Investment Commonality across Insurance Companies: Fire Sale Risk and Corporate Yield Spreads*

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Abstract

Insurance companies often follow highly correlated investment strategies. As major investors in corporate bonds, their investment commonalities subject investors to fire-sale risk when regulatory restrictions prompt widespread divestment of a bond following a rating downgrade. Reflective of fire-sale risk, clustering of insurance companies in a bond has significant explanatory power for yield spreads, controlling for liquidity, credit risk and other factors. The effect of fire-sale risk on bond yield spreads is more evident: for bonds held to a greater extent by capital-constrained insurance companies, those with ratings closer to NAIC risk-categories with larger capital requirements, and during the financial crisis.

JEL classification: G11, G12, G18, G22

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1. Introduction

The global financial crisis of 2007-2009 has spurred substantial debate on the potential systemic risks that the insurance industry could impose on the broader economy. Much of the debate has focused on the possibility that an individual insurance company could become systemically important or "Too Big To Fail." As illustrated by the failure of AIG, nontraditional activities of a large insurer, such as derivative trading, financial-guarantee insurance, and certain securities lending operations, can contribute to systemic risk. In an attempt to address this concern, the Dodd-Frank Wall Street Reform and Consumer Protection Act supplements the traditional state based insurance regulation by subjecting systemically important insurers to enhanced regulations by the Federal Reserve.[1]

However, systemic risk in the insurance industry can arise outside of individual entities. As noted by Acharya, Biggs, Richardson, and Ryan (2009), an important linkage between the insurance industry and the rest of the financial system is that insurers are major investors in certain classes of financial assets. Furthermore, the investment strategies of insurers are often highly correlated, which causes them to be exposed to similar risks. It is argued that the combination of commonality in insurers' investment strategies and their massive collective role as investors has the potential to cause system-wide financial instability (Schwarcz and Schwarcz (2014)).

Despite the concerns arising from insurers' correlated investment behavior, there has been little evidence on their potential risks to the financial markets, partly due to the fact that it is challenging to identify such effects. Nor is there evidence that market participants are cognizant of such risks, as reflected in the pricing of financial assets in which the primary investors are insurance companies. In this paper we seek a better understanding of the economic implications

[1] AIG, MetLife, and Prudential are the three insurance-focused non-bank entities that have been designated as systemically risky.

of insurer investment commonality. We focus on the U.S. corporate bond market in which insurance companies are dominant investors and have a tendency to hold similar types of bonds (e.g., Cai et al. (2016)).[2] The commonality in insurers' bond investments can be attributed to several factors such as facing similar regulatory constraints as prescribed by NAIC, following similar business models (e.g., favoring long-term bonds to mitigate potential asset-liability mismatch (Schwarcz and Schwarcz (2014)), chasing liquidity premium by investing in relatively illiquid bonds (Huang et al. (2014)), or reaching for yield (Becker and Ivashina (2015)).

Our contention is that the substantial and correlated bond holdings by insurance companies can exacerbate price risk and impose a negative externality on other bond investors. This can be best illustrated during times of insurers' fire sales of downgraded bonds induced by regulatory constraints. Following a bond's rating downgrade from investment to speculative grade, regulations (either a prohibition or larger capital requirements on the holdings of the bond) force insurers, especially those that are capital-constrained, to collectively sell their holdings of the bond, causing its price to fall significantly below the fundamental value (Ellul, Jotikasthira, and Lundblad (2011)). Such regulation-induced fire sales impose spillover costs on other investors in the bond. For example, the portfolios of bond dealers, banks, and mutual funds are marked to market and require fair value losses to be recognized, even if their holdings are not sold. In addition, mutual funds with uncertain redemption and withdrawals may be affected when holding bonds with a risk of fire sales. Fund outflows can be triggered by their lower Net Asset Values (NAVs) caused by the fire sales of bonds. Moreover, fund withdrawals tend to occur during periods

[2] Financial institutions hold over three quarters of the total outstanding corporate bonds, and institutional trades account for over 90% of the secondary market trade volume (Data Source: U.S. Flow of Funds Accounts). The institutional investing in the corporate bond market is dominated by insurance companies. During the period from 2002-2011, for instance, the total par amount of investment-grade corporate bonds held by insurers exceeded the overall holdings of all other institutional investors pooled together (Data Source: Lipper's eMAXX Institutional bond holdings database).

of overall stress in the mutual fund industry and a weak macroeconomic environment, precisely when credit rating downgrades and regulation-induced fire sales are also more likely to occur. This correlation can exacerbate the cost of fire sales to mutual funds. Finally, bond dealers rely on the repo market to finance their bond inventories that can, in turn, serve as collateral. Fire sales of these bonds diminish their collateral values in repo transactions, and force dealers to post additional collateral.

The above discussion highlights the risk engendered by the clustering of insurance companies in a given bond, as manifested by the instances of regulation-induced fire sales. The risk and severity of a fire sale in the event of a rating downgrade can be expected to be higher when the combined ownership of a bond by insurance companies is greater. Relying on this intuition, we propose a simple equilibrium model of bond investment in the context of fire sale risk in which both the holdings of bonds by insurance companies and the pricing of bonds are endogenously determined. An implication of the model, that we subject to empirical tests, is that exogenous increases in the holdings of specific bond issues by insurance companies will result in these bonds exhibiting higher yield spreads.

Using Lipper's eMAXX institutional bond holding data, we estimate the clustering of insurers in a given bond by the percentage of the bond's outstanding amount held by insurance companies, and use it as a proxy for fire sale risk. We then empirically test whether a bond's yield spread is affected by the insurance companies' holdings of this bond, after controlling for liquidity, credit risk, and other common bond pricing factors in existing corporate bond pricing models. Studying the relationship between yield spread and holdings by insurance companies is complicated by the fact that insurers' investment decisions can be affected by factors that also affect yield spreads. For example, Becker and Ivashina (2015) finds insurers attempt to increase yield on their bond portfolios by taking on unobservable credit risks that are priced in a bond's yield spread. Therefore, the portion of a bond's yield spread ("residual risk") that is not explained by bond and firm characteristics and macro-economic conditions, could affect the insurance companies' holdings of this bond.

To address this endogeneity concern, we use two instrumental variables that are related to holdings of insurance companies but are not directly related to a bond's yield spread. Our first instrument is a dummy variable for the year 2005, in which the insurance industry was buffeted by losses on account of 15 hurricanes, including Hurricane Katrina, the costliest natural disaster in the history of America. The year 2005 is the worst year for the insurance industry in our sample, both in terms of the estimated total insured losses and the number of deaths. We expect that the large increase in claims for property damages and human deaths in 2005 forced insurance companies to divest their corporate bond holdings, thereby generating an exogenous shock to holdings, even if the issuers of the bonds were not directly affected by the natural disasters.

Our second instrument is the total par amount of all rating- and maturity-matched bonds held by insurance companies that reach maturity within the quarter, normalized by total par amount of new issues. Based on an analysis of how insurance companies reinvest proceeds from maturing bonds, we find that there is a tendency to invest in bonds that are similar to the maturing bonds, in both credit ratings and time to maturity (when acquired). It follows, therefore, that the greater the extent to which insurance company bond holdings of a certain maturity and rating mature, the greater is the rollover demand for outstanding bonds with similar characteristics. We further normalize the amount of maturing bonds with the amount of new issues to reflect the demand for outstanding bonds, relative to newly issued bonds.

Our main finding is that bonds held more by insurance companies, hence subject to greater risks of regulation-induced fire sales, exhibit a significantly higher yield spread after controlling for the impact of general liquidity, credit risk, and other common bond pricing factors from existing corporate bond pricing models. For our full sample of investment-grade corporate bonds, a one-standard-deviation increase of 22.50% in the percentage held by insurance companies is associated with a 1.61% increase in the yield spread.

To shed more light on the potential risk introduced by correlated investment behavior of insurance companies, we conduct two additional tests based on the expectation that fire sale risk is likely to be exacerbated when a bond is held to a significant extent by insurance companies that face regulatory constraints and when the bond has a credit rating such that a downgrade will significantly increase the regulatory burden. First, we separate our measure of insurer clustering into two measures according to insurers' regulatory capital constraints: the percentage of a bond's total amount outstanding held by more capital-constrained insurers and that held by less capital-constrained insurers. We find that being held by more constrained insurers has a significantly larger impact on yield spread than being held by less constrained insurers.

Second, we test if proximity to a higher capital requirement is associated with a larger effect of insurer clustering. We compare the effect of fire sale risk in the subsample of AAA- and AA-rated bonds and the subsample of A-rated and BBB-rated bonds. The latter are located on the boundaries of two NAIC risk categories with different capital requirements.[3] Accordingly a rating downgrade is likely to make a bond of the latter subsample subject to a larger capital requirement, which may trigger a fire sale among insurance companies. In addition, we compare the effect within the subsample of A-rated and BBB-rated bonds. Although both are on the boundaries, BBB-

[3] Table 1 provides information on the various risk categories and the associated capital charges.

rated bonds carry a higher risk of fire sales since the possibility of being downgraded into speculative grade entails a strict holding restriction, in addition to the largest percentage increase in capital requirements. In both comparison tests, we find that the latter subsamples exhibit significantly higher effects of insurance company ownership on bond yield spread. Since there are no significant differences in liquidity among investment-grade bonds (see Chen, Lesmond, and Wei (2007)), our findings are unlikely to be explained by differences in liquidity.

We also examine how the effect of insurance company ownership on corporate yield spreads varies with the onset of the recent financial crisis. While Becker and Ivashina (2015) finds that “reaching for yield” by insurance companies disappears during the recent financial crisis, we find that the insurer holdings actually exhibits a *stronger* influence on bond yield spreads in the crisis period. This finding suggests that irrespective of the specific reason behind each individual insurer’s investment in a bond, yield spreads will widen as long as there is an increase in the clustering of insurance companies that face regulatory constraints in their bond investments. The greater effect of insurance company ownership during the crisis period is consistent with an increased probability of rating downgrade, industry-wide capital constraints, and a larger risk premium that investors require when market conditions deteriorate. It also provides further support that our findings reflect the impact of investment commonality among insurance companies on bond yield spreads.

Our paper carries important policy implications for the regulation of insurance companies. Traditionally, the insurance industry has been regulated at the state level. As pointed out by Schwarcz and Schwarcz (2014), although Dodd-Frank improves insurance regulation by subjecting a small number of systemically important insurers to federal regulation, it does not address the potential concern that insurance companies, including the small ones, could collectively impose systemic risks on the broader economy due to their role as large asset owners and the commonalities in their investment behavior. Our paper lends direct support to Schwarcz and Schwarcz (2014) by showing that the bond market perceives and prices the risk of fire sales due to clustered holdings of insurance companies. The risk connotes the potential for systemic effects, suggesting a possible role for federal regulation.

The rest of the paper is structured as follows. Section 2 provides a literature review and the theoretical intuition for how collective ownership by insurance companies can affect corporate bond yield spreads. Section 3 provides a description of our data and illustrates our methodology on measuring insurer clustering and corporate bond yield spreads. In Section 4, we first conduct analyses on how insurance companies reinvest their proceeds from bond redemptions at maturity, and then empirically test whether the measure of insurer clustering affects corporate bond yield spreads after controlling for liquidity and other traditional bond pricing factors. Section 5 analyzes how the effect of insurer holdings is related to insurers' current capital constraints, a bond's proximity to a NAIC risk category with a higher capital requirement, and the recent financial crisis. Section 6 concludes.

2. Literature Review and Hypotheses Development

2.1 Literature Review

Our paper contributes to several strands of literatures. First, this study is related to recent heated debate on the role of credit ratings in financial markets. Credit rating agencies face various types of conflicts of interest, including those inherent in their "issuer-pay" business model[4] and those arising from their ownership structures (Kedia, Rajgopal, and Zhou (2014, 2015)). However, without regulatory reliance on credit ratings, conflicts of interest in credit rating agencies do not

[4] See for example, Mathis, McAndrews, and Rochet (2009), Becker and Milbourn (2011), Griffin and Tang (2012), Jiang, Stanford and Xie (2012), He, Qian, and Strahan (2012), Cornaggia and Cornaggia (2013)).

necessarily lead to rating inflation (Opp, Opp, and Harris (2013)). In fact, because of the regulatory implications of credit ratings, these ratings have been shown to affect a firm's capital structure decisions (Kisgen (2006)). In addition, Kisgen and Strahan (2010) show that rating-based regulations can affect a firm's cost of debt. By comparing the ratings from Dominion Bond Rating Service (DBRS) before and after it being designated by SEC as a Nationally Recognized Statistical Rating Organization (NRSRO), they find that the change in DBRS's regulatory status affects the yields on the bonds they rate. Although Dodd-Frank removes references to credit ratings from federal regulations, insurance regulations are still dependent on credit ratings since insurers are regulated at the state level. Our paper illustrates a new channel through which rating-based regulations can directly affect a firm's cost of debt by introducing a new risk factor in bond yield spreads.

Second, it speaks to the growing literature on fire sales. Shleifer and Vishny (1992, 2011) provide a theoretical framework to understand asset fire sales. They argue that asset prices fall because potential buyers from the industry, that place a relatively higher value on the assets, are resource constrained since they have suffered a common industry shock. An early empirical study on fire sales of real assets is Pulvino's (1998) study of prices of used airplanes. Coval and Stafford (2007) find mutual fund withdrawals can trigger fire sales when several funds meet redemptions by liquidating portfolio positions with some of the same stocks. In the bond market, Ellul, Jotikasthira, and Lundblad (2012) show that downgrades of investment to speculative grade can lead to fire sales because of regulatory requirements that induce divestment by insurance companies. Our study shows that the risk of such fire sales arising from insurers' correlated investment behavior can have a significant pricing effect.

Third, it contributes to the vast literature on the "credit spread puzzle" — the finding that standard bond pricing models, including both structural and reduced form models, have had limited success in explaining the observed bond yield spreads. Empirical applications of these bond-pricing models find that credit risk accounts for only a fraction of yield spreads (e.g., Collin-Dufresne, Goldstein, and Martin (2001), Huang and Huang (2012)). Recent studies suggest that some of the variation could be driven by the effect of liquidity on bond prices: either on account of increased transaction costs (Longstaff, Mithal, and Neis (2005), Chen, Lesmond, and Wei (2007), Bao, Pan, and Wang (2011)) or an additional risk factor (de Jong and Driessen (2012)). However, we note that the literature documents the "credit spread puzzle" mainly for investment grade bonds, where liquidity is generally higher than in speculative grade bonds. This suggests that while liquidity might explain some of the variations in yield spreads, it is unlikely to be the sole explanation. In our study, the risk of fire sales arising from the collective liquidation of downgraded bonds by insurance companies primarily exists in investment-grade bonds since insurance companies rarely hold speculative-grade bonds. Our study contributes to the literature by showing that the clustering of investors facing regulatory constraints can be an additional source of risk that has not yet been considered in existing bond pricing models.

2.2 Insurance Investors and Fire-Sale Risk: Hypotheses and Empirical Predictions

In this section we develop our hypotheses on the relation between corporate bond yields and holdings of corporate bonds by insurance companies and other investors. We propose a simple model to illustrate that in equilibrium, investors require higher yield to hold bonds that are subject to higher fire sale risk due to the clustering of insurance companies

2.2.1 Model of Bond Pricing with Insurer Fire Sales and Mutual-Fund Liquidity Shocks

In the model we assume, for simplicity, that there are two classes of bond investors: insurance companies and other institutional investors such as mutual funds. All investors are risk-neutral and the risk-free rate is taken to be zero for simplicity. For expositional ease, we consider an investment-grade bond that has a 2-period maturity and no coupon payments.

There are some key differences in investment horizon between insurance companies and other investors in our model: (1) First, insurance companies have longer investment horizons (e.g., matched to their liabilities) and typically hold bonds till maturity, unless the bonds suffer a rating downgrade. The selling of the bond by many insurance companies at the same time can result in a fire sale and depress the market price of the bond in the short-run. The insurance companies' decision to sell post-downgrade will depend on the cost of additional reserves required on account of the drop in rating versus selling the bond at a depressed price. (2) Unlike insurance companies, other bond investors are assumed to face stochastic liquidity shocks (e.g., fund withdrawals in the case of mutual funds) that may force them to liquidate their bond holdings prior to the maturity of the bonds. As a consequence, non-insurance investors can expect to face selling costs that are increasing in the illiquidity of the bond. These investors are also exposed to the risk of having to liquidate during a downgrade-induced fire sale.

There are three relevant dates. A particular bond issue, say *i*, is brought to the market on date 1. The bond matures on date 3. We normalize the face value of the bond to be one dollar. This bond has a positive probability of default on date 3, with investors receiving only part of the promised payment. All investors have the option to invest in risk-free bonds (e.g., Treasuries). Since the risk-free rate is normalized to zero, bond *i* would be priced at 1 dollar on date 1 if there were no default risk (or liquidity/transaction costs).

Date 2 is an intermediate date on which new public information about the default likelihood of the bond arrives. If the news is negative, as occurs with an exogenous probability π_i, the rating of bond *i* drops from investment-grade to speculative-grade. The negative news implies that the expected payoff of these bonds is $P_{2i} < \$1$ on date 3. The alternative to downgrade is that positive news arrives with probability $(1 - \pi_i)$. The positive news implies that the bond's default probability is zero, i.e., it will have a payoff of $1 on date 3.

It is also on the intermediate date that non-insurance investors could be subject to a liquidity shock. Any non-insurance investor has a probability γ (independent of π_i and of other non-insurance investors) of encountering a liquidity shock on date 2. These investors face liquidity costs λ and the ex-ante probability that a non-insurance investor sells during a downgrade is: $\pi_i \gamma$.

We now discuss the effect of bond *i* being downgraded on date 2. As we have noted, a bond downgrade, especially if the downgrade moves the bond from investment to speculative grade, can be costly for insurance companies that hold the bond. First, there are regulatory constraints on the fraction of an insurer's assets (20%) that can be invested in speculative-grade bonds. Additionally, investing in lower rated bonds requires the insurer to hold more reserve capital. As a consequence, we expect many insurance companies to divest the downgraded bond. Since selling occurs in a concentrated fashion, it can lead to a "fire sale" in which bond *i* will sell below their fundamental value of P_2, if the quantity of bonds offloaded is sufficiently large (see Ellul, Jotikasthira, and Lundblad (2011)). The notion is that if the aggregate selling is sufficiently large, there may be insufficient demand to absorb the bonds on account of 'slow-moving capital', leading to the bond price being depressed for some time.

The fraction of bond *i* held in aggregate by insurance companies is denoted as α_i. In event of a downgrade, the selling by insurance companies is expected to push down the market-clearing price by an amount, denoted by $\Gamma(\alpha_i)$, below the bond's fundamental value. The magnitude of Γ is determined by the aggregate level of insurance companies' ownership of the bond issue, as well as factors such as alternative sources of funding available to insurance companies and the presence of arbitrageurs that limit mispricing of the bond when there is a fire sale. We take $\Gamma(\alpha_i)$ to be strictly increasing in α_i. As we have noted, the fire sale imposes an externality on non-insurance investors that may need to liquidate their holdings on date 2. In addition, these investors suffer a liquidity cost λ to sell their bond holdings.

We now analyze the pricing of the bond issue and its allocation between insurance and non-insurance investors *i.e.*, α_i and $(1-\alpha_i)$, respectively. We assume that the equilibrium is one in which each type of investor holds at least some of the bond issue. Since any investor can always invest at the risk-free rate of zero, we can use this to value bond *i* from the vantage of the different investor types. As both types of investors hold the bond in a competitive bond market, their valuation on the margin will equal the market price of the bond on date 1, say P_{1i}.

From the valuation of an insurance investor, we have:

$$P_{1i} = (1-\pi_i) + \pi_i P_{2i} - \pi_i \Gamma(\alpha_i) - K(\pi_0) + A_i. \quad (1)$$

The terms on the right-hand-side of equation (1) are as follows. The first two terms are the fundamental values of the bond in the two possible states on date 2. With probability $(1-\pi_i)$ the bond goes up to \$1, while with probability π_i there is a downgrade and the bond value drops to P_{2i}. The third term $\pi_i\Gamma(\alpha_i)$ is the expected cost of the fire sale to the marginal insurance investor. The term $K(\pi_0)$ represents the regulatory burden, such as capital reserve requirements, associated with holding risky bonds with $K(\pi_0)$ strictly increasing in π_0. We allow for the possibility that a bond is rated as being of somewhat lower or greater risk π_0 that the (actual) risk π_i perceived by investors. This allows for the possibility of "regulatory arbitrage." Finally, A_i represents exogenous features of the bond and/or timing of the issue that may make a bond more or less attractive to insurance investors: e.g., if the bond is brought to the market just when insurance investors have more funds to invest.

We turn now to the valuation of the bond by the marginal non-insurance investor. We can state:

$$P_{1i} = (1 - \pi_i) + \pi_i P_{2i} - \gamma \pi_i \Gamma(\alpha_i) - \gamma\lambda. \qquad (2)$$

As in equation (1), the expected payoff to the marginal non-insurance investor from holding the bond equals the price P_{1i} on date 1. The terms on the right-hand-side of equation (2) are the following: the first two terms represent the expected fundamental value of the bond on date 2, as in equation (1). A non-insurance investor expects to sell his bonds with probability γ in period 2. The third term represents the incremental cost from having to sell bond when there is a downgrade, while the fourth represents the anticipated liquidity cost of selling.

We can combine equations (1) and (2) above to obtain the following relation in equilibrium:

$$\pi_i \Gamma(\alpha_i) + K(\pi_0) - A_i = \gamma \pi_i \Gamma(\alpha_i) + \gamma\lambda \qquad (3)$$

$$\Longrightarrow \quad \pi_i \, \Gamma(\alpha_i) \, (1 - \gamma) + K(\pi_0) = \gamma\lambda + A_i. \qquad (4)$$

In the equilibrium posed above, there are two endogenous variables: the bond price P_{1i} and α_i, the fraction of the bond issue held by insurance companies (in aggregate). The bond pricing equilibrium can be viewed as being characterized by the two equations (2) and (4). Equation (4) ties the effect of exogenous demand shocks A_i, to aggregate insurance company holdings α_i, given the various parameters $\pi_i, \gamma, \lambda, \pi_0$ and A_i; while equation (2) represents the effect of insurance company holdings α_i on bond price. In the model, yield spread is given by $\Delta_{1i} = (1 - P_{1i})/P_{1i}$, which is monotonically deceasing in the bond price P_{1i}.[5]

2.2.2. Demand and Other Shocks

We now consider the effect of variation of the exogenous parameter A_i that represents shifts in demand or preferences of insurance companies for particular bonds (keeping the exogenous parameters fixed). For instance, depending on circumstances, insurance companies may have a greater or lower demand for bonds with certain attributes. As we show, the general pattern induced by demand shifts is that yield spreads on bonds tend to be positively correlated with increases in the holdings by insurance companies.

Prediction 1: *An exogenous increase (decrease) in the demand for a bond issue by insurance companies, i.e., an exogenous increase (decrease) in A_i, will be accompanied by an increase (decrease) in the bond's yield Δ_{1i} and an increase (decrease) in the holdings by insurance companies α_t.*

This is a direct implication of equation (4). Suppose there is an equilibrium level $0 < \alpha_i^* < 1$ in equilibrium. Then an exogenous increase (decrease) in demand, represented by A_i, will result in an equilibrium $\alpha_i^\#$ such that $\alpha_i^\# > \alpha_i^*$ ($\alpha_i^\# < \alpha_i^*$), since $\Gamma(\alpha_i)$ is strictly increasing in α_i. From equation (2), the increase (decrease) in holdings is associated with a decrease (increase) in price P_{1i}. It follows that both the holdings and yield spread will increase (decrease) when A_i increases (deceases). ■

2.2.3 Capital Constraints and Downgrade Risk

[5] In principle, equation (4) constitutes the first stage of our identification strategy in which our instruments capture demand shocks that cause an exogenous variation in insurance company holdings. We can then use the instrumented holdings in the second stage to identify the effect of insurance company holdings on bond yields.

Despite the fact that insurance companies are regulated at the state level, they face similar regulations as prescribed by the National Association of Insurance Commissioners (NAIC) when investing in corporate bonds. As shown in Table 1, NAIC classifies corporate bonds into six risk categories, NAIC1 to NAIC6, directly tied to bond credit ratings, and requires insurance companies to maintain a higher level of capital when investing in bonds in a higher risk category. In addition, insurance companies are usually required to invest no more than 20% of their assets in bonds below NAIC risk category 2 (NAIC2), i.e., speculative-grade bonds.

Due to these regulations, the cost for an insurance company to hold a bond increases when its credit rating is downgraded to a higher NAIC risk category. Such costs can be harder to bear for capital-constrained insurance companies, who may not be able to meet the greater capital requirements and be forced to liquidate their bond holdings at unattractive prices. In the model this can be interpreted as an increase in fire sale cost Γ per unit of bond ownership anticipated by these insurance companies. Hence, larger holdings by constrained insurance companies will be associated with a larger marginal increase in the bond's yield spread.

Also because of these rating based regulations, certain rating downgrades, such as from an investment to non-investment category, are associated with a sharp increase in capital requirements and other regulatory burdens. Hence, the bonds that are, for instance, rated just above speculative grade face greater expected fire sale costs. Insurer holdings will imply a greater increase in yield spread for such bonds. This too can be interpreted as an increase in the cost Γ per unit of bond ownership. From equation (2), we can then state:

Prediction 2: *For a bond held by more capital-constrained insurance companies and a bond with credit ratings such that a downgrade would sharply increase the regulatory burden, an exogenous* *change in the holdings α_i by insurance companies will have a greater impact on the bond's yield spread.*

2.2.4 Downgrade Risk during Financial Crisis

A rise in the probability of downgrade π_i also plays a role in determining the impact of insurer bond holdings on the yield spread. Considering equation (1), the derivative of bond price with respect to (w.r.t.) insurers' holdings is negative: $-\pi_i \Gamma'(\alpha_i)$. In a prolonged economic contraction, the probability of downgrade π_i is likely to increase, which heightens the impact of insurers' bond holdings on the yield spread. In addition, an industry-wide capital constraint can occur during a prolonged economic contraction, which may also exacerbates the impact of insurers' bond holdings on the yield spread (following Prediction 2).

Prediction 3: *During a prolonged economic contraction such as the recent financial crisis, an exogenous change in the demand for a bond issue by insurance companies will have a greater impact on the bond's yield spread.*

To see this, we rearrange equation (4) as:

$$\pi_i \, \Gamma(\alpha_i) \, (1 - \gamma) - \gamma\lambda = A_i - K(\pi_0). \qquad (4^{\#})$$

Next, let us take the right-hand-side of the above equation to be fixed (i.e., there is no change in the bond rating as indicated by π_0) and assume that there is an increase in the default risk π_i. Then, since the left-hand-side (LHS) of the above equation is increasing in π_i (*i.e.*, the derivative of the LHS w.r.t. π_i is positive: $\Gamma(\alpha_i)\,(1 - \gamma) > 0$), there must a *decrease* in α_i if equation ($4^{\#}$) is to be satisfied in equilibrium (since $\Gamma(\alpha_i)$ is increasing in α_i). Note that an increase in π_i implies (from equation (1)) a lower bond price or higher yield spread. Hence, under these conditions, bonds experience an increase in yield spreads on account of an increase in default risk (though their rating may not have changed), will be held to a lower extent by insurance companies. ■

It is worth noting that the apparent disappearance of insurance companies' "reaching for yield" during the recent financial crisis, as documented in Becker and Ivashina (2015), can be explained by our model. In Becker and Ivashina (2015), the focus is on examining insurers' investment behavior, with yield spread being exogenously given. However, in our model, both yield spread and holdings by insurance companies are endogenously determined. In particular, reversal of the positive relationship between yield spread and holdings by insurers can occur in our model under certain conditions. Interestingly, these conditions are generally consistent with changes in yields on account of an increase in risk of bond downgrade/default – that may well have occurred during the financial crisis years.

3. Insurer Clustering, Yield Spread Estimation, and Sample Description

To empirically test whether bond yield spread is affected by regulation-induced fire sale risk that originates in insurer investment commonality, we describe in this section the various data files we use, and illustrate our approach in estimating the clustering of insurance companies and corporate bond yield spreads.

3.1. Clustering of Insurance Companies

We estimate the clustering of insurance companies in a bond for a given quarter by the total amount of par value held by insurance companies, as opposed to the other investors, and use it as a proxy for fire sale risk. We obtain data on institutions' quarterly holdings in corporate bonds from the Lipper eMAXX database for the period from the third quarter of 2002 to the last quarter of 2011. This database covers comprehensive information on quarterly ownership of corporate bonds and other fixed income securities by nearly 20,000 U.S. and European insurance companies, U.S., Canadian, and European mutual funds, and leading U.S. public pension funds. Holdings by other pension funds, hedge funds, banks, private investors, and foreign entities are not tracked by

Lipper.[6] Lipper eMAXX data on corporate bond holdings by insurance companies are nearly complete as they are based on insurance companies' regulatory disclosure to the NAIC. Data on mutual fund holdings are also very comprehensive as they are based on mutual funds' regulatory disclosure to the SEC. For other institutions, the data coverage is much less complete and they are based on voluntary disclosures. To control for the issue size effects, we divide the total par amount held by insurance companies by the bond's total par amount outstanding in the same quarter, and name it as *PCT Held by Insurers*.

3.2. Corporate Bond Yield Spread Estimation

We follow the prior literature and estimate the yield spread of a corporate bond as the spread of the yield to maturity on a corporate bond over the yield to maturity on a default-free bond with the same time to maturity and coupon rate for the period from July 1st, 2002 to December 31st, 2011. For a given corporate bond on a given day within our sample period, we first calculate the price of its matching default-free bond by discounting the corporate bond's contractual cash flow with the default-free yield curve, which is estimated daily using the extended Nelson-Siegel model (see Bliss (1997)). The extended Nelson-Siegel model fits an exponential approximation of the discount rate function directly to observed Treasury bond prices, which are obtained from CRSP Treasury Daily files. We then back out the yield to maturity on this hypothetical default-free bond from the estimated price on the given day.

The yield spread of the corporate bond on the day is then calculated by subtracting the yield to maturity on this default-free bond from that on the original corporate bond on the same day. To get the yield to maturity for corporate bonds on a daily basis, we rely on bond transaction data from the enhanced TRACE database, which provides for each bond trade information on the date,

[6] This dataset has been analyzed in several studies such as Manconi, Massa and Yasuda (2012), Massa, Yasuda and Zhang (2013), Dass and Massa (2014), and Becker and Ivashina (2015).

time, quantity, price and yield to maturity, among many other attributes. We focus on all dealer-customer trades in TRACE from the period from July 1st, 2002 to December 31st, 2011. We exclude the following transactions: when-issued, cancelled, subsequently corrected, reversed trades, commission trades, and trades with special sales conditions or longer than 2-day settlements. We also delete potentially erroneous records such as transactions with missing price or quantity values, prices outside the range of 10 and 500, and price reversals over 20% in adjacent trades (e.g., Edwards, Lawrence, and Piwowar (2007), Goldstein, Hotchkiss, and Sirri (2007)). A corporate bond's yield to maturity on a given day is then calculated by taking the volume-weighted average of the yield to maturity across all transactions in the bond within the day. Finally, the daily yield spread estimates are averaged within a quarter for each bond to obtain the yield spread estimate at the bond-quarter level.

3.3. Sample Description

We start with a sample of corporate bonds which are determined from merging the corporate bond yield spread estimates from the TRACE database with the *PCT Held by Insurers* estimates from Lipper eMAXX database. The merged data are at the bond-quarter level and they cover the period from the third quarter of 2002 to the last quarter of 2011. For bonds in the merged sample, we obtain data on bond characteristics, including historical credit ratings by Moody's and S&P, historical amount outstanding, offering and maturity date, and coupon rate from Mergent's Fixed Income Securities Database (FISD). We assign a numeric value to each notch of S&P (Moody's) credit rating, with 1, 2, 3, 4 … denoting AAA (Aaa), AA+ (Aa1), AA (Aa2), AA- (Aa3), …, respectively, and we take the higher of S&P and Moody's numeric rating as a bond's credit rating. As insurance companies not only face higher capital requirements in investing in speculative-grade bonds, but also are not allowed to invest more than 20% of their assets in speculative-grade bonds, the majority of speculative-grade bonds are not held by insurance companies, and hence are less likely to be subject to potential fire sale risk. We therefore focus on investment-grade bonds in our study. We also exclude bond-quarters when either age or remaining maturity is less than a year.[7] In addition, we rely on the FISD data to focus on plain-vanilla coupon bonds and exclude asset-backed issues, 144A bonds, Yankee bonds, Canadian bonds, issues denominated in foreign currency, and issues offered globally. Finally, to obtain information about the issuers of bonds in our sample, we require the issuers to be covered by both Compustat and CRSP. Our final sample consists of 39,884 bond-quarter observations over the period from the third quarter of 2002 to the last quarter of 2011. It includes 3,249 investment-grade bonds issued by 547 companies.

As shown in Table 2, investment-grade bond issuers tend to be larger, with average total assets of $108 billion. They have an average market-to-book ratio of 1.2, and leverage ratio of 30%. The issuers on average have an operating margin of 19%, and their pre-tax interest coverage ratio is about 10. The mean and standard deviation of the issuer's daily excess stock returns during our sample period is -1.8% and 1.4% respectively.

Table 2 also shows that our sample bonds have a median rating A- by S&P (A3 by Moody's). On average, these bonds are 5.8 years old, and they have a little over 10 years to maturity. The average total par amount outstanding during our sample period is $496 million, with an average 6.27% coupon rate.

Consistent with insurance companies being the largest institutional holder of corporate bonds, Table 3 shows that insurance companies together hold almost half of the total par amount

[7] We exclude bonds that are newly issued because trading in these bonds tends to be unusual (Goldstein and Hotchkiss (2012)). In addition, we exclude bonds maturing within one year since their chance of being downgraded before maturity is small. Even if a bond is downgraded when approaching maturity, insurers have little incentives to sell their holdings due to high trading costs.

outstanding of our sample bonds, with the mean and median *PCT Held by Insurers* being 48.48% and 48.36% respectively. Partitioning the sample by credit rating, we find that *PCT Held by Insurers* increases in lower rated bonds. Insurance companies on average hold about 30% of AAA- or AA-rated bonds. Their share increases to almost 49% in A-rated bonds, and further to over 51% in BBB-rated bonds. In addition, insurance companies own a larger share of long-term bonds. For bonds with more than 7 years to maturity, almost 54% of total par amount outstanding is held by insurance companies. For bonds with time to maturity between 1 year and 7 years, insurance companies hold about 44%.

4. Insurer Clustering and Corporate Yield Spread

4.1. Regression Analyses

To empirically test whether the clustering of insurance companies possesses explanatory power for corporate bond yield spreads, we regress the yield spread for bond *i* in quarter *t*, $YieldSpread_{i,t}$, on the bond's insurer clustering measure in that quarter ($PCT\ Held\ by\ Insurers_{i,t}$) along with various control variables. For control variables we use various factors considered in existing empirical models for corporate bond yield spreads (e.g., Campbell and Taksler (2003), Chen, Lesmond, and Wei (2007), Bao, Pan, and Wang (2011)):

$$YieldSpread_{i,t} = \alpha + \beta\ PCT\ Held\ by\ Insurers_{i,t} + \sum_k \gamma^k ControlVar_{i,t}^k + \varepsilon_{i,t}. \quad (5)$$

The first set of control variables includes bond-specific characteristics, including *Credit Rating*, *Time to Maturity*, *Age*, *Coupon*, and *Amount Outstanding*. To the extent that these bond characteristics are linked to bond liquidity, including them as explanatory variables in the regression allows us to control for at least some of the impact of liquidity on bond yield spreads. In addition, since insurance companies tend to buy and hold, the more a bond is held by insurance companies, the less it is available to trade, and hence the lower the liquidity. Therefore, to ensure that our *PCT Held by Insurers*$_{i,t}$ variable is not simply capturing the liquidity effect, we also include as control variable a bond's total trade volume in a given quarter, *Trade Volume*.

Our second set of control variables is related to the issuers of the bonds: total debt to capitalization (*Leverage*), long-term debt leverage (*LTD Leverage*), market-to-book ratio (*M/B*), *Operating Margin*, four variables constructed to measure the incremental influence of the pre-Tax interest coverage (*pretax d1- d4*) using the procedure outlined in Blume, Lim, and MacKinlay (1998), and the mean and variance of the issuer's daily excess stock returns within the quarter (*Issuer Equity Return* and *Issuer Equity Volatility*). These variables capture the issuer's capital structure and firm value, which determines the amount of credit risk in the bond.

Since macroeconomic conditions can affect bond credit risk and liquidity, we include the following general market and macroeconomic variables in our set of control variables: *VIX*, *Stock Market Return*, *EuroDollar*, *Credit Spread*, and the level and slope of the term structure of interest rates (*Term Level* and *Term Slope*). Appendix 1 provides detailed explanation for each of the control variables.

Studying the impact of insurance companies' holdings on corporate bond yield spread is complicated by the possibility that the investment decisions of insurance companies can be driven by unknown risk factors that are priced in corporate bond yield spreads. For example, Becker and Ivashina (2015) find that insurance companies reach for yield in corporate bonds by taking on more priced risks that are not captured in easily measurable risk benchmarks, such as credit ratings. Therefore, any estimated relationship between *PCT Held by Insurers*$_{i,t}$ and *YieldSpread*$_{i,t}$ could be the result of omitted risk factors that drive both corporate yield spreads and insurance companies' investment decisions.

To address these endogeneity concerns, we identify exogenous changes in the demand for a bond issue by insurance companies as suggested by our model. We use an instrumental variable (IV) method to estimate equation (5) and test our Prediction 1. A valid instrument should be correlated with insurance companies' holdings in a bond, but not correlated with the bond's yield spread for reasons beyond its effect on the holdings. We consider two instrumental variables. The first instrument is a dummy variable for the year 2005 (*2005Dummy*). It is developed based on the occurrence of large natural disasters that led insurance companies to liquidate some of their bond holdings. Massa and Zhang (2011) use the event of Hurricane Katrina to study how an exogenous shock to the demand of bonds by insurance companies affects the choice of a firm's debt financing. They document that the insurance companies hit by Katrina liquidate their bond stakes to meet the expected damage claims. Importantly, they find that Hurricane Katrina generates an externality impact on bonds through insurance companies, even if the issuers of the bonds are not directly affected by the hurricane.

Over our sample period from 2002 to 2011, 2005 is the worst year for insurance companies. Hurricane Katrina, which occurred in late August of 2005, is the costliest natural disaster in U.S. history. According to Insurance Information Institute, Hurricane Katrina alone accounted for over 48 billion dollars of insured losses, which are larger than the aggregate insured losses from hurricanes of any other years in our sample period. In addition, as shown by Table 4, the year 2005 has the highest number of (catastrophic) hurricanes. The estimated total insured losses in 2005 is over $66 billion in 2011 dollars, which is more than twice as large as that of 2004, the year with the second largest insured losses from hurricanes in our sample. Moreover, in 2005, hurricanes caused a total of 1,518 deaths, almost eight times greater than the number of hurricane deaths from the other nine years in our sample put together. Therefore, the year 2005 represents a large exogenous shock to the insurance industry. The sudden increase in claims for property damages and human deaths is likely to have forced insurance companies to divest a significant portion of their corporate bond holdings in 2005.

Our second instrument is the total par amount of all rating- and maturity- matched bonds held by insurance companies that reach maturity within the quarter, normalized by the total par amount of new bond issues in the same rating- and maturity-matched group. The rationale is the following. Redemption at maturity creates a need for reinvestment net of claim payouts. The larger the quantity of bonds that mature in insurance companies' portfolios in a given quarter, the greater the demand for outstanding bonds. Our instrument is based on the evidence, discussed below, that insurance companies tend to reinvest proceeds from bond redemption at maturity in similar bonds, i.e., ones with similar rating and time to maturity (when acquired). In this process, we expect newly-issued bonds to also compete for the proceeds from bond redemption and we normalize the redemption amount with the amount of new bond issuance.

To develop the instrument, we start with an analysis of insurance companies' investment behavior in the corporate bond market. Consistent with the notion that insurance companies tend to buy and hold corporate bonds, Table 5 shows that for the 3,982 insurance companies in our sample, on average, over 60% of their bond portfolios are held to maturity, and almost 13% are sold within one year of a downgrade by either Moody's or S&P. At the time when a bond is acquired by an insurance company, the mean age is about 2 years, while the median is only a little over half year. This suggests that while some bonds are purchased by insurance companies when they are well seasoned, the majority are purchased shortly after their issuance. In addition, Table 5 shows that at the time of acquisition by an insurance company, the average time to maturity for a bond is about 10 years. The average bond carries an A- rating and its average par amount outstanding is about $840 million.

We then study how insurance companies roll over their bond portfolios. In Panel A of Table 6, we first partition bonds into groups based on their credit ratings, and examine the correlation coefficients between an insurer's total par amount of quarterly redemption normalized by the par amount of new issues in each group and its total par amount of quarterly acquisition of outstanding bonds in each group. The correlations on the diagonal of the table are much higher than those in the same row, suggesting that insurance companies tend to reinvest proceeds from bond redemption into bonds belonging to the same credit rating category. We next conduct a similar analysis by forming bond groups based on their time to maturity at acquisition. Since insurance companies rarely acquire bonds within one year to maturity, we classify bonds maturing between 1 year and 7 years as short-term bonds, and those with time to maturity longer than 7 years as long-term bonds. Panel B suggests that insurance companies are likely to reinvest proceeds from bond redemption into bonds belonging to the same time to maturity category.

Since Panels A and B of Table 6 suggest that both credit rating and time to maturity are important considerations in insurance companies' rollover decisions, we now form eight bond groups by interacting those four credit rating categories with two term categories. Panel C shows that on-the-diagonal correlations are always statistically significant and they are higher than off-the-diagonal correlations on the same row. It suggests that insurance companies tend to reinvest proceeds from bond redemption at maturity into bonds within the same credit rating and time to maturity category.

One potential concern with the correlation coefficients is that they might be driven by a few insurance companies in our sample. It is also possible that the overall correlation coefficients reflect the relationship between bond redemption and bond acquisition by insurance companies during certain time periods in our sample. To address these concerns, we conduct the following multivariate analyses to examine whether the rollover style demonstrated by the correlation coefficients in Table 6 is general to insurance companies' reinvestment behavior in bonds:

$$Acquistion_{j,t}^{g} = \alpha + \sum_{p=1}^{8} \beta^{p} Redemption_{j,t}^{p} + \varepsilon_{j,t}, \qquad (6)$$

where $Acquistion_{j,t}^{g}$ and $Redemption_{j,t}^{p}$ refer to the natural logarithm of the total par amount of quarterly acquisition and the total par amount of quarterly redemption normalized by new issues respectively, in group *g* or *p* by insurance company *j* in quarter *t*. For each of the eight bond groups formed on credit rating and time to maturity, we estimate equation (6) with both firm and time fixed effects.

Table 7 shows that the general conclusion regarding how insurance companies rollover their bond portfolios (Table 6) holds in the multivariate analysis. For a specific bond group *g*, the coefficient for $Redemption_{j,t}^{g}$ is always positive and highly significant at the 1% level. More importantly, the magnitude of the coefficient for $Redemption_{j,t}^{g}$ is always the highest among the coefficients for the eight $Redemption_{j,t}^{p}$ where p=1, 2, …, 8. We also test the difference between $Redemption_{j,t}^{g}$ and $Redemption_{j,t}^{p}$ for $p \neq g$, and find that the difference is always statistically significant at the 1% level. In sum, the amount of maturing bonds in an insurance company's portfolio affects its holdings of outstanding bonds with similar risk characteristics. Based on this finding, we develop our second instrumental variable, $Redemption\ at\ Maturity_{i,t}$, for each bond *i* in quarter *t*. $Redemption\ at\ Maturity_{i,t}$ is equal to the total proceeds from all bond redemptions at maturity by all insurance companies, normalized by the total par amount of new issues, with the same credit rating and initial time to maturity as bond *i* in quarter *t*.

With these two instrumentale variables, we estimate equation (5) using two-stage least square and the results are presented in Table 8. In the first stage, our proxy for a bond's regulation-induced fire sale risks, *PCT Held by Insurers*$_{i,t}$, is regressed on the two instrumental variables, *2005Dummy* and *Redemption at Maturity*$_{i,t}$, and all the control variables in equation (5). Column (1) shows that the coefficient for *2005Dummy* is negative and statistically significant at the 5% level. This is consistent with our expectation that insurance companies liquidate their bond holdings to resolve the sudden rise in claims resulting from catastrophic natural disasters in 2005. The coefficient for the other instrument, *Redemption at Maturity*$_{i,t}$, is positive and significant at the 1% level. This finding confirms that insurance companies tend to reinvest proceeds from bond redemption to bonds with similar risk characteristics. In addition, we conduct an *F*-test on the strength of the two instruments in the first stage. As reported, the *F*-test is highly significant at the 1% level.

In the second stage, we replace *PCT Held by Insurers*$_{i,t}$ with its predicted value from the first stage regression and estimate equation (5).[8] As shown in Column (2) of Table 8, the coefficient of the fire sale risk proxy is positive and significant at the 1% level. The coefficient of 7.165 is also economically meaningful since it suggests that a one-standard-deviation increase in *PCT Held by Insurers*$_{i,t}$ is associated with a 1.61% (7.165×22.499%) increase in yield spread. This empirical finding lends strong support to our hypothesis that the clustering of insurers in a bond has significant explanatory power for its yield spread.

[8] Standard errors are adjusted for estimated regressor from first-stage.

Consistent with prior studies on the liquidity effects on corporate yield spreads (e.g., Chen, Lesmond, and Wei (2007), and Bao, Pan, and Wang (2011)), the coefficient for *Trade Volume* is negative and highly significant, suggesting that bonds with higher liquidity tends to have lower yield spreads. Including *Trade Volume* to control for the liquidity effect diminishes the significance of some liquidity-related bond characteristics such as *Time to Maturity* and *Amount Outstanding*, but not others, such as *Credit Rating* and *Age*, which are still significant and carry the expected signs.[9] We also find that higher coupon bonds carry higher yield spreads, which might reflect the tax effect of coupon payments as pointed out by Elton, Gruber, Agrawal and Mann (2001).

The coefficients of firm specific variables are also generally consistent with previous studies. For example, bonds issued by firms with lower leverage, higher stock returns, or higher market-to-book ratio tend to have lower yield spreads. Also, issuer stock volatility is positively related to bond yield spread as documented by Campbell and Taksler (2003). Coefficients on the other variables, such as pretax interest coverage variables (*pretax d1-pretax d4)* and *LTD Leverage* are also consistent with those in previous studies (e.g., Chen, Lesmond, and Wei (2007)).

With respect to the macroeconomic variables, we find that corporate bond yield spread widens when market volatility (measured by *VIX*) increases, when stock market declines, and when the overall market credit condition as approximated by *Credit Spread* deteriorates. The positive coefficient for *EuroDollar* is consistent with the market liquidity effects on corporate bonds relative to treasury bonds. The coefficient on the level of the term structure (*Term Level*) is negative and highly significant, supporting Longstaff and Schwartz (1995) that an increase in risk free interest rate implies an upward drift in the risk-neutral process for the firm value, and hence a

[9] The negative and significant coefficient of Credit Rating also suggests that yield spreads are wider for lower rated bonds as they have higher credit risks.

reduction in the risk-neutral probability of default. The slope of the term structure is negative but not statistically significant.

In sum, findings in this section confirm our Prediction 1 that an exogenous increase (decrease) in the demand for a bond issue by insurance companies is accompanied by an increase (decrease) in the bond's yield spread and an increase (decrease) in the holdings by insurance companies.

4.2. Robustness Checks

4.2.1. Excluding Bonds Issued by Firms Residing in States Directly Affected by Hurricane Katrina

In 2005, there were five states: Louisiana, Mississippi, Florida, Georgia, and Alabama, that were directly hit by Hurricane Katrina. Firms residing in these states may have been directly affected by Katrina, leading to an increase in their bonds' credit risk. This in turn, can raise concerns about the use of *2005Dummy* as a valid instrument since for issuers residing in Katrina affected states, the yield spread of their bonds could be directly correlated with the *2005Dummy*. In this section, we exclude a total of 202 bonds issued by firms residing in the five Katrina affected states, and re-estimate model (5) using the IV approach. Column (1) of Table 9 shows that the coefficient of *PCT Held by Insurers* remains positive and highly significant. Therefore, the potential correlation between the *2005Dummy* and the *YieldSpread* for some bonds in our sample does not have any material impact on our results.

4.2.2. Excluding Bonds Issued by Insurers

Another concern with *2005Dummy* being a valid instrument is that our sample includes bonds issued by insurance companies, some of which suffered substantial losses from Hurricane Katrina. In fact, several insurers were put on negative watch or review by rating agencies S&P and A.M. Best following Hurricane Katrina. To ensure *YieldSpread* is not directly related to the

2005Dummy, we exclude bonds issued by all 54 insurance companies in our sample. Column (2) of Table 9 shows that our results continue to hold. The coefficient of *PCT Held by Insurers* stays positive and highly significant.

4.2.3. Holdings by Life Insurers

Compared to Property & Casualty (P&C) insurers, Life insurers hold substantially more corporate bonds, especially in the long-term category. During our sample period, the total par amount of corporate bonds held by Life insurers is more than six times larger than that by P&C insurers. Therefore, we would expect the effect of insurer clustering on bond yield spread to be more pronounced for Life insurers. To examine whether this is the case, we re-estimate *PCT Held by Insurers* by using the percent of total par amount outstanding held by Life insurers and re-estimate Model (5) using the IV approach.[10] Column (3) of Table 9 shows that the coefficient for *PCT Held by Insurers* increases in magnitude and remains significant at the 1% level.

5. Variations in the Effect of Insurer Clustering on Corporate Yield Spreads

The risk of fire sales of downgraded corporate bonds by insurance companies is induced by their regulatory constraints. A fire sale is more likely to occur at the time of a downgrade when the regulatory capital requirement becomes more binding for insurance companies. In this section, we examine whether various proxies for regulatory capital constraints strengthen the effect of insurer holdings on corporate bond yield spreads. Specifically, we empirically test our Predictions 2 and 3 on how the effect of insurer holdings varies in relation to insurer current capital constraints,

[10] Although the financial impact of Hurricanes Katrina and Rita was more direct on P&C insurers, life insurers, were also adversely affected when their P&C affiliates were stressed to the limit during the year of 2005. For example, several life insurers had to inject cash into their P&C affiliates to cover losses and shore up capital. In fact, life insurers, such as Mutual Savings Life Insurance Company, XL Life Insurance and Annuity, and XL Life Ltd (Bermuda), were put on negative review by rating agency A.M. Best. Several multi-line insurance companies with life insurance units, such as Allstate Corp., Balboa Insurance Group, Society of Lloyd's, and State Farm, were put on negative watch or review by rating agencies S&P and A.M. Best. For more information on the impact of Hurricane Katrina on the insurance industry, see Towers Watson (2015).

a bond's proximity to a NAIC risk category with a higher capital requirement, and the recent financial crisis.

5.1. Insurer Regulatory Capital Constraint

Prediction 2 states that a bond that is largely held by regulatory-constrained insurance companies will be subject to greater fire sale risk and exhibit a higher yield spread, *ceteris paribus*. To test this part of Prediction 2, we first follow Ellul, Jotikasthira, and Lundblad (2011) and employ the following two capitalization ratios to measure regulatory constraints: the NAIC risk-based capital ratio (RBC ratio) and Weiss Rating's risk-adjusted capital ratio 1 (RACR1).[11] RBC ratio is defined as the ratio of an insurer's total adjusted capital to NAIC risk-based capital (RBC), which is the minimum amount of capital appropriate for an insurance company to support its overall business operations in consideration of its size and risk profile. A lower RBC ratio indicates that an insurance firm is less capitalized. RACR1 is similar to RBC ratio except that the risk-adjusted capital in the denominator of RACR1 is calculated based on Weiss Rating's own risk assessment.

We then classify insurance companies into more and less regulatory constrained categories based on its RBC ratio or RACR1. Specifically, an insurer is considered to be more regulatory constrained if its RBC ratio (RACR1) is less than the median of our sample.[12] We respectively calculate the quarterly holdings by more constrained insurers and less constrained insurers as percentage of the total bonds outstanding: *PCT by More CONSTRNT* and *PCT by Less*

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[11] Weiss Rating is a provider of bank, credit union, and insurance company financial strength ratings and sovereign debt ratings. It does not accept compensation from the companies it rates for issuing the ratings and does not allow companies to influence the ratings they receive or to suppress the release of their ratings. Weiss Rating was sold to The Street.com in 2006 and then bought back to Weiss Group in 2010.

[12] Using median instead of mean has the benefit to avoid the possibility that our findings could be dominated by a few insurers with very large or small capitalization ratios. Ellul, Jotikasthira, and Lundblad (2011) finds that in terms of regulatory constraints, life and property insurers are similar at the median, but very different at the mean. The property insurers in the right tail have extremely high capitalization ratios and hold significantly less speculative-grade bonds due to their relatively uncertain claims.

CONSTRNT. Finally, we replace *PCT held by Insurers* with *PCT by More CONSTRNT* and *PCT by Less CONSTRNT* and use the IV method to re-estimate equation (5). Specifically, we use the two instrumental variables, *2005Dummy* and *Redemption at Maturity*, to estimate two first-stage regressions and one second-stage regression jointly. The two first-stage regressions have the dependent variable of *PCT by More CONSTRNT* and *PCT by Less CONSTRNT* respectively and both fitted values are included in the second-stage regression. Results are presented in Table 10.

As shown in Panel A where RBC ratio is used as the measure of regulatory constraint, the coefficients for our instrumental variables carry the expected signs and are highly significant in both first-stage regressions. Interestingly, the coefficient on *Redemption at Maturity* is smaller when explaining *PCT by More CONSTRNT* than when explaining *PCT by Less CONSTRNT*. This finding suggests that proceeds from bond redemption may be partially preserved by more constrained insurers to improve their RBC ratios. Comparing the estimated coefficients on *2005Dummy*, there is a significantly larger reduction in the percentage of bonds owned by more constrained insurers in 2005, indicating that more bonds were sold by those insurers to cover claims from the catastrophic hurricanes. As reported, the *F*-tests of the strength of the instruments in the two first-stage regressions are both highly significant.

More importantly, the coefficients on *PCT by More CONSTRNT* in the second-stage regression is positive and highly significant, and it is higher than that on *PCT by Less CONSTRNT*, with the difference being statistically significant at the 1% level. This finding confirms the first part of Prediction 2 that holdings by more constrained insurers have a larger effect on bond yield spread. It also alleviates the concern that holdings by insurance companies are simply capturing general liquidity effects. The coefficient on *PCT by Less CONSTRNT* is also positive and highly significant, suggesting that the market could be pricing the possibility that some of the currently less constrained insurers may suffer from financial struggles in the future. We also conduct the analyses using RACR1 as the measure of regulatory constraint and the results are qualitatively the same (see Panel B of Table 10).

5.2. Proximity to the Higher Capital Requirement

Prediction 2 also implies that the effect of insurer holding on yield spread should be stronger for bonds closer to NAIC risk category boundaries, (and hence more likely to be subject to higher capital requirements), especially between investment grade and speculative grade. To test this portion of Prediction 2, we divide our sample into two subsamples: bonds on the risk category boundaries (A and BBB) and those that are not (AAA and AA). We then re-estimate equation (5) on each of the two subsamples. As shown by Panel A of Table 11, the coefficient for *PCT Held by Insurers* is positive and highly significant for both subsamples. More importantly, the coefficient estimate of *PCT Held by Insurers* for the subsample of bonds on the risk category boundaries is more than 3 times larger than that for the non-boundary bonds, and the difference is statistically significant at the 1% level. This finding suggests that bonds with ratings closer to a higher risk category with higher capital requirements are indeed subject to higher fire sale risks.

Furthermore, the capital requirement progressively increases when moving from one risk category to the next higher-risk category. The highest percentage increase happens from category 2 (investment grade) to category 3 (speculative grade), equivalent to a credit rating downgrade by S&P from BBB to BB. In addition, insurance companies are often forced to sell when a bond is downgraded to speculative grade since they are usually required to invest no more than 20% of their portfolio in speculative-grade bonds. Therefore, we hypothesize that the effect of regulation-induced fire sale risk should be more pronounced for BBB-rated bonds than A-rated bonds, although both of them lie at the boundaries of NAIC risk categories. This hypothesis also follows from the second part of Prediction 2.

To test this hypothesis, we re-estimate our equation (5) separately in A- and BBB-rated bonds. Again, the evidence is consistent with the conjecture that bonds closer to the cutoff between investment grade and speculative grade are subject to higher fire sale risk (Panel B of Table 11). The coefficient of *PCT Held by Insurers* is 17.58 for BBB-rated bonds, which is statistically significantly higher than that for A-rated bonds (10.505). In sum, our findings provide support for Prediction 2 that fire sale risk in bonds varies in relation to their proximity to higher risk categories that are subject to higher regulatory capital requirements and other restrictions.

5.3. Financial Crisis

During the recent financial crisis, the downgrade probability for a bond's credit rating increased dramatically. According to the 2012 Annual Global Corporate Default Study and Rating Transitions published by S&P, the average percentage of corporate rating downgrades among all issuers is 9.68% between 2003 and 2007. However, this percentage increased to 16.05% in 2008 and 19.18% in 2009.

Meanwhile, the insurance industry had been adversely affected during the crisis (Koijen and Yogo (2015)). Using our sample data, we also find that the average RBC ratio was 30.15 between 2002 and 2007 whereas the average declined to 11.08 between 2008 and 2010. This decline indicates that the overall insurance industry experienced regulatory capital constraints from the onset of the financial crisis. The increased downgrade probabilities as well as the industry-wide capital constraints lead us to expect a greater effect of fire sale risk on the corporate yield spread during the financial crisis. This corresponds to our Prediction 3.

To test this hypothesis, we divide our sample into pre-crisis period (2002:Q3 to 2007:Q2) and post-crisis period (2007:Q3 to 2011:Q4). Equation (5) is then re-estimated for each period and the results are reported in Table 12. Consistent with our hypothesis, the estimated coefficient on *PCT Held by Insurers* is 1.39 for the pre-crisis period and in contrast, 8.93 for the post-crisis period, and the difference is statistically significant at the 1% level. Becker and Ivashiva (2015) find that "reaching for yield" by insurance companies disappears following the onset of financial crisis. Our results suggest bonds are still subject to fire sale risks as long as there is clustered investment from insurance companies that face regulatory constraints. Indeed, the effect of fire sale risk is heightened by the higher probability of downgrade and the more restrictive capital constraints that insurance companies face during the financial crisis.

6. Conclusions

This paper explores the collective role of insurance companies as major corporate bond investors in determining corporate bond yield spreads. During our sample period from 2002-2011, the insurance industry held almost half of outstanding investment-grade corporate bonds. In addition, investment decisions among insurance companies are highly correlated with one another. Meanwhile, insurance companies operate under regulations that constrain their risk-taking capacity. Their collective need to divest a downgraded issue due to binding regulatory constraints can induce a fire sale. Such regulation-induced fire sales cause bond prices to fall significantly below fundamental values for an uncertain period of time and can be detrimental to other investors in the market.

We hypothesize that the risk of regulation-induced fire sales, which arises from the investment commonality across insurance companies, can affect corporate bond pricing. Investors require higher yield for holding bonds with greater clustering of insurance companies (and hence subject to higher risk of fire sales), all else equal. We estimate the clustering of insurance companies in a bond by the percentage of par amount outstanding held by insurance companies and use it as a proxy for the amount of fire sale risk. We find that the clustering proxy has significant explanatory power for corporate bond yield spreads, after controlling for potential endogeneity bias and the general effect of liquidity, credit risk and other traditional bond pricing factors. In particular, for our full sample of investment-grade corporate bonds, a one-standard-deviation increase of 22.50% in the percentage held by insurance companies is associated with a 1.61% increase in the yield spread. The effect of insurer clustering on bond yield spreads is more pronounced when the bond is held by more regulation-constrained insurance companies. For the subsample of bonds with credit ratings in the proximity of ratings with higher capital requirements, the effect of insurer clustering is stronger on yield spreads. This is consistent with a credit rating downgrade being more likely to make these bonds subject to higher capital requirements. In addition, the effect of insurer clustering is heightened during the recent financial crisis. We attribute this finding to increased probability of rating downgrade among all bond issues and more restrictive capital constraints faced by insurance companies during the financial crisis.

Our study suggests that correlated investment activities among insurance companies, as major investors in bonds, creates an additional source of risk in the corporate bond market. Clustering of insurance companies in certain bonds can expose all investors to damages from fire-sale prices in the aftermath of rating downgrades. Our empirical results support the argument by Schwarcz and Schwarcz (2015) that regulators should attempt to address the potential systemic risks arising from the collective investment decisions of insurers, in addition to risks from individually “Too Big To Fail” firms.

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Appendix 1: Variable Definition

This appendix presents the definition of all variables in Tables 8-11.

Variable Name	Variable Definition
Yield Spread	The spread of the yield on a corporate bond over the yield on a default-free bond with the same maturity and coupon.
PCT Held by Insurers	The ratio of par amount held by insurance companies to the total par amount outstanding for a given bond in a given quarter.
Redemption at Maturity	Total par amount of bonds redeemed within a rating- and term-based group, normalized by the total par amount of new issuance in the same group.
2005Dummy	A dummy variable that takes the value one for 2005 when six catastrophic hurricanes occurred, causing $66.1 billion dollars of total insured losses (in 2011 dollars) and 1,518 deaths.
Credit Rating	The lower of Moody's and S&P's ratings. A numeric value is assigned to each notch of Moody's (S&P's) credit rating, with 1, 2, 3,… denoting Aaa (AAA), Aa1(AA+), Aa2(AA) …, respectively.
Time to Maturity	Number of years for the bond to mature.
Coupon	A bond's coupon rate, denoted as a percentage of a bond's face value.
Age	Number of years since the issuance of the bond.
Amout Outstanding	The log of the total par amount outstanding of the bond.
Trade Volume	The log of total par amount traded in a bond within a quarter.
Leverage	The ratio of total debt to total capitalization, which is the market value of equity plus the book value of debt.
LTD Leverage	The ratio of long-term debt to total assets.
M/B	Market-to-book ratio.
Operating Margin	Operating income before depreciation divided by net sales.
Pretax d1	First increment of pretax interest coverage ratio between 0 and 5, using the procedure in Blume, Lim, and MacKinlay (1998).
Pretax d2	Second increment of pretax interest coverage ratio between 5 and 10, using the procedure in Blume, Lim, and MacKinlay (1998).
Pretax d3	Third increment of pretax interest coverage ratio between 10 and 20, using the procedure in Blume, Lim, and MacKinlay (1998).
Pretax d4	Fourth increment of pretax interest coverage ratio between 20 and 100, using the procedure in Blume, Lim, and MacKinlay (1998).
Issuer Equity Return	The mean of the daily beta adjusted excess return of the issuer's stock within a quarter.
Issuer Equity Volatility	The variance of the daily beta adjusted excess return of the issuer's stock within a quarter.
VIX	CBOE S&P500 implied volatility index.
Stock Market Return	The mean of the stock market index returns within a quarter, measured using CRSP value-weighted index returns.
EuroDollar	The difference between the 30-day Eurodollar and Tresaury bill rate.
Credit Spread	Moody's seasoned corporate credit spreads between Baa and Aaa bonds.
Term Level	The 1-year treasury rate.
Term Slope	The difference between 10-year and 2-year treasury rates.

Table 1: NAIC Risk-Based Capital Requirements

This table summarizes National Association of Insurance Commissioners (NAIC) pre-tax capital requirement factors (capital charges) for each NAIC risk category and its corresponding credit ratings from S&P. Information is obtained from the report published by American Academy of Actuaries C1 Work Group (2015).

NAIC Category	Credit Ratings	Capital Charge
U.S. Federal Government		0.0%
NAIC 1	AAA, AA, A	0.4%
NAIC 2	BBB	1.3%
NAIC 3	BB	4.6%
NAIC 4	B	10%
NAIC 5	CCC	23%
NAIC 6	CC or below	30%

Table 2: Descriptive Information on Issuer and Issue Characteristics

The sample includes 3,249 U.S. investment-grade corporate bonds issued by 547 companies and covers the period from the third quarter of 2002 to the last quarter of 2011. Data on bond characteristics are obtained from Mergent Fixed Income Security Database (FISD). Data on issuer characteristics are obtained from CRSP and Compustat. *Total Assets* is the book value of total assets. *Market-to-Book Ratio* is the ratio of total capitalization to *Total Assets*. Total capitalization is the market value of equity plus the book value of liabilities. *Leverage* is defined as the ratio of total debt to total capitalization. *Operating Margin* is defined as operating income before depreciation divided by net sales. *Pre-Tax Interest Coverage Ratio* is defined as the ratio of operating income after depreciation plus interest expense to interest expense. *Issuer Excess Stock Return* and *Issuer Excess Stock Return Volatility* refer to the mean and variance of the daily beta adjusted excess return of the issuer's stock within a quarter respectively. *Credit Rating* is the lower of Moody's and S&P's ratings. A numeric value is assigned to each notch of Moody's (S&P's) credit rating, with 1, 2, 3, 4,… denoting Aaa (AAA), Aaa1 (AA+), Aa2 (AA), Aa3 (AA-) …, respectively. *Time to Maturity* is the number of years till a bond's maturity date. *Age* refers to the number of years since issuance. *Coupon* is a bond's coupon rate and *Amount Outstanding* is a bond's total par amount outstanding.

	Mean	Median	STD	Nobs
Issuer Characteristics:				
Total Assets ($ Million)	108117.460	25249.500	292540.540	39884
Market-to-Book Ratio	1.204	1.003	0.741	39884
Leverage (%)	30.212	0.237	0.211	39884
Oprating Margin (%)	19.021	18.546	132.777	39884
Pre-Tax Interest Coverage Ratio	9.861	7.102	10.057	39884
Issuer Excess Stock Return (%)	-1.845	-1.351	19.833	39884
Issuer Excess Stock Return Volatility (%)	1.427	1.181	1.013	39884
Issue Characteristics:				
Credit Rating	7.260	7.000	1.932	39884
Time to Maturity (Years)	10.554	6.465	11.519	39884
Age (Years)	5.780	4.724	4.072	39884
Coupon (%)	6.271	6.250	1.265	39884
Amount Outstanding ($ Million)	495.755	300.000	564.919	39884

Table 3: Summary Statistics on the Percentage of Par Amount Outstanding Held by Insurers

This table provides summary statistics on the quarterly holding in individual investment-grade corporate bond by insurance companies as a percentage of a bond's total par amount outstanding. Data on bond holdings for insurance companies are obtained from Lipper's eMAXX database. Data on bond characteristics, such as par amount outstanding, credit rating, and maturity date are obtained from Mergent FISD. Our sample covers the period from the third quarter of 2002 to the last quarter of 2011. Summary statistics on the percentage of par amount outstanding held by insurers are provided for the full sample, for each rating category, and for each term group. The lower of Moody's and S&P's credit ratings is used to form rating subsamples. A bond's time to maturity is used to form term subsamples. Bonds with time to maturity between 1 and 7 years are classified as short-term bonds, and those mature after 7 years are classified as long-term bonds.

	Mean	Median	STD	Nobs
Full Sample:				
	48.478%	48.361%	22.499%	39884
By Credit Rating:				
AAA	30.391%	31.311%	15.902%	388
AA	29.926%	25.845%	18.456%	2452
A	48.649%	48.775%	22.096%	18695
BBB	51.166%	51.086%	22.178%	18349
By Time to Maturity:				
Short-term (between 1 and 7 years)	43.932%	42.863%	21.817%	21409
Long-term (greater than 7 years)	53.746%	54.885%	22.126%	18475

Table 4: Insured Property Losses and Number of Deaths from Hurricanes: 2002-2011

This table reports summary information on yearly Hurricane damages for our sample period 2002-2011 using data from Insurance Information Institute. Catastrophic hurricanes are the ones causing insured property losses of at least $33 million in 2011 dollars and affecting a significant number of policyholders and insurers. The estimated insured losses are for catastrophic hurricanes only and the figure excludes losses covered by the federally administered National Flood Insurance Program. The number of deaths includes fatalities from high winds of less than hurricane force from tropical storms. Source: http://www.iii.org/fact-statistic/hurricanes .

Year	Total Number of Hurricanes	Number of Catastrophic Hurricanes	Estimated Insured Losses in 2011 Dollars (Billions)	Number of Deaths
2002	4	1	0.5	5
2003	7	2	2.1	24
2004	9	5	26.8	59
2005	15	6	66.1	1518
2006	5	0	NA	0
2007	6	0	NA	1
2008	8	3	15.8	41
2009	3	0	NA	6
2010	12	0	NA	11
2011	7	1	4.3	44

Table 5: Descriptive Information on Insurers' Investment in Corporate Bonds

This table examines investment behavior of 3,982 insurance companies in the investment-grade corporate bond market over the sample period from the third quarter of 2002 to the last quarter of 2011. Data on corporate bond holdings for insurance companies are obtained from Lipper's eMAXX database. Data on bond characteristics, such as par amount outstanding, credit rating, and maturity date are obtained from Mergent FISD. *PCT of Par Amount Held to Maturity* is defined as the ratio of par amount held to maturity to the sum of par amount held to maturity and par amount sold prior to maturity for each insurance company. *PCT of Par Amount Held to Downgrade* is defined as the ratio of par amount sold within one year of a downgrade by either Moody's or S&P to the sum of par amount held to maturity and par amount sold prior to maturity for each insurance company. For the total of 894,714 bond acquisitions by insurance companies during our sample period, we present summary statistics on the bonds, including *Time to Maturity*, *Credit Rating*, *Age*, and *Par Amount Outstanding*, at the time of acquisition.

	Mean	Median	STD	Nobs
PCT of Par Amount Held to Maturity (%)	60.04	60.80	26.75	3982
PCT of Par Amount Held to Downgrade (%)	12.91	11.09	11.07	3982
Time to Maturity of Bonds at Acquisition (Year)	9.840	8.008	8.522	894714
Credit Rating of Bonds at Acquisition	6.739	7	2.248	855550
Age of Bonds at Acquisition (Year)	1.909	0.562	2.862	894714
Par Amount Outstanding of Bonds at Acquisition ($ Million)	840.517	550.000	924.274	894714

Table 6: Reinvestment of Proceeds from Bond Redemption at Maturity by Insurers – Correlations

This table reports Pearson correlation coefficients to examine the style characteristics of proceed reinvestment by insurance companies from quarterly bond redemption at maturity. P-values are reported in parentheses. The sample period is from the third quarter of 2002 to the last quarter of 2011. Rating categories are formed based on the lower of Moody's and S&P's credit ratings. Term categories are formed based on each bond's time to maturity. Bonds with time to maturity between 1 and 7 years are classified as short-term bonds, and those mature after 7 years are classified as long-term bonds. Acquisition (redemption) in a rating- or/and term-based group refers to the total par amount of bonds in the group acquired (redeemed) by an insurance company in a quarter. In Panel A and Panel B, bond groups are formed on credit rating and term, respectively. In Panel C, bond groups are formed on both credit rating and term.

Panel A. By Rating:

	Acquisition AAA	Acquisition AA	Acquisition A	Acquistion BBB
Redemption AAA	0.111	0.039	0.032	0.033
	(0.000)	(0.000)	(0.000)	(0.000)
Redemption AA	0.037	0.123	0.051	0.057
	(0.000)	(0.000)	(0.000)	(0.000)
Redemption A	0.047	0.062	0.135	0.082
	(0.000)	(0.000)	(0.000)	(0.000)
Redemption BBB	0.053	0.082	0.093	0.168
	(0.000)	(0.000)	(0.000)	(0.000)

Panel B. By Term:

	Acquisition Short-Term	Acquisition Long-Term
Redemption Short-Term	0.153	0.089
	(0.000)	(0.000)
Redemption Long-Term	0.052	0.185
	(0.000)	(0.000)

Panel C. By both Rating and Term:

	Acquisition Short-Term AAA	Acquisition Long-Term AAA	Acquisition Short-Term AA	Acquisition Long-Term AA	Acquisition Short-Term A	Acquisition Long-Term A	Acquisition Short-Term BBB	Acquisition Long-Term BBB
Redemption Short-Term AAA	0.116	0.055	0.040	0.082	0.049	0.062	0.033	0.048
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Redemption Long-Term AAA	-0.005	0.163	0.012	0.025	-0.004	0.024	0.005	0.024
	(0.187)	(0.005)	(0.003)	(0.000)	(0.212)	(0.000)	(0.119)	(0.000)
Redemption Short-Term AA	0.083	0.037	0.220	0.042	0.011	0.038	0.016	0.045
	(0.031)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Redemption Long-Term AA	0.020	0.033	0.017	0.256	0.022	0.069	0.029	0.070
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Redemption Short-Term A	0.027	0.078	0.142	0.097	0.241	0.071	0.049	0.086
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Redemption Long-Term A	0.020	0.056	0.036	0.066	0.108	0.292	0.149	0.169
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Redemption Short-Term BBB	0.034	0.062	0.097	0.084	0.073	0.102	0.260	0.110
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Redemption Long-Term BBB	0.097	0.071	0.101	0.139	0.176	0.165	0.089	0.268
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 7: Reinvestment of Proceeds from Bond Redemption at Maturity by Insurers – Multivariate Analyses

This table reports results from multivariate regression analyses to examine the style characteristics of proceed reinvestment by insurance companies from bond redemption at maturity. The sample period is from the third quarter of 2002 to the last quarter of 2011. Observations are firm-quarters. We first form eight bond groups by interacting four rating categories (AAA, AA, A and BBB) with two term categories (short-term and long-term). Acquisition (redemption) in a bond group refers to the total par amount of bonds in the group acquired (redeemed) by an insurance company in a quarter. The dependent variable is the natural logarithm of acquisition amount in one of the eight bond groups for the eight columns of this table. The independent variables are the redemption amount normalized by the total par amount of new bond issues in the eight bond groups. All regressions are estimated with both time and firm fixed effects. Heteroscedasticity adjusted robust *p*-values are provided next to each estimate.

	(1) Acquisition in Short-Term AAA		(2) Acquisition in Long-Term AAA		(3) Acquisition in Short-Term AA		(4) Acquisition in Long-Term AA		(5) Acquisition in Short-Term A		(6) Acquisition in Long-Term A		(7) Acquisition in Short-Term BBB		(8) Acquisition in Long-Term BBB	
	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value
Redemption in Short-Term AAA	2.259	0.022	0.011	0.893	-0.225	0.007	-0.085	0.342	0.037	0.718	-0.125	0.238	-0.099	0.321	-0.259	0.016
Redemption in Long-Term AAA	0.055	0.656	2.193	0.012	-0.249	0.066	-0.374	0.009	-0.237	0.143	0.082	0.629	-0.301	0.064	0.323	0.065
Redemption in Short-Term AA	-0.187	0.040	0.179	0.063	2.076	0.001	0.309	0.004	0.031	0.797	0.140	0.270	0.182	0.129	0.176	0.168
Redemption in Long-Term AA	-0.005	0.650	0.001	0.964	-0.023	0.057	3.725	0.029	-0.009	0.553	-0.031	0.039	0.014	0.330	0.019	0.213
Redemption in Short-Term A	-0.142	0.630	-0.199	0.534	-1.578	0.000	-0.923	0.007	3.560	0.000	-2.072	0.000	-1.315	0.001	-1.625	0.000
Redemption in Long-Term A	-1.300	0.000	0.083	0.790	0.301	0.342	0.760	0.024	-0.544	0.153	8.654	0.000	-0.503	0.181	-0.879	0.025
Redemption in Short-Term BBB	-0.094	0.542	-0.458	0.005	0.413	0.012	-0.237	0.183	0.024	0.904	-0.723	0.001	5.818	0.000	-1.346	0.000
Redemption in Long-Term BBB	0.328	0.257	-0.483	0.123	0.537	0.083	0.099	0.764	-1.558	0.000	-1.317	0.001	-1.267	0.001	6.582	0.000
Nobs	32488		45033		68957		69224		80336		94080		101396		119545	
Adj. R^2	0.209		0.244		0.400		0.265		0.287		0.343		0.339		0.405	
Time Fixed Effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Firm Fixed Effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	

Table 8: Fire Sale Risk and Corporate Bond Yield Spreads

This table reports the results from the two-stage least squares regression as illustrated in equation (5). The sample period is from the third quarter of 2002 to the last quarter of 2011. The results from the first-stage and the second-stage regressions are presented in Columns (1) and (2) respectively. The dependent variable for the first stage is *PCT Held by Insurers*, which is defined as the ratio of a bond's par amount held by insurance companies to the bond's total par amount outstanding. In the second stage, the dependent variable is a bond's yield spread. Our instrumental variables are *Redemption at Maturity* and *2005Dummy*. All variables are defined in Appendix 1. Heteroscedasticity adjusted *p*-values are provided next to each estimate. First-stage *F*-test is the test of excluded IV in the first-stage regression.

	(1) 1st Stage		(2) 2nd Stage	
	Estimate	P-value	Estimate	P-value
Intercept	1.570	0.000	-4.375	0.007
Redemption at Maturity	0.605	0.000		
2005Dummy	-0.009	0.016		
Pct Held by Insurers			7.165	0.000
Credit Rating	0.011	0.000	0.109	0.000
Time to Maturity	0.002	0.000	-0.003	0.488
Coupon	-0.005	0.000	0.093	0.000
Age	0.000	0.853	0.015	0.000
Amount Outstanding	-0.033	0.000	0.150	0.342
Trade Volume	-0.029	0.000	-0.206	0.000
Leverage	-0.333	0.000	3.135	0.000
LTD Leverage	0.224	0.000	-1.931	0.000
M/B	-0.041	0.000	0.292	0.000
Operating Margin	-0.002	0.001	0.007	0.341
Pretax d1	-0.005	0.000	-0.092	0.000
Pretax d2	-0.010	0.000	0.110	0.000
Pretax d3	0.003	0.000	-0.031	0.000
Pretax d4	0.001	0.000	-0.002	0.217
Issuer Equity Return	0.010	0.048	-0.153	0.001
Issuer Equity Volatility	-0.009	0.000	0.581	0.000
VIX	-0.003	0.000	0.021	0.000
Stock Market Return	-0.078	0.000	-0.470	0.051
EuroDollar	0.003	0.241	0.218	0.000
Credit Spread	0.020	0.000	0.785	0.000
Term Level	-0.013	0.000	-0.100	0.001
Term Slope	-0.019	0.000	-0.042	0.354
Nobs	39884		39884	
First-stage F-test (p-value)	0.000			
Adj. R^2	0.318		0.372	

Table 9: Robustness Checks

This table presents results from robustness checks of the analyses on the effect of insurer clustering on corporate yield spread. Equation (5) is estimated in each column and the results from the second-stage regressions are provided. In Column (1), bonds issued by firms in states directly affected by Katrina are excluded from the sample. In Column (2), bonds issued by insurance companies are excluded from the sample. In Column (3), we re-estimate *PCT Held by Insurers* by using the percent of total par amount outstanding held by Life insurers. All variables are defined in Appendix 1. Heteroscedasticity adjusted p-values are provided next to each estimate.

	(1) Excluding issuers in Katrina states		(2) Excluding bonds issued by insurers		(3) Holdings by Life insurers	
	Estimate	P-value	Estimate	P-value	Estimate	P-value
Intercept	-5.069	0.009	-4.695	0.000	-8.146	0.000
PCT Held by Insurers	8.118	0.000	6.511	0.000	11.049	0.006
Credit Rating	0.103	0.000	0.103	0.000	0.079	0.097
Time to Maturity	-0.006	0.227	-0.001	0.800	-0.003	0.772
Coupon	0.095	0.000	0.065	0.000	0.033	0.009
Age	0.017	0.000	0.021	0.000	0.003	0.553
Amout Outstanding	0.186	0.074	0.181	0.075	0.128	0.165
Trade Volume	-0.229	0.000	-0.179	0.000	-0.030	0.005
Leverage	3.481	0.000	2.760	0.000	3.932	0.000
LTD Leverage	-2.283	0.000	-1.544	0.000	-2.557	0.000
M/B	0.339	0.000	0.364	0.000	0.527	0.000
Oprating Margin	0.010	0.230	-0.112	0.090	0.017	0.109
Pretax d1	-0.098	0.000	-0.082	0.000	-0.061	0.006
Pretax d2	0.129	0.000	0.078	0.000	0.128	0.000
Pretax d3	-0.037	0.000	-0.037	0.000	-0.048	0.000
Pretax d4	-0.004	0.059	-0.003	0.193	-0.007	0.026
Issuer Equity Return	-0.167	0.001	-0.175	0.000	-0.204	0.002
Issuer Equity Volatility	0.603	0.000	0.594	0.000	0.602	0.000
VIX	0.024	0.000	0.017	0.000	0.030	0.000
Stock Market Return	0.553	0.000	0.317	0.026	0.634	0.001
EuroDollar	0.188	0.000	0.259	0.000	0.169	0.000
Credit Spread	0.725	0.000	0.748	0.000	0.718	0.000
Term Level	-0.082	0.016	-0.114	0.000	-0.025	0.614
Term Slope	-0.024	0.634	-0.055	0.213	0.086	0.272
Nobs	37912		36301		39884	
Adj. R^2	0.327		0.372		0.235	

Table 10: Capital Constraints and the Effect of Fire Sale Risk on Corporate Bond Yield Spreads

This table relates the effect of fire sale risk on corporate bond yield spreads to the regulatory capital constraints faced by insurers. The sample period is from the third quarter of 2002 to the last quarter of 2011. We use two alternative measures of regulatory constraints: NAIC Risk-Based Capital Ratio (RBC Ratio) and Risk-Adjusted Capital Ratio 1 (RACR1), and the results are presented in Panels A and B respectively. An insurance company is considered as being more (less) constraint if its RBC ratio or RACR1 is lower (higher) than the median of our sample. *PCT by More CONSTRNT* (*PCT by Less CONSTRNT*) is defined as the ratio of a bond's par amount held by more (less) constraint insurance companies to the bond's total par amount outstanding. For Columns (1) and (4), the dependent variable is *PCT by More CONSTRNT*. For Columns (2) and (5), the dependent variable is *PCT by Less CONSTRNT*. For Columns (3) and (6), the dependent variable is Yield Spread. All the other variables are defined in Appendix 1. Heteroscedasticity adjusted p-values are provided next to each estimate. First-stage *F*-test is the test of excluded IV in the first-stage regression. We also test on the difference between *PCT by More CONSTRNT* and *PCT by Less CONSTRNT* in Columns (3) and (6) and provide the *p*-values of the *F*-test in the bottom of the table.

	Panel A. RBC Ratio						Panel B. RACR1					
	(1) 1st Stage: More Constraint		(2) 1st Stage: Less Constraint		(3) 2nd Stage		(4) 1st Stage: More Constraint		(5) 1st Stage: Less Constraint		(6) 2nd Stage	
	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value
Intercept	1.171	0.000	0.345	0.000	-4.311	0.006	1.175	0.000	0.362	0.000	-4.710	0.004
Redemption at Maturity	0.170	0.044	0.690	0.001			0.150	0.036	0.590	0.000		
2005Dummy	-0.064	0.000	-0.007	0.012			-0.068	0.000	-0.019	0.000		
PCT by More CONSTRNT					7.853	0.000					8.330	0.000
PCT by Less CONSTRNT					4.662	0.000					5.371	0.000
Credit Rating	0.004	0.000	0.007	0.000	0.168	0.000	0.007	0.000	0.004	0.000	0.156	0.000
Time to Maturity	0.000	0.000	0.003	0.000	0.014	0.000	-0.001	0.000	0.003	0.000	0.027	0.000
Coupon	0.010	0.000	-0.009	0.000	0.074	0.000	-0.003	0.001	0.001	0.153	0.056	0.000
Age	0.002	0.000	-0.003	0.000	0.011	0.000	-0.001	0.000	-0.001	0.010	0.020	0.000
Amout Outstanding	-0.019	0.000	-0.013	0.000	-0.012	0.740	-0.025	0.000	-0.007	0.000	-0.023	0.534
Trade Volume	-0.015	0.000	-0.013	0.000	-0.065	0.029	-0.017	0.000	-0.011	0.000	-0.067	0.048
Leverage	-0.164	0.000	-0.165	0.000	1.434	0.000	-0.149	0.000	-0.181	0.000	1.070	0.014
LTD Leverage	0.094	0.000	0.112	0.000	-0.596	0.012	0.077	0.000	0.130	0.000	-0.267	0.366
M/B	-0.014	0.000	-0.024	0.000	0.055	0.218	-0.015	0.000	-0.023	0.000	0.012	0.824
Oprating Margin	-0.001	0.042	-0.001	0.009	-0.005	0.270	-0.001	0.006	-0.001	0.042	-0.005	0.364
Pretax d1	-0.004	0.000	0.002	0.068	-0.112	0.000	-0.005	0.000	0.002	0.006	-0.095	0.000
Pretax d2	-0.006	0.000	-0.006	0.000	0.071	0.000	-0.006	0.000	-0.006	0.000	0.062	0.000
Pretax d3	0.000	0.213	0.003	0.000	-0.014	0.002	0.000	0.603	0.003	0.000	-0.004	0.482
Pretax d4	0.000	0.083	0.001	0.000	0.002	0.099	0.001	0.000	0.000	0.268	0.000	0.997
Issuer Equity Return	0.011	0.002	-0.003	0.367	-0.110	0.000	0.009	0.017	-0.001	0.812	-0.118	0.000
Issuer Equity Volatility	-0.011	0.000	0.001	0.320	0.561	0.000	-0.011	0.000	0.001	0.341	0.579	0.000
VIX	-0.003	0.000	0.000	0.757	0.015	0.000	-0.002	0.000	0.000	0.062	0.016	0.000
Stock Market Return	-0.068	0.000	-0.025	0.002	-0.350	0.000	-0.063	0.000	-0.019	0.015	-0.250	0.025
EuroDollar	0.021	0.000	-0.016	0.000	0.156	0.000	0.015	0.000	-0.010	0.000	0.125	0.000
Credit Spread	-0.007	0.067	0.027	0.000	0.852	0.000	0.012	0.002	0.007	0.050	0.794	0.000
Term Level	-0.082	0.000	0.066	0.000	-0.017	0.476	-0.050	0.000	0.035	0.000	0.063	0.074
Term Slope	-0.126	0.000	0.101	0.000	0.048	0.206	-0.081	0.000	0.056	0.000	0.193	0.001
Nobs	34641		34641		34641		34641		34641		34641	
First-stage F-test (P-value)	0.000		0.000				0.000		0.000			
Adj. R^2	0.235		0.244		0.532		0.253		0.231		0.564	
Test: difference in regression coefficients PCT by More CONSTRNT vs. PCT by Less CONSTRNT												
P-value						0.000						0.000

Table 11: Capital Requirements and Fire Sale Risk

This table analyzes whether the effect of fire sale risk on corporate bond yield spreads varies across different risk categories as determined by NAIC. NAIC classifies corporate bonds into six risk categories using credit ratings, and imposes different capital requirements on insurers for holding bonds in different risk categories. Investment-grade bonds belong to the top 2 risk categories, with bonds rated AAA, AA and A classified as NAIC Category 1 and those rated BBB classified as NAIC Category 2. In columns (1) and (2), we compare the effect of fire sale risks on bond yield spreads between a sample of AAA-rated and AA-rated bonds with a sample of A- and BBB-rated bonds. The latter sample includes bonds with ratings that are on the boundaries of NAIC risk categories 1 and 2. In columns (3) and (4), we examine within the sample of bonds which are at the boundary of risk categories. For BBB-rated bonds that are closer to the cutoff between investment grade and speculative grade, fire sale risks have a larger impact on yield spread. Equation (5) is estimated for each sample and the results from the second-stage regressions are provided in the table. All variables are defined in Appendix 1. Heteroscedasticity adjusted *p*-values are provided next to each estimate. We also conduct F-tests on whether the coefficient on *PCT Held by Insurers* varies across sub-samples and provide the *p*-values from the tests in the bottom of the table.

	Whether on the boundary of NAIC risk categories				Distance to the cutoff between investment grade and speculative grade			
	(1) AAA & AA		(2) A & BBB		(3) A		(4) BBB	
	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value
Intercept	-4.474	0.039	-1.703	0.043	-11.716	0.008	0.669	0.013
PCT Held by Insurers	6.114	0.008	19.425	0.008	10.505	0.000	17.580	0.000
Time to Maturity	-0.026	0.069	-0.028	0.145	-0.010	0.085	0.025	0.000
Coupon	0.027	0.200	0.208	0.000	0.010	0.555	0.033	0.331
Age	-0.028	0.113	0.009	0.252	0.061	0.000	0.032	0.010
Amout Outstanding	0.301	0.120	-0.163	0.028	0.552	0.094	-0.287	0.000
Trade Volume	-0.120	0.001	-0.608	0.022	-0.208	0.000	-0.307	0.017
Leverage	1.700	0.000	6.861	0.021	4.784	0.000	2.063	0.059
LTD Leverage	0.380	0.115	-4.825	0.034	-0.997	0.000	-0.851	0.224
M/B	-0.141	0.012	0.724	0.067	0.355	0.000	-0.232	0.025
Oprating Margin	-0.016	0.457	0.035	0.130	0.006	0.532	-0.258	0.005
Pretax d1	-0.010	0.832	-0.028	0.614	-0.065	0.007	-0.176	0.000
Pretax d2	0.048	0.047	0.222	0.020	0.168	0.000	-0.038	0.204
Pretax d3	-0.027	0.004	-0.079	0.005	-0.006	0.324	0.026	0.299
Pretax d4	0.003	0.164	-0.025	0.039	-0.009	0.005	0.017	0.037
Issuer Equity Return	0.120	0.269	-0.339	0.016	-0.363	0.000	-0.023	0.730
Issuer Equity Volatility	0.379	0.000	0.790	0.000	0.618	0.000	0.473	0.000
VIX	0.001	0.877	0.046	0.030	0.037	0.000	0.001	0.895
Stock Market Return	-0.022	0.923	-1.287	0.031	-0.932	0.000	-0.328	0.075
EuroDollar	0.191	0.070	0.258	0.000	-0.027	0.726	0.025	0.764
Credit Spread	0.527	0.000	0.532	0.001	0.391	0.000	1.272	0.000
Term Level	0.040	0.635	-0.045	0.706	0.062	0.357	-0.270	0.000
Term Slope	0.208	0.159	0.058	0.756	0.087	0	-0.310	0.000
Nobs	2840		37044		18695		18349	
Adj. R^2	0.447		0.195		0.218		0.372	

Test: difference in regression coefficients on Pct by Insurers across sub-samples		
	AAA & AA vs. A & BBB	A vs. BBB
P-value	0.000	0.000

Table 12: Financial Crisis and Fire Sale Risk

This table analyzes whether the effect of fire sale risk on corporate bond yield spreads changes following the onset of financial crisis. Pre-crisis period is from the third quarter of 2002 to the second quarter of 2007. Post-crisis period covers the third quarter of 2007 till the last quarter of 2011. Equation (5) is estimated for pre- and post-crisis periods separately and the results from the second-stage regressions are provided in the table. All variables are defined in Appendix 1. Heteroscedasticity adjusted p-values are provided next to each estimate. We also conduct *F*-test on the difference in regression coefficient on *PCT Held by Insurers* between the two samples. The *p*-value from the test is provided in the bottom of the table.

	(1) Pre-crisis		(2) Post-crisis	
	Estimate	P-value	Estimate	P-value
Intercept	-1.182	0.025	-4.799	0.079
PCT Held by Insurers	1.394	0.035	8.932	0.001
Credit Rating	0.091	0.000	0.201	0.000
Time to Maturity	0.015	0.000	-0.006	0.454
Coupon	-0.009	0.621	0.299	0.001
Age	0.035	0.000	-0.039	0.113
Amout Outstanding	0.005	0.842	0.201	0.287
Trade Volume	-0.023	0.091	-0.353	0.056
Leverage	0.707	0.001	3.532	0.006
LTD Leverage	-0.078	0.661	-2.072	0.009
M/B	-0.010	0.706	0.351	0.056
Oprating Margin	0.005	0.136	-0.004	0.786
Pretax d1	-0.123	0.000	-0.055	0.242
Pretax d2	0.047	0.000	0.109	0.002
Pretax d3	-0.008	0.011	-0.027	0.015
Pretax d4	0.001	0.069	-0.001	0.765
Issuer Equity Return	-0.058	0.058	-0.155	0.033
Issuer Equity Volatility	0.388	0.000	0.613	0.000
VIX	0.028	0.000	0.008	0.078
Stock Market Return	0.018	0.808	-0.271	0.094
EuroDollar	0.022	0.701	0.140	0.002
Credit Spread	0.428	0.000	0.901	0.000
Term Level	-0.028	0.063	-0.086	0.069
Term Slope	-0.053	0.016	-0.160	0.007
Nobs	18784		21100	
Adj. R^2	0.391		0.370	
Test: difference in regression coefficients on Pct by Insurers between pre- and post-crisis periods				
P-value			0.001	