Duration	-0.007***	-0.001	-0.006***	0.001	-0.015	-0.005
	(0.002)	(0.001)	(0.001)	(0.001)	(0.010)	(0.003)
Bond return	0.048	0.054***	0.072	0.082***	-0.141	-0.051
	(0.057)	(0.019)	(0.046)	(0.024)	(0.085)	(0.036)
Bid-ask spread	0.584***	-0.091*	0.582***	-0.055	0.900***	0.161
	(0.125)	(0.053)	(0.131)	(0.063)	(0.313)	(0.166)
ln(Trading volume)	0.007***	0.003***	0.004***	0.003***	0.012***	0.006***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.002)	(0.002)
ln(Number of trades)	0.006***	0.002**	0.001	0.003***	0.022***	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.003)
Bond volatility	-0.357***	0.473***	-0.164	0.247***	-0.698***	0.823***
	(0.089)	(0.067)	(0.105)	(0.062)	(0.181)	(0.154)
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Rating-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	222,641	222,641	167,387	167,387	32,629	32,629
Adj. R^2	0.221	0.113	0.219	0.140	0.292	0.147

Table A.2: **Within-Issue Relation Between Rating Dispersion and Rating Changes - Continued**

	Panel B: Probability-based Dispersion					
	Full sample		NAIC<3 (Safe)		NAIC>3 (Risky)	
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
Rating Change	Downgrade	Upgrade	Downgrade	Upgrade	Downgrade	Upgrade
Rating dispersion	1.048***	0.341***	1.814**	6.865***	0.907***	-0.175
	(0.145)	(0.103)	(0.763)	(0.874)	(0.159)	(0.110)
Single rating dummy	-0.042***	0.037***	-0.011	0.027**	-0.045***	0.024
	(0.012)	(0.011)	(0.015)	(0.013)	(0.015)	(0.018)
Yield spread	1.698***	0.019	1.667***	0.201**	1.054***	-0.214**
	(0.167)	(0.060)	(0.324)	(0.075)	(0.176)	(0.084)
Duration	-0.008***	-0.001	-0.007***	0.001	-0.015	-0.004
	(0.002)	(0.001)	(0.001)	(0.001)	(0.010)	(0.003)
Bond return	0.051	0.055***	0.077	0.077***	-0.140	-0.051
	(0.057)	(0.019)	(0.047)	(0.023)	(0.086)	(0.035)
Bid-ask spread	0.590***	-0.089	0.585***	-0.050	0.909***	0.153
	(0.123)	(0.053)	(0.129)	(0.064)	(0.317)	(0.168)
ln(Trading volume)	0.007***	0.003***	0.004***	0.003***	0.012***	0.006***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.002)	(0.002)
ln(Number of trades)	0.006***	0.002**	0.001	0.003***	0.022***	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.003)
Bond volatility	-0.345***	0.477***	-0.159	0.216***	-0.703***	0.837***
	(0.089)	(0.067)	(0.104)	(0.060)	(0.182)	(0.157)
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Rating-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	222,641	222,641	167,387	167,387	32,629	32,629
Adj. R^2	0.217	0.112	0.215	0.143	0.290	0.145

Table A.3: **Rating Dispersion and Yield Spreads With NAIC Group**

This table reports estimates of panel regression results of the fraction of corporate bonds held by insurance companies on measures of rating dispersion and various control variables, with interaction of yield spread and NAIC groups, including bond fixed effects. *Rating dispersion* is the standard deviation of credit rating scores for a bond issue scaled by the square root of its NAIC score, or its equivalent measured with historical survival probabilities. *NAIC_group* is the credit rating category defined by NAIC. *Yield spread* is a bond's yield in excess of a maturity-matched treasury yield. Other variable definitions are as in Appendix A. Rating dispersion and other control variables are measured in the prior quarter. Various fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

Dependent Variable:	Rating-based			Probability-based		
Insurers' Holdings	(1)	(2)	(3)	(4)	(5)	(6)
Rating dispersion	-0.040***	-0.035***	-0.034***	-1.709***	-1.504***	-1.321***
	(0.010)	(0.010)	(0.009)	(0.285)	(0.278)	(0.234)
Dispersion × NAIC_group	0.015***	0.014***	0.013***	0.394***	0.355***	0.310***
	(0.004)	(0.004)	(0.003)	(0.062)	(0.061)	(0.051)
Yield spread	0.102	-0.059	-0.099	0.107	-0.055	-0.098
	(0.116)	(0.103)	(0.097)	(0.120)	(0.104)	(0.099)
Yield spread × NAIC_group	-0.012	0.048*	0.049**	-0.008	0.051*	0.052**
	(0.030)	(0.026)	(0.024)	(0.031)	(0.026)	(0.025)
Single rating dummy	-0.006	-0.007	-0.006	-0.008	-0.008	-0.007
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Duration		0.018***	0.016***		0.017***	0.016***
		(0.002)	(0.001)		(0.002)	(0.001)
Bond return		-0.015	-0.012		-0.014	-0.011
		(0.011)	(0.009)		(0.010)	(0.009)
Bid-ask spread		-0.042	-0.070		-0.042	-0.070
		(0.047)	(0.042)		(0.047)	(0.042)
ln(Trading volume)		-0.005***	-0.004***		-0.005***	-0.004***
		(0.000)	(0.000)		(0.000)	(0.000)
ln(Number of trades)		-0.001	-0.001		-0.001	-0.001
		(0.001)	(0.001)		(0.001)	(0.001)
Bond volatility		0.016	0.033		0.026	0.041
		(0.045)	(0.040)		(0.045)	(0.040)
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Rating-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Quarter FE			Yes			Yes
Observations	222,817	222,817	222,800	222,817	222,817	222,800
Adj. R^2	0.916	0.919	0.923	0.917	0.919	0.923

Table A.4: **Exposure to Capital Surplus Pressure**

This table reports estimates of panel regression results of the fraction of corporate bonds held by insurance companies on measures of rating dispersion and various control variables, by exposure to low capital surplus funds. Low surplus funds are defined as those in the bottom 33% of the total sample sorted by capital surplus. *High Exposure* are bonds with above-median holdings by low capital surplus funds by NAIC group and quarter, therefore with higher capital surplus related pressure; *Low Exposure* is the subsample of bonds with below-median holdings. *Rating dispersion NAIC N* equals a bond's *Rating dispersion* if the bond belongs to $NAIC\_group\ N$ and zero otherwise, where $N = 1$ (safest),...,5 (most risky). Other variable definitions are as in Appendix A. Rating dispersion and other control variables are measured in the prior quarter. Various fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

Dependent Variable:	Rating-based		Probability-based	
Insurers' Holdings	(1) Low Exposure	(2) High Exposure	(3) Low Exposure	(4) High Exposure
Rating dispersion NAIC1 & 2	-0.016***	-0.014*	-0.831***	-1.154***
	(0.006)	(0.007)	(0.230)	(0.281)
Rating dispersion NAIC3	0.019*	-0.009	0.061	-0.408**
	(0.011)	(0.017)	(0.138)	(0.159)
Rating dispersion NAIC4 & 5	0.015	0.025**	0.050	0.094*
	(0.009)	(0.011)	(0.052)	(0.048)
Single rating dummy	-0.022	0.019*	-0.022	0.018
	(0.016)	(0.011)	(0.016)	(0.011)
Yield spread	0.044	0.033	0.051	0.042
	(0.044)	(0.046)	(0.044)	(0.047)
Duration	0.013***	0.011***	0.013***	0.011***
	(0.002)	(0.001)	(0.002)	(0.001)
Bond return	-0.007	-0.001	-0.006	-0.000
	(0.010)	(0.010)	(0.010)	(0.009)
Bid-ask spread	0.055	-0.090*	0.052	-0.087*
	(0.053)	(0.045)	(0.053)	(0.045)
ln(Trading volume)	-0.003***	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
ln(Number of trades)	0.000	-0.003**	0.000	-0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Bond volatility	-0.004	0.046	-0.002	0.052
	(0.039)	(0.048)	(0.039)	(0.048)
Bond FE	Yes	Yes	Yes	Yes
Rating-Quarter FE	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes
Observations	110,448	110,432	110,448	110,432
Adj. R^2	0.927	0.916	0.927	0.916

Table A.5: **Exposure to Leverage Pressure**

This table reports estimates of panel regression results of the fraction of corporate bonds held by insurance companies on measures of rating dispersion and various control variables, by exposure to high leverage funds. High leverage funds are defined as those in the top 66% of the total sample sorted by leverage. *High Exposure* are bonds with above-median holdings by high leverage funds by NAIC group and quarter, therefore with higher leverage related pressure; *Low Exposure* is the subsample of bonds with below-median holdings. *Rating dispersion NAIC N* equals a bond's *Rating dispersion* if the bond belongs to *NAIC_group N* and zero otherwise, where $N = 1$ (safest),...,5 (most risky). Other variable definitions are as in Appendix A. Rating dispersion and other control variables are measured in the prior quarter. Various fixed effects are included, and standard errors, clustered by both issuer and quarter, appear in parentheses below the coefficient estimates. The sample period is from Q3 of 2002 to Q1 of 2015.

Dependent Variable:	Rating-based		Probability-based	
Insurers' Holdings	(1) Low Exposure	(2) High Exposure	(3) Low Exposure	(4) High Exposure
Rating dispersion NAIC1 & 2	-0.019***	-0.015**	-1.032***	-1.036***
	(0.006)	(0.007)	(0.236)	(0.309)
Rating dispersion NAIC3	0.025*	-0.008	0.059	-0.364**
	(0.013)	(0.017)	(0.153)	(0.159)
Rating dispersion NAIC4 & 5	0.021**	0.020*	0.073	0.063
	(0.009)	(0.010)	(0.050)	(0.046)
Single rating dummy	-0.014	0.016	-0.015	0.015
	(0.013)	(0.010)	(0.013)	(0.009)
Yield spread	0.056	0.002	0.064	0.010
	(0.042)	(0.047)	(0.042)	(0.048)
Duration	0.012***	0.010***	0.012***	0.010***
	(0.002)	(0.002)	(0.002)	(0.002)
Bond return	0.005	-0.002	0.006	-0.002
	(0.011)	(0.010)	(0.011)	(0.010)
Bid-ask spread	0.038	-0.090*	0.037	-0.089*
	(0.050)	(0.045)	(0.050)	(0.045)
ln(Trading volume)	-0.003***	-0.004***	-0.003***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
ln(Number of trades)	0.001	-0.003**	0.001	-0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Bond volatility	0.014	0.039	0.019	0.045
	(0.041)	(0.044)	(0.041)	(0.044)
Bond FE	Yes	Yes	Yes	Yes
Rating-Quarter FE	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes
Observations	110,366	110,501	110,366	110,501
Adj. R^2	0.929	0.917	0.929	0.917