Regulatory Pressure and Fire Sales in the Corporate Bond Markets

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Abstract

This paper investigates fire sales of downgraded corporate bonds induced by regulatory constraints imposed on insurance companies. Regulations either prohibit or impose large capital requirements on the holdings of speculative-grade bonds. As insurance companies hold over one third of all outstanding corporate bonds, the *collective* need to divest downgraded issues may be limited by a scarcity of counterparties and associated bargaining power. Using insurance company transaction data from 2001-2005, we document both elevated selling pressure around the downgrade and subsequent price reversals that suggest significant periods during which transaction prices deviate from fundamental values. Most importantly, insurance companies that are relatively *more constrained* by regulation are, on average, more likely to sell downgraded bonds, and bonds widely held by these firms experience significantly larger price reversals. Investors providing liquidity to this market appear to earn abnormal returns.

JEL classifications: G11; G12; G14; G18; G22

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1. Introduction

This paper investigates fire sales of downgraded corporate bonds induced by regulatory constraints imposed on insurance companies. Shleifer and Vishny (1992) show that forced selling of industry-specific assets may yield transaction prices that are significantly below fundamental values. In these circumstances, buyers in the same industry may be facing financial constraints of their own and therefore will be unable to provide liquidity unless at discount prices.[1] The trading activity of downgraded bonds by insurance companies provides an environment in which to study forced selling. Insurance companies constitute an important part of the corporate bond market and, at the same time, face regulations that either prohibit or impose large capital requirements on the holdings of speculative-grade bonds.

Forced selling, coupled with the lack of liquidity, is likely to generate significant and persistent price pressures. Indeed, the empirical literature on asset fire sales provides several related examples in which transaction prices may deviate from fundamental values. Coval and Stafford (2007) study equity market transactions induced by open-end mutual fund redemptions. Mitchell, Pedersen and Pulvino (2007) investigate the price reaction of convertible bonds around convertible hedge fund redemptions.[2] Pulvino (1998) studies commercial aircraft transactions initiated by constrained versus unconstrained airlines. Finally, Campbell, Giglio and Pathak (2008) consider forced selling in the real estate market due to events such as foreclosures. In contrast, we examine a new channel that should produce fire sales, regulatory constraints. Regulations governing the investing behavior of insurance companies may effectively force the sale of certain assets and simultaneously prevent other insurance companies from stepping in as buyers. These effects are industry-wide, whereas mutual fund redemptions, for example, are more likely to be fund-specific.

Duffie, Garleanu and Pedersen (2007) provide some recent theoretical guidance. They show that the speed with which transaction prices recover depends to a large extent on the intensity of counterparty search costs and the associated level of market liquidity.

[1] Distressed sellers may end up being forced to sell to industry outsiders who face significant costs of acquiring and managing the assets.
[2] They also study the widening of merger spreads during the 1987 market crash and concurrently proposed antitakeover legislation.

In illiquid environments, a price recovery may take a significant period of time as market participants await a sufficient number of counterparties. For downgraded bonds, this becomes particularly problematic as insurance companies collectively hold between one-third and forty percent of all investment-grade corporate bonds (see Schultz (2001)). Since insurance companies face shared regulation, the resulting *collective* need to divest downgraded issues may be limited by a scarcity of counterparties and associated bargaining power.[3] Fire sale prices will obtain, leading to transaction prices significantly below fundamental values. Liquidity provision, then, has to come from outside of the insurance industry. The gradual emergence of alternative investors in high search cost markets, like that for downgraded corporate bonds, will generate a slow reversal of transaction prices and an eventual realignment with fundamental values.

To empirically test the fire sale hypothesis in the corporate bond market as related to regulatory requirements, we construct a dataset of 1,179 bonds that were downgraded to speculative-grade over the period 2001-2005. We combine information on these bonds with observations on insurance companies' holdings and transactions provided by the National Association of Insurance Commissioners (NAIC). Finally, we obtain data on the financial position and strength of *each insurance company* from the Street.com. We employ several industry-standard risk-based measures to determine which insurance companies have the lowest risk capacity and are thus most likely (to have) to sell the downgraded corporate bond if the regulatory pressure hypothesis is valid.

Several key empirical results deserve attention. First, we find that more constrained insurance companies are more likely to immediately sell (at least part of) their holdings of a downgraded corporate bond. This result obtains even after controlling for insurance company and bond characteristics. This result implies that regulatory-constrained insurance companies are forced to sell in the weeks surrounding the downgrade. In a related paper, Ambrose, Cai and Helwege (2008) show that while selling pressure by insurance companies is indeed elevated around corporate bond downgrades, it remains fairly small relative to insurance company holdings. Indeed,

[3] In a similar context, Garleanu and Pedersen (2007) show that tighter risk management leads to market illiquidity, which further tightens the risk management, and so on. This 'snowballing' illiquidity can arise when financial institutions have to collectively reduce risky positions in response to an increase in volatility or a widespread reduction in their risk-bearing capacity.

although the net sell volume around the downgrade event is somewhat modest in absolute terms, the selling pressure is *significantly larger* than in other periods. Further, their paper does not explore the link between the trades a particular insurance company may execute and the regulatory pressure they individually face, whereas we document that the probability of selling is significantly larger for firms that have lower levels of risk capacity. Most important, the immediacy required by these constrained sellers may induce significant, but temporary price deviations. The Duffie, Garleanu and Pedersen (2007) model implies that the transaction price is among the most important dimensions to consider in a market plagued by significant search costs and limited counterparties. Ambrose et al. (2008) do not explore price effects.

In line with the theoretical predictions, we find that (even modest) forced selling produces significant price reversals in downgraded bonds, as shown in Figure 1, suggesting that there are periods over which transaction prices deviate significantly from fundamental values.

[Enter Figure 1 here]

The median cumulative abnormal return in the first three weeks for downgraded bonds is more than 11%, and that is largely reversed by week +16. It is precisely this persistent divergence of bonds' transaction prices from their fundamental values and the subsequent price reversals that we focus on in this paper. These price patterns beg the question: why do agents holding downgraded corporate bonds, in our case insurance companies, sell around the downgrade? Given that the corporate bond market is notoriously illiquid, selling at such times is likely to exacerbate the price impact in the face of limited counterparties and high search costs. If other investors were to provide liquidity, we should not find similar price effects, but instead observe an adjustment of transaction prices to a revised fundamental value that properly reflects the information contained in the downgrade. A reasonable explanation for the lack of counterparties is related to the fact that a very large group of potential counterparties – other insurance companies – are sufficiently prevented from providing liquidity. Fire sales caused by regulatory constraints seem to be the most appropriate explanation for such trading behavior.

The final piece of important evidence is related to the observation that the price impact and subsequent reversal is significantly larger for bonds that are more widely held by regulatory-constrained insurance companies. For example, the median cumulative abnormal returns in the first five weeks after the downgrade is over -14% for bonds held by insurance companies with low levels of risk-based capital ratio, but less than -8% for bonds held by insurance companies with high risk-based capital ratio; the price reversals stop around 16 weeks after the downgrade for each. The departure from fundamentals is temporary in both cases, but larger in magnitude for bonds widely held by more constrained insurance companies. As we observe that these same firms demonstrate a larger probability of selling downgraded bonds, the evidence again points to a market imbalance generated by regulatory pressure.

Clearly, one important caveat is the fact that the fundamental value is not directly observable. Hence, measuring departures from fundamental values requires some explanation. Following Coval and Stafford (2007), we identify the fundamental value *ex post* by documenting the systematic patterns of transaction prices over time. Evaluating fundamental values in this way is admittedly complicated by the fact that the downgrade itself contains information. That said, the pronounced price reversals we document are indicative of temporary departures from the revised fundamental value. Indeed, extant empirical evidence documents that bonds' transaction prices appear to fall much further than their fundamental values when downgraded to speculative grade, but that the prices eventually recover in subsequent weeks. For example, Fridson and Cherry (1992) and Fridson and Sterling (2006) show that investors buying downgraded bonds soon after the downgrade earn positive abnormal returns relative to other similarly rated high-yield bonds. A similar pattern is found by Hradsky and Long (1989) when investigating the impact of defaults on high-yield bonds. We forge ahead with this methodology, but consider several alternative specifications as robustness checks.

The fire sales explanation also has to be distinguished from the pure price pressure hypothesis offered by Scholes (1972). Under this alternative explanation, transaction prices diverge from fundamental values because of an uninformed shock caused by either excess demand or supply. Providers of liquidity have to be compensated and this results in transaction price overshooting. The evidence so far shows that such price overshooting is temporary, and can last from a few hours (Gemmill (1996) and Ellul (2006)) to a few days (Harris and Gurel (1986), Kraus and Stoll (1972), Scholes (1972), and Shleifer (1986)). On the other hand, the fire sales story is likely to have a much longer temporal impact on prices, with slow reversals towards the fundamental value taking weeks or months.

To further develop and explore the alternative explanations, we gauge the robustness of our findings by documenting the price patterns of several alternative control groups that should not exhibit significant reversals if our hypothesis on the primacy of regulatory pressure is correct. First, we collect bonds that are downgraded but remain above the investment/speculative grade threshold. Because these bonds are downgraded, their price levels should also suffer from a shift in fundamental values. However, because they do not have to be sold due to regulatory constraints, fire sale prices (and the associated price reversals) need not apply. Second, to rule out the simple liquidity story, we explore the price impact of very large sell trades in the corporate bond market that are unrelated to changes in credit ratings. As we do not observe comparable price reversals in either case, the evidence lends credence to our claim that there is an important role for regulation.

The remainder of the paper is organized as follows. Section 2 discusses the sample construction and describes the summary statistics of the data. Section 3 presents our main empirical analysis and discusses the results. Section 4 investigates alternative explanations. Section 5 concludes.

2. The Data

2.1 Sample Construction

We use three main sources of data. First, the insurance companies' transaction and year-end position data are from the National Association of Insurance Commissioners (NAIC). Second, the information on the characteristics of each bond (including maturity, offering date, credit rating, etc.) is from Mergent Fixed Income Securities Database (FISD). Third, the annual information on the financial strength of each insurance company is from the Street.com Ratings (SR). SR is a wholly-owned subsidiary of the Street.com, a provider of financial information and company analysis reports. SR provides financial strength ratings, as well as the components that are used to construct the ratings, for financial institutions, stocks, mutual funds, and insurance companies. Our sample period is from 2001 to 2005.[4]

NAIC data, for different sample periods, are used by Schultz (2001), Campbell and Taksler (2003), Krishnan, Ritchken and Thomson (2005), and Bessembinder, Maxwell and Venkataraman (2006) among others.[5] While the NAIC data are not exhaustive, they represent a substantial portion of the corporate bond market.[6] Schultz (2001) estimates that insurance companies collectively hold between one-third and forty percent of investment-grade corporate bonds. Comparing the NAIC data to the more complete TRACE data for TRACE-eligible bonds, Bessembinder et al. (2006), find that insurance companies completed about 12.5% of dollar trading volume in these bonds during the second half of 2002. In sum, insurance companies represent an important part of the corporate bond market.

NAIC *transaction* data include detailed transaction information including insurance company identification, bond identification, dealer identification, trade date, direction, price, and size. As Bessembinder et al. (2006) point out, NAIC transaction data does not contain transaction time so any estimation that requires time ordering of trades is not readily possible.[7] However, they show in a simulation that if returns are calculated based on a trade on the prior trading day, the parameter estimates of the Huang and Stoll (1997)-type indicator regression will be unbiased. In the subsequent analysis of abnormal returns around the downgrade events, we follow their suggested method.[8]

NAIC *position* data provide year-end holding information including insurance company identification, bond identification, holding size in par and market value terms,

[4] NAIC data that we have cover full years from 2001 to 2005. FISD data end in August 2005; as a result, we exclude transactions on bonds that are issued after September 2005. The Street.com data include year-end financial standings from 2000 to 2007.
[5] Krishnan et al. (2005) provide a detailed description of this data source.
[6] We do not use the TRACE data, which cover a far greater portion of transactions in the corporate bond market, because TRACE did not cover non-investment grade bonds until 2006 and did not have customers' buy/sell indicators until November 2008. Also, TRACE did not report identities of traders.
[7] This difficulty only applies to the case in which more than one trades take place on the same day, which is not very common in our data.
[8] We use the indicator regression to control for transaction costs, in addition to fundamental changes in price. Bessembinder et al. (2006) report that one-way trading costs for TRACE-eligible bonds and other comparable bonds in 2002 are 12 basis points and 24 basis points, respectively.

and other accounting information. We merge the position data with the transaction data to infer quarter-end positions from year-end positions. For each bond in each quarter, we use the latest quarter-end positions (before the event) to identify which insurance companies hold the downgraded bonds and to calculate the aggregate holders' characteristics, including the regulatory constraints they face.

Second, we merge the transaction and position data to FISD static bond characteristics by CUSIP. Other characteristics such as bond age and years to maturity are calculated based on the trade, position, and static information. We use these characteristics to screen bonds and as control variables. We use a separate rating history file from FISD to identify credit ratings for each bond at each point in time and the rating change events. We use the lower of Moody's and S&P's ratings.[9] The rating change event is defined as the date of announcement by the rating agency that acts first.

Finally, we merge SR insurance company data to our NAIC transaction and position data by NAIC company code. SR uses information on insurance companies from many sources, including NAIC, to calculate different measures (some are based on prescribed formulas while others are based on proprietary formulas) of financial strength of insurance companies.[10]

Table 1 summarizes our data. The original NAIC transaction data begins with 1,708,248 transactions on 119,790 bonds issued by 29,468 different issuers (based on the 6-digit CUSIP). We exclude some transactions based on the criteria described in Table 1. The two biggest exclusions are for obvious errors (e.g. negative or missing prices or par values) and for non-secondary market transactions (e.g. redemptions and calls). The merge with FISD data results in a small additional exclusion of trades, mostly on bonds that are issued after August 2005 (end of our FISD data). Using the merged characteristics, we include only dollar-denominated corporate debentures and medium term notes that have an issue size greater than $50 million and do not have sinking funds provisions. The merge with SR insurance company data has little effect on the sample size since companies that are not covered by SR are small and trade relative infrequently.

[9] If rating from only one source exists, we use that rating.
[10] NAIC provide a variety of data suites covering different dimensions of insurance companies, extracted from the quarterly and annual reports the companies submitted. Our transaction and position data is from Schedule D.

[Insert Table 1]

The final transaction sample contains 483,710 transactions on 14,074 bonds issued by 4,228 different issuers. There are 3,042 insurance companies behind the trades, of which 982 are life and health companies and 2,060 are property and casualty companies. In subsequent analyses, we pick bonds that are of our interest from this sample. To ensure the reliability of our transaction prices, we compare them with those reported in TRACE for TRACE-eligible bonds. We find no systematic or significant differences.

Since we control for fundamental bond values for our analysis, we also collect NAIC transaction data with the data on stock returns, default-free bond yields, and corporate bond spreads. We use the CRSP value-weighted total return index as the market index. We use changes in the Fed's 10-year constant-maturity Treasury bond yield as proxy for the change in the default-free bond yield. We use the average yields of Barclay's U.S. high-yield and investment-grade corporate bond baskets as proxies for speculative- grade and investment-grade bond yields. These yields are then converted into spreads by subtracting the default-free rate. We use changes in these spreads as proxies for changes in corporate bond spreads. Finally, we multiply changes in default-free yield and credit spreads by bond maturity to obtain approximate price returns (or percentage price changes) for each bond between two trade dates.

2.2 Descriptive Statistics

Table 2 (Panel A) describes important bond characteristics. We classify bonds as investment-grade bonds if their credit ratings remain at or above BBB- through the sample period, as downgraded bonds if they are downgraded from BBB- or above to BB+ or below at least once, and as non-investment grade bonds otherwise.[11] We construct a control group made up of bonds that are downgraded from BBB and above to BBB-. The bonds in this group also suffer from a downgrade, implying bad news that should be

[11] Bonds are classified as non-rated if they do not have credit ratings from either rating agency.

reflected in prices. However, these bonds do not become speculative-grade and thus insurance companies to tighter regulatory constraints.

[Insert Table 2]

Most of the bonds in the sample are investment-grade, callable, and issued by industrial companies.[12] Compared to speculative-grade bonds, investment-grade bonds trade more often, have a larger issue size and longer maturity, and are less likely to be callable or issued by industrial firms. Our sample of 1,179 downgraded bonds, as well as our control sample, resembles the investment-grade sample more than it does the non-investment grade sample. Interestingly, bonds in our two downgrade samples trade more often, most likely due to activities around the downgrade events.

Table 2 (Panel B) shows that, on average, insurance companies hold about 34 percent of investment-grade bonds (consistent with Schultz (2001)) and only 8 percent of non-investment grade bonds. Property companies hold considerably less of the bond issues than do life companies. Insurance companies significantly reduce their holdings after rating downgrades, both from investment grade to speculative grade and from BBB and above to BBB-. The former group, however, suffers larger reductions, an observation that may be consistent with the importance of regulation.

Table 2 (Panel C) characterizes transactions by rating category. Several patterns emerge. First, investment-grade bonds trade at higher prices and lower volatility.[13] Second, for the two downgrade samples, prices decline and volatilities increase substantially after the downgrade (mostly driven by trading in the weeks afterward). This pattern is particularly pronounced for bonds downgraded to non-investment status. Third, the average trade size is considerably larger for investment-grade bonds. Fourth, on average, insurance companies buy investment-grade bonds but sell non-investment grade bonds. For both downgrade samples, insurance companies tend to buy before the downgrade and sell after the downgrade. This evidence, along with the holdings statistics

[12] Non-investment grade bonds (and non-rated bonds) are, in greater proportion, callable and issued by industrial firms.
[13] The difference seems to be driven by the left tail of non-investment grade bonds. These bonds trade at distress prices at some points in time and display significant price volatility.

in Panel B, suggests that bonds downgraded into a non-investment grade rating are likely to be heavily sold.

For the sample of bonds that are downgraded to non-investment ratings, we investigate the ratings before and after the downgrade. Table 3 shows that of the 1,179 downgraded bonds, 918 previously held a rating of BBB- and 209 a BBB. This means that almost 96% of the downgraded bonds were within two steps of the non-investment grade level (78% were within one step). These statistics suggest that the downgrade should not have come as a surprise to the market and thus its information content is likely to be small.[14] Given that public information on the bond issuers is regularly updated, some investors may have expected a downgrade before it is effectively decided. Therefore, selling volume may start picking up weeks before the official downgrade. Finally, since these downgrades happen mostly in the proximity of BBB- and BB+, they should be fairly similar in information content and impact to the downgrades from BBB and above to BBB+ in our control group.[15] One important exception is that a downgrade within BBB does not result in an increase in risk-based capital for insurance companies while a downgrade into BB+ clearly does.

[Insert Table 3]

Table 4 describes the financial position of insurance companies. The detailed definitions of different variables are provided in Appendix A. Life companies are larger both by total invested assets and by capital and surplus. The mean and median amount of capital and surplus are $270 million and $31 million for life companies and $187 million and $24 million for property companies. The difference in total invested assets is large, due to leverage, which is particularly high for life companies.[16] The extreme positive skewness in company size means that most insurance companies are small while a few companies in the right tail are extremely large.

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[14] Many of these bonds have been put in the "watch list" months before the official downgrade. In addition, bond issuers report quarterly financial information that may allow investors to better anticipate the downgrade.

[15] The bond and transaction characteristics in Table 2 confirm this conjecture.

[16] A larger part of life companies' invested assets are managed against liabilities incurred through underwriting savings and investment products. This is reflected is the higher average leverage (not reported) of life insurance companies.

[Insert Table 4]

Finally, we provide summary information on the measures of regulatory pressure we employ: the NAIC risk-based capital ratio (RBC ratio) and the SR's risk-adjusted capital ratios (RACR1 and RACR2). RBC ratio is the ratio of total adjusted capital to NAIC risk-based capital (RBC). RBC is the minimum amount of capital that the insurance company must maintain based on the inherent risks in its operations. RBC is calculated based on the NAIC's formula which reflects its assessment of risks of different asset classes and businesses. Insurance companies with higher RBC ratios are considered better capitalized. Insurance companies with RBC ratio below 2.0 are subject to supervisory interventions. RACR1 and RACR2 differ from RBC ratio in that the risk-adjusted capitals in the denominator of RACR1 and RACR2 are calculated based on SR's risk assessment. For example, bonds rated BB- to BB+ are subject to the capital requirement of 1.3% in the RBC formula but 2% and 5%, respectively, in the RACR1 and RACR2 formulas.

In terms of regulatory constraints, life and property companies are similar at the median, but very different at the mean. The reason is that property companies in the right tail have extremely high capitalization ratios.[17] For example, the median RBC ratios are 8.28 for life companies and 7.40 for property companies while the 90th percentiles are 40.19 and 70.20, respectively. Property companies hold significantly less non-investment grade bonds, possibly because their claims are more uncertain and their business liabilities are relatively short term compared to life insurance companies. To the extent that the differences in distribution of both the constraint measures and the size measures are driven by the nature of business, we need to treat the two types of insurance separately in studying how they make investment decisions.[18] Moreover, due to the extreme positive skewness of size and capitalization ratios, we take the log and winsorize the tails in our empirical analysis.

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[17] SR did not produce the combined capitalization index for property companies until 2003. They argued that most of the factors underlying the index are accounted for in the capitalization ratios. Thus, we do not use capitalization indexes in our empirical analyses.

[18] However, life and property companies are similar with respect to the distribution of their liquidity index.

Table 4 also reports statistics on investment risk taking, which might reflect risk appetite or investment flexibility (e.g. due to company size or business risk).[19] In general, life and property companies invest about the same percentage of their portfolios in "risky" assets. Consistent with insurance company regulation, we classify the following assets as risky: non-investment grade bonds, common and preferred stocks, non-performing mortgages, real estate, and other investments. The compositions of these assets, however, are different between the two types of insurance companies. Life companies invest more in non-investment grade bonds than do property companies; the mean percentages are 2.66 and 0.72, respectively. This suggests that property companies may be selling the downgraded bonds more heavily around the downgrade.

Life companies account for a bigger portion of all insurance companies that trade bonds in the two downgrade samples. Compared to an average insurance company in the overall sample, an average company in the two downgrade samples is larger, has lower capitalization ratios, and holds more non-investment grade bonds. Part of the reason is that the downgraded bonds are of lower quality even before the downgrade occurs and therefore are held more widely by life companies. This degree of heterogeneity across insurance company type reiterates the importance of separating the two groups in our analyses.

3. Empirical Methodologies and Results

3.1 Median Cumulative Abnormal Returns

We start by investigating cumulative abnormal returns from 20 weeks before to 20 weeks after the downgrade. To detect and disentangle price pressure from information revelation, we follow the approach used by Mitchell, Pulvino and Stafford (2004) and Coval and Stafford (2007). Specifically, we examine price changes around the events that are likely to trigger fire sales and the events that are not and look for evidence of price drops followed by a significant reversal. If insurance companies' trading around the downgrade is motivated by information, then we should expect transaction prices

[19] Baranoff and Sager (2002) and Cummins and Sommer (1996) study the relationships between risk-taking activities and capital of life companies and property companies, respectively.

(and fundamental values) to drop during the period of heavy sales and then stabilize permanently at the lower level. On the other hand, if insurance companies have to sell immediately due to regulatory constraints, then these companies will get fire-sale prices, which are significantly lower than fundamentals. In this case, we should see a drop in transaction prices, followed by series of positive abnormal returns compensating liquidity providers for stepping in.

We measure abnormal returns using a simple market model that controls for both fundamental value changes and transaction costs. Our model is similar in spirit to the models used by Bessembinder et al. (2006) and Schultz (2001), among others. We start by assuming that the observed trade price of bond *i* on date *t*, denoted by $P_{i,t}$, equals the fundamental bond value $E_t(V_i)$ adjusted up or down by the percentage half spread $A_{i,t}$:

(1) $$P_{i,t} = (1 + A_{i,t} Q_{i,t}) \times E_t(V_i)$$

where $Q_{i,t}$ denotes an indicator variable that equals 1 (-1) if the trade on date *t* of bond *i* is an insurance company's buy (sell). The logged price return (or change in logged price) from one trade date to the next is thus given by:

(2) $$\ln(P_{i,t} / P_{i,t-1}) \cong (A_{i,t} Q_{i,t} - A_{i,t-1} Q_{i,t-1}) + \ln(E_t(V_i) / E_{t-1}(V_i))$$

We specify the half spread as a function of trade size $S_{i,t}$ in the form:[20]

(3) $$A_{i,t} = \gamma_0 + \gamma_1 \ln(S_{i,t}) + \eta_{i,t},$$

where $E(\eta_{i,t}) = 0$. Guided by the structural model of Merton (1974), we specify the change in fundamental value as a function of change in (a) government bond yield, (b) investment-grade corporate spread, (c) high-yield corporate spread, and (d) market return. We account for the duration effect by making the government bond and corporate spread

[20] Virtually all studies of corporate bond trading costs (e.g. Bessembinder et al. (2006)) find that trading costs can be extremely large for small trades and that trading costs decline sharply with trade size. Bao and Pan (2008) find that corporate bond prices exhibit excess volatility (compared to what is predicted by Merton's (1974) model) and that the degree of excess volatility is negatively related to measures of bond liquidity including the average trade size. In extracting abnormal returns, controlling for the effect of trade size on trading costs is equivalent to assigning some potentially large residuals associated with smaller trades to the non event-related time-invariant microstructure effects.

returns proportional to the remaining years to maturity of bond *i*. Let these variables from trade dates *t*-1 to *t* be denoted by $Z_{i,t-1,t}$. Assuming a linear relationship, we then have:

$$\ln(E_t(V_i)/E_{t-1}(V_i)) = \alpha + \beta Z_{i,t-1,t} + \nu_{i,t-1,t} \tag{4}$$

where $E(\nu_{i,t-1,t}) = 0$. Substituting (3) and (4) into (2), we obtain:

$$\ln(P_{i,t}/P_{i,t-1}) \cong \alpha + \beta Z_{i,t-1,t} + \gamma_0(Q_{i,t} - Q_{i,t-1}) + \gamma_1(Q_{i,t}\ln(S_{i,t}) - Q_{i,t-1}\ln(S_{i,t-1})) + \varepsilon_{i,t-1,t} \tag{5}$$

By construction $\varepsilon_{i,t-1,t} = \nu_{i,t-1,t} + Q_{i,t}\eta_{i,t} - Q_{i,t-1}\eta_{i,t-1}$ and $E(\varepsilon_{i,t-1,t}) = 0$. We further make the usual assumption that the right-hand side variables and ε are uncorrelated.

We estimate the parameters of (5) together for all the bonds of interest and across time, essentially imposing the restriction that the parameters are the same for all bonds.[21] The reason is that bonds do not trade often and so separate estimates for each bond are highly imprecise.[22] We use two estimation periods to obtain two separate sets of parameters: (i) from the start of our sample to 30 weeks before the event, and (ii) from 30 weeks after the event to the end of our sample. Intuitively, the relationship (5) changes around the event (not necessarily at the event) in the sense that bonds in the lower rating categories are relatively more risky and equity-like, and therefore load more on the change in the high-yield spread and the stock market return. Moreover, Edwards, Harris and Piwowar (2007) finds that transaction costs are substantially larger for high-yield bonds than for investment-grade bonds. We use relatively long estimation periods to maximize power, which is particularly low due to infrequent trading and the general noisiness of the data.

We define the event period (period not used in our parameter estimation) as the period from 30 weeks before to 30 weeks after the event. The abnormal return $AR_{i,t-1,t}$ is

[21] Since the NAIC data does not contain transaction time, we cannot order trades that take place on the same day. We follow Bessembinder et al. (2006) and calculate return based on a trade on the prior trading day. Bessembinder et al. show in a simulation that this approach yields unbiased parameter estimates.

[22] For example, bonds that are downgraded from an investment-grade rating to a non-investment grade rating only trade 27 times at the median and 56 times on average in our sample period. Edwards, Harris and Piwowar (2007) estimate a similar model separately for each bond but they use TRACE data which is much denser.

the error term $\varepsilon_{i,t-1,t}$ for observations in the event period calculated using the parameter estimates from the estimation period. Notice that *AR* contains both the informational (permanent) component associated with change in the fundamental value and the liquidity (temporary) component associated with trading costs or price concessions. To obtain the cumulative abnormal return $CAR_{i,t}$, we accumulate the abnormal returns up to date *t*. We use the median (or the average, depending on specifications) abnormal return in the case that multiple trades on the same bond take place on the same day at different prices. To reduce noise, we further aggregate *CAR* for each bond by week relative to the event. We normalize the interpolated *CAR* for each bond to zero at event week -20. Finally, we calculate the median cumulative abnormal return, *MCAR*, as the median of the normalized *CAR*s across all the bonds that trade in each event week.[23]

As shown in Figure 1 and Panel A of Table 5, the pattern of median cumulative abnormal returns around the downgrade is very striking. The *MCAR*s turn negative several weeks before the downgrade, reach about -10% in week -2, and remain in that range until week +4. Most importantly, only a small (though statistically significant) portion of the large negative *MCAR*s (about -2%) remains in week +20. Prices seem to stabilize from week +16 onwards. Arguably, prices converge to fundamental values around this time and the information-driven impact is only 2%. The same qualitative patterns can be observed in the Average Cumulative Abnormal Returns (*ACAR*s), which are not reported for brevity.[24]

[Insert Table 5]

To investigate the robustness of our results, we also calculate *MCAR*s using two other methods (see Brown and Warner (1985)): (i) mean adjustment, and (ii) bond index adjustment. The mean adjusted abnormal returns equal the actual bond returns minus the mean return during the estimation period. The bond index adjusted returns are calculated

[23] Since two corporate bond trades may be weeks apart, we do not have abnormal returns for each event week. Therefore, we cannot calculate the weekly median or average first and then accumulate the aggregate statistic over time (as in Coval and Stafford (2007)).

[24] The magnitudes of *ACAR*s are quite different, however. Due to the large outliers on the negative side, we consider *MCAR*s more appropriate and use them only from this point onwards.

as the actual bond returns minus the rating-matched Barclays Bond Index (price) returns.[25] Figure 2 illustrates that the price patterns in Figure 1 are robust to these alternative methodologies.

[Insert Figure 2]

Table 5 Panel A also compares *MCAR*s around the downgrade of corporate bonds into a speculative grade with those around the downgrade into a BBB- grade as a control group. Starting in week -14, *MCAR*s for our sample become statistically more negative than those for the control group. The difference starts at a small economic magnitude, reaches its peak around weeks -3 to +3 (at about 8%), shrinks slowly, and becomes statistically insignificant after week +14 or so. It thus appears than transaction prices deviate from fundamental values for the bonds that are downgraded into a speculative grade for several weeks around the downgrade announcement. Figure 3 visually confirms this finding.

[Insert Figure 3]

In order to reduce noise and improve statistical power, we examine the *MCAR*s by 5-week period in Panel B of Table 5. The results are in line with what we have previously documented. In particular, the permanent change in price is about the same in both the downgrade into a speculative grade and the downgrade into BBB-, while the temporary change around the downgrade differs. To directly investigate price reversals, we calculate and report the changes in *MCAR*s from the 5-week period immediately after the downgrade to subsequent periods. We find positive and statistically significant abnormal returns starting as early as week +6 after the downgrade of bonds into a speculative grade. Liquidity providers who buy during weeks +1 to +5 and sell during weeks +16 to +20 earn abnormal returns of about 6% at the median (almost 20% in annualized terms). These positive abnormal returns or "price reversals" are not observed for bonds that are downgraded but remain investment-grade. For these bonds, the

[25] Barclays Bond Indexes are formerly known as Lehman Brothers Indexes.

*MCAR*s fluctuate around -3.5% to -3.9% from weeks 0 to +20. That is, the price impact for these bonds appears to be permanent and informationally induced.

In sum, the price patterns shown in Table 5 for the downgrade of bonds into a speculative grade cannot be explained entirely by the information content of the downgrade. While the downgrade should intuitively generate a negative impact on both the transaction prices and the fundamental values, there should not be any reversal in (observed) transaction prices. If we believe that in the long term transaction prices will converge to the fundamental values, then the convergence seems to prevail from week +16 onwards. The significant difference in price reversals between our sample and control group is consistent with the fire sales hypothesis induced by regulation.[26]

The predictability of price reversals begs an important question: why don't buyers enter immediately after the downgrade, provide the necessary liquidity to sellers, and earn abnormal returns? For example, Berk and Green (2004) show that fund flows chase performance and this behavior eliminates predictable price patterns. The same forces should apply in our setting as well. The persistence of *MCAR*s (i.e. very slow price correction) must therefore be due to market frictions or other forces that lead to imperfect competition among potential buyers (see Duffie, Garleanu and Pedersen (2007) and Pritsker (2005)).[27] In our case, regulatory constraints eliminate (or reduce the capacity of) a large group of potential liquidity providers: other insurance companies. This explanation is consistent with the model of Shleifer and Vishny (1992) in which a distressed firm is forced to sell its specialized assets when other firms in the same industry also perform poorly (and hence the asset demand is low).

3.2 Trading Volume around the Downgrade

We next investigate insurance companies' trading volume to examine the extent to which it is related to the deviation of transaction prices from fundamental values and the subsequent reversals documented above. In Table 6, we report summary statistics of trading volume around the downgrade of corporate bonds both into a speculative grade

[26] Shleifer (1986) discusses some potential explanations for the downward-sloping demand curve in the stock markets.

[27] Large potential buyers may collusively front-run insurance companies and slowly buy back the downgraded bonds (Brunnermeier and Pedersen (2005)). Buyers may also demand liquidity premium (Acharya and Pedersen (2005)) or lack the infrastructure and information to trade the downgraded bonds (Merton (1987)).

and into a BBB- grade. We find that the total volume spikes in the event week for *both* samples, largely due to heavy selling. However, the pattern is significantly more pronounced for the downgrade into a speculative grade. The average total volume per bond-week for this sample is almost \$2.5 million in the event week, significantly greater than \$1.7 million for the control group. Interestingly, the volume declines rapidly to less than \$1 million just 5 weeks later. After week +10, the average volume for our sample becomes statistically lower than that for the control group. This finding confirms the simple statistics in Table 2 that non-investment grade bonds do not trade frequently.

[Insert Table 6]

The net dollar volume turns negative from about 20 weeks before the downgrade of corporate bonds to a speculative grade. The selling pressure gains momentum towards the event, reaching its maximum at over \$1.3 million in the event week.[28] This pattern suggests that some immediate selling occurs soon after the downgrade is announced. Starting from week +1, the selling pressure declines and the trade imbalance diminishes over time (though remains negative). The net selling volume in the event week is almost 3 times larger for the bonds that are downgraded to a speculative grade than for those that are downgraded but remain in an investment grade. This suggests that our observed immediate selling is distinct to fallen angels. The difference in volume imbalance between the sample and the control group remains statistically significant up to week +10.

Although the net sell volume around the downgrade event is somewhat modest in absolute terms (as pointed out by Ambrose et al. (2008)), the selling pressure is *significantly larger* than in other periods. Most importantly, the Duffie, Garleanu and Pedersen (2007) model implies that the transaction price is a very important dimension in a market plagued by significant search costs and limited counterparties. Panels A and B of Figure 4 show the weekly *MCAR*s along with the net per-bond dollar volume around

[28] The net dollar volume reaches the highest imbalance level in the event week, even though we also see higher buying volume (\$0.6 million compared to \$0.3 million in the five weeks before the downgrade). This suggests that some less constrained insurance companies may also be buying, taking advantage of potentially fire sale prices.

the downgrades. The evidence confirms the findings in Table 6 that the biggest imbalance occurs around the event and that this imbalance is significantly more pronounced for bonds downgraded to speculative grade. For the bonds in the control group, we find that the selling pressure appears to spread out almost evenly over several weeks after the downgrade. One can observe a positive relationship between volume imbalances and *MCAR*s both across time and across the two downgrade samples. In particular, the price declines and subsequent reversals seem to be driven by the unusually large selling pressure around the downgrade of bonds to a speculative grade.

[Insert Figure 4]

Panel C of Figure 4 reports the insurance companies' holdings of downgraded bonds. We measure the holdings as percentage of the issue size and take the median of these holdings across all downgraded bonds in each quarter relative to the event. Quarter 0 is the latest calendar quarter end preceding the event. For the bonds that are downgraded to a speculative grade, insurance companies hold about 34% of a median issue in quarter -3 and slowly decrease their holdings to about 31% in quarter 0. The next two quarters see a sharp reduction; the median holdings stand at 23% at quarter +2.[29] Insurance companies continue divesting the downgraded bonds but at a slower pace in subsequent quarters. In comparison, for bonds that are downgraded to BBB-, insurance companies only start reducing their holdings after the downgrade. The pace of reduction is also slower in the first two quarters after the downgrade and is almost constant over several quarters.

Figure 4 (Panel C) also shows that although heavy selling occurs between quarters 0 and +2, insurance companies do not stampede to sell downgraded bonds but rather behave in a manner that appears to be strategic (selling slowly over time). These companies seem to avoid selling when liquidity is particularly low and a large price impact is likely. Still, some companies do immediately sell at transaction prices that appear to be substantially below fundamental values. This raises important questions:

[29] Unreported results show that selling continues further as suggested by the summary statistics in Table 2.

who is forced to immediately sell and is propensity related to the regulatory constraints these firms face? We answer this question in the next section.

3.3 Probability of Immediate Selling After the Downgrade

The fire sale hypothesis predicts that constrained insurance companies are likely to sell assets immediately after an event that increases their holding costs. To test this hypothesis, we model the probability that an insurance company (holding the bonds at the quarter end preceding the downgrade) will sell the downgraded bonds during weeks 0 to +5 after the downgrade as a probit function:

(6) $$\Pr(D_{i,j,k} = 1) = \Phi(\delta_0 + \delta_X X_{i,k} + \delta_Y Y_{i,j,k} + \delta_W W_k)$$

where $\Phi(\cdot)$ denotes the standard normal distribution, $D_{i,j,k}$ is a dummy variable that equals one if the insurance company *j* (holding bond *i*) sells bond *i* during weeks +0 and +5 of event *k* and zero otherwise, $X_{i,k}$ is a vector of bond *i*'s static characteristics (e.g. issue size) and time-varying characteristics (e.g. bond age) at the time of event *k*, $Y_{i,j,k}$ is a vector of insurance company *j*'s characteristics before event *k* and possibly with regard to bond *i* (e.g. company *j*'s holding of bond *i* before event *k*), W_k is a vector of event-specific control variables (e.g. quarter-year dummies), and δ's are the corresponding vectors of coefficients to be estimated.

We include proxies for regulatory constraints along with several control variables. To measure regulatory constraints, we first use the distinction between life companies and property companies. Property companies face relatively short-term and more uncertain liabilities than do life companies. We expect that property companies are more likely to immediately sell downgraded bonds. We also use other more direct measures of regulatory constraints, including the company's RBC ratio, RACR1, capitalization indexes, and liquidity index. We examine property and life companies separately. We are particularly interested in the company's (logged) RBC ratio since it is actually reported to and used by regulators. To avoid outliers, we estimate our probit models using only the insurance companies with RBC ratios (most recently before the event) between the 5th and 90th percentiles. The coefficient estimates and the marginal effects from our probit models are reported in Table 7.

[Insert Table 7]

The result in the first column of Table 7 is consistent with the fire sale hypothesis: property companies are significantly more likely to immediately sell downgraded bonds. Panel B shows that the probability of selling is 2.64% higher for property companies compared to life companies. This effect is economically significant, given that the mean probability of selling for the entire sample is only 7.1%.

We examine the effects of other constraint measures separately for life and property companies since they differ significantly in the nature of their business, liabilities, size, capitalization, and liquidity. We employ 16,006 observations for the life sample and 6,264 observations for the property sample. Columns (2) to (5) report the results for life companies, and columns (6) to (9) do so for the property companies. For most of the regulatory constraint measures, we find that the *more constrained* is the insurance company, the more likely that it will immediately sell the downgraded bonds. This finding holds separately for both life and property companies. The effect of regulatory constraint on selling probability is also economically significant. Considering the property sample as an example, if we take a company and increase its RBC ratio (holding everything else constant) from the 25th percentile to the 75th percentile of the sample (hence making it less regulatory constrained), this company's probability of selling will decrease by 1.8%. This effect is sizeable considering that the mean selling probability for property companies is 9.5%. An interesting question, to which we will turn in the next section, is the extent to which this increased likelihood of selling after the downgrade exacerbates the documented price deviation and subsequent reversal.

It is also important to note that the impact of regulatory constraints on the probability of immediate selling is robust to the inclusion of a host of control variables that may be associated with selling for unrelated reasons. Significant variables include the proportion of risky assets in the portfolio of insurance companies, the dummy that indicates whether the downgrade is into the BB class, and the age and issue size of the downgraded bond.[30] Their coefficients are as expected. First, property companies with higher risk appetite or higher capacity to bear risk, as proxied by their risky asset holdings, are less likely to sell the downgraded bonds.

Bonds that are downgraded to the BB grade (highest among the non-investment grade group) are less likely to be immediately sold. This may be due to the differential degrees of negative information across rating classes or the regulation that imposes much higher capital charge for holding bonds rated below BB-. We also find that insurance companies are more likely to sell younger bonds and bonds with larger issue size. Edwards, Harris and Piwowar (2007), among others, find that bid-ask spreads increase with bond age and decrease with bond issue size.[31] Thus, one interpretation of our results is that insurance companies actively try to minimize price impact by avoiding the sale of the most illiquid bonds. Price declines and subsequent reversals may then actually be *larger* for relatively more liquid bonds, as they are more heavily sold. This interpretation is consistent with the prediction of Oehmke (2008).

All results are obtained after the inclusion of year-quarter dummies and U.S. state (of incorporation) dummies. The first set of dummies control for market-wide conditions that occur during the time of downgrade. We use these dummies out of convenience, given that our interest lies more in the cross section than in the time series. The second set of dummies control for the regulations faced by insurance companies, which differ across U.S. states.

3.4 Regulatory Constraints and Price Reversals

In this section, we reconcile the previous findings that in the weeks immediately after the downgrade: (i) the negative *MCAR*s and the net selling volumes are largest, and (ii) more constrained insurance companies are more likely to sell. These findings point to the direction of regulatory-constrained insurance companies being behind the large price declines and subsequent reversals we document in Table 5. Specifically, bonds held

[30] We also consider a variety of other control variables, most of which turn out to be either insignificant or generate a multi-collinearity problem (making the other coefficients hard to interpret). The impact of regulatory constraints, however, remains largely unchanged.

[31] See also Hong and Warga (2000) and Schultz (2001). Driessen (2005) uses bond age to identify the liquidity component of credit spreads.

widely by constrained insurance companies should experience larger reversals if regulation is indeed primary.

We use the RBC ratio and the predicted immediate selling probability (from the probit analysis) as proxies for regulatory-induced selling pressure. To analyze the price effects of regulatory pressure, we aggregate the insurance company-level constraint variables into the bond-level variables by averaging across all companies that hold the bond at the end of the quarter preceding the event. We equally weight every company for two reasons. First, as argued by Coval and Stafford (2007), one company looking to liquidate a large position can more easily mitigate the price impact of its trades than can several companies looking to liquidate smaller positions at the same time. Second, the insurance industry is dominated by a handful of extremely large life companies. If larger positions get higher weights, then these companies will dominate the bond-level constraint measures for any bond.

The downgraded bonds are grouped by the average RBC ratio or by the average selling probability. The low (high) RBC ratio group includes bonds with the average holders' RBC ratio below (above) the median. The high (low) selling probability group includes bonds with the average holders' selling probability above (below) the median. Table 8 and Figure 5 compare the dynamics of *MCAR*s between the high and low regulatory constraint groups.

[Insert Table 8 and Figure 5]

Figure 5 demonstrates that bonds held by more constrained companies or those with higher immediate selling propensity experience larger deviation from fundamentals and subsequent price reversals. The differences are economically and statistically significant. Panel A of Table 8 shows that during the first five weeks after the downgrade, the *MCAR*s are significantly more negative for the low RBC ratio group than for the high RBC ratio group (-14.11% vs. -7.89%). This difference largely disappears after week +11. An almost identical pattern emerges for the split along selling probability. However, *MCAR*s for the high selling probability group remain significantly more negative than those of the low selling probability group through 20 weeks after the downgrade. This is likely due to the fact that selling probability reflects both information about the bond and the regulatory constraints.

Panel B of Table 8 directly compares price reversals, as measured by the change in *MCAR*s from the period between weeks +1 and +5 to later periods, across regulatory constraint groups. Price reversals seem to take place after week +11 and are significantly larger for bonds in the low RBC ratio group than for those in the high RBC ratio group. The results are similar, albeit less significant, for the split along average selling probability. Together, the results are strongly consistent with the fire sale hypothesis and the associated role for regulation.

3.5 Multivariate Analysis of Price Reversals

We next investigate the relationship between regulatory constraints and price reversals in a multivariate framework. Theoretically, price reversals are the change in transaction prices from the fire sales period to a later period in which prices have reached fundamental values. Consistent with our analysis of selling propensity, we define the fire sales period as event weeks +0 to +5. We count each trade in this period as one observation so that bonds that trade multiple times in this period will carry more weight. The actual trade price $P_{i,t}$ is used. Based on the pattern of *MCAR*s in Figure 1, we define the period from week +16 onwards as the period in which price reversals have stopped. For each bond, we calculate the benchmark price $\overline{P}_{i,T}$ by averaging the prices of all the trades in this period. Thus, only bonds that trade at least once during event weeks +0 to +5 and at least once in or after event week +16 enter our estimation. The price reversal for bond *i* based on trade *t* is calculated as:

$$R_{i,t,T} = \ln(\overline{P}_{i,T} / P_{i,t}), \ \forall t \in \text{[week +0, +5] and } T = \text{[week +16, end of sample]}.$$

Based on Coval and Stafford (2007) and Duffie, Garleanu and Pedersen (2007), immediate non-informational selling by constrained insurance companies will depress the bond price below its fundamental value in the short run and these deviations then reverse slowly overtime.

We test our hypothesis fire sales of downgraded bonds are driven by regulatory pressure, we regress price reversals on a proxy of bond-level regulatory constraints. We control for changes in bond and stock market conditions, transaction costs, and other bond characteristics, as follows:

$$(7) \qquad R_{i,t,T} = \beta_0 + \beta_C C_i + \beta_Z Z_{t,T} + \beta_X X_i + (\overline{A}_{i,T}\overline{Q}_{i,T} - A_{i,t}Q_{i,t}) + \xi_{i,t,T}$$

where $C_{i,t}$ is the proxy of regulatory constraint for bond *i* on date *t*, $Z_{t,T}$ is a vector of changes in market conditions from *t* to *T*, $X_{i,t}$ is a vector of bond static and time-varying characteristics, $A_{i,t}$ is a percentage half spread for trade *t* on bond *i* specified as in (2), and $Q_{i,t}$ equals 1 (-1) for a buy (sell) trade. The upper bar denotes the average of the variable over period *T*.

We estimate the parameters of (7) both by OLS (with heteroskedasticity-adjusted standard errors) and by quantile regressions to reduce the impact of outliers.[32] The results are shown in Table 9. The first column uses holdings by property insurance companies as a proxy for constraints. The positive coefficient suggests that the more widely a bond is held by property companies, the larger are its price reversals. The effect is both statistically and economically significant. If we shock the percentage holding of the bond by property companies from the 25th to the 75th percentiles, price reversals will increase by 0.76% (compared to the sample mean reversal of 8.25%).

[Insert Table 9]

In the second column of Table 9, we use (the log of) the RBC ratio as a measure of regulatory constraints. Consistent with previous results, the negative coefficient indicates that the lower the RBC ratio of the insurance companies holding the downgraded bond, the larger the price reversals. This coefficient is statistically significant at conventional level. Investigating the economic impact, we find that if we shock (the log of) the RBC ratio from the 25th to the 75th percentiles (from more to less constrained), the price reversal will decrease by 1.17%.

[32] We also obtain the same results using Iterated Weighted Least Squares (IWLS) in which we place higher weight on more precise observations.

Given that both the price reversals and our right-hand side variables are highly skewed, we also estimate equation (7) by quantile regression. Panel B of Table 9 reports the quantile regression estimates, which largely confirm our OLS results in Panel A. However, the coefficients of our regulatory constraint measures increase dramatically from the .25 quantile to the .75 quantile, indicating that the action concentrates in the upper half of the conditional distribution of reversals (that is when reversals are relatively large).

To ensure that our estimates are not driven by our methodology or sample period, we also jointly estimate equation (7) with our sample of downgraded bonds and the control group together. In this regression, we add a dummy variable indicating the sample of interest (bonds downgraded into a speculative grade), and interact this dummy variable with C_i to tease out the differential effects of regulatory constraints. Again, we also control for (i) insurance company characteristics, (ii) market-wide movements, (iii) transaction costs, and (iv) bond characteristics. Table 10 reports the results (coefficients of control variables not reported for brevity). As we argue earlier, the downgrade of bonds into another rating within the investment grade should not trigger fire sales and hence the price reversals for our control group should be small and relatively unaffected by regulatory constraints.

[Insert Table 10]

We find that price reversals are approximately 2.5% larger for bonds downgraded to a speculative grade than for those in the control group.[33] This result, in a multivariate setting, confirms what we have already demonstrated in Figure 3 and Table 5. In addition, we find that regulatory constraints have a greater impact on our sample bonds than on bonds in the control group, corroborating the primary role regulation appears to play. For example, consider the holdings of bonds by property insurance companies as the measure of constraints. We find that if the property insurance holdings increase from the 25th to the 75th percentiles, the price reversals will increase by 0.22% for the bonds in

[33] Given the multivariate econometric environment employed in this specification, the statistics here are based on the mean as opposed to the median in our *MCAR* analysis used throughout the paper.

the control group and 0.76% for the sample bonds. The incremental impact of 0.54% is both statistically and economically significant. The same result obtains if we consider (the log of) the RBC ratio as the measure of regulatory constraints. In this case, increasing the RBC ratio from the 25th to the 75th percentiles will decrease price reversals by only 0.03% for the control group vs. 0.67% for the bonds downgraded to a speculative grade.

In sum, our findings are consistent with the fire sales hypothesis: (i) constrained insurance companies are more likely to sell the downgraded bonds immediately after the downgrade, and (ii) bonds held widely by constrained companies experience larger deviation from fundamentals and subsequent price reversals. These results are robust to a variety of methods and controls. Most significantly, they only apply to the downgrades from an investment grade to a non-investment grade.

4. Alternative Explanations

4.1 Are price drops and reversals simply due to large sell volume?

One obvious alternative explanation of our results is the pure price pressure hypothesis offered by Scholes (1972). Transaction prices diverge from fundamental values because of an uninformed shock caused by either excess demand or excess supply. The evidence shows that the deviation of transaction prices from fundamental values can last from few hours (Gemmill (1996) and Ellul (2006)) and up to few days (Harris and Gurel (1986), Kraus and Stoll (1972), Scholes (1972), and Shleifer (1986)).

We investigate the pure price pressure (or transaction cost) explanation by reproducing the *MCAR*s around large sell trades that are unrelated to obvious information events such as a downgrade. Specifically, sell trades are divided into four size groups corresponding to four quartiles of selling volume of downgraded corporate bonds during weeks 0 and +5. In this way, the size of trade in each group is comparable to the net selling volume in each quartile. We then define as an event the largest sell trade in each size group for each bond. We use the price impact of trades in the small groups as benchmark for evaluating the impact of large trades.

[Insert Figure 6]

Figure 6 shows the weekly *MCAR*s around large trade events. No significant price drops or reversals are observed for sell trades of all size, suggesting that the simple liquidity story does not explain the large price reversals observed after corporate bond downgrades. Rather, this finding supports the view that the collective need of insurance companies to sell immediately and the lack of unconstrained buyers are of first-order importance. In fact, the slow speed at which price reversals take place after the downgrades seem to also reject the pure price pressure story outright.

4.2 Do insurance companies try to avoid fire sales?

To reduce their portfolio risk and the associated regulatory capital, insurance companies can sell either the downgraded bonds or some other bonds they hold. The latter should be preferred given that the downgraded bonds are likely to trade at fire sale prices. To test this conjecture, we examine trading activities in other bonds held by insurance companies that hold the downgraded bonds. We will refer to these companies as "affected companies." We calculate the average trading volume in other bonds separately for the group of affected companies and the group of other companies that hold the same bonds. If the affected companies try to avoid fire sales, they sell these other bonds around the downgrade event more heavily than other companies.

We run a simple regression of net trading volume in other bonds (per bond per insurance company per week) on dummies representing different time periods relative to the event and the interactions of these dummies with the affected company dummy. Table 11 reports the coefficient estimates. Affected companies seem to sell other speculative-grade bonds more intensely than other companies that hold the same bonds. The difference is statistically significant at conventional level up to week +10 after the downgrade. That said, the magnitude of the difference is rather small ranging from about $30,000 per bond per company per week in the event week to about $6,000 during weeks +6 and +10. For bonds rated in the BBB class and those rated A- and above, affected companies do not appear to behave differently from other companies that hold the same bonds.

[Insert Table 11]

The fact that affected insurance companies sell other speculative-grade bonds upon the downgrade of a nominally unrelated bond raises an important question: are there spillover effects of price drops and reversals from the downgraded bonds to other speculative-grade bonds? We investigate this question visually in Figure 7. Clearly, other speculative-grade bonds held by affected insurance companies also experience price drops and reversals around the downgrade events. The magnitude of the spillover effects is economically small but statistically significant. For example, the average *MCAR* from weeks 0 to +5 is about -1.5% compared to about -0.3% from weeks +16 to +20. These admittedly small spillover effects are nonetheless consistent with the small differences in net selling volume between affected and unaffected companies we document above. The magnitudes are small because the *collective* divestment which follows a downgrade is absent from this environment. Still, given that there is no apparent value-relevant information about these bonds, this finding is very interesting.

[Insert Figure 7]

5. Conclusions

This paper investigates fire sales of corporate bonds by insurance companies. These companies operate under regulations that constrain their risk-taking capacity. An insurance company that faces binding regulatory constraints often has to sell some of its risky assets. Since insurance companies as a group hold over a third of outstanding corporate bonds, any event that forces them to immediately and collectively sell the same bonds can induce a fire sale.

We study the bond price patterns and the trading behavior of regulated insurance companies when investment-grade corporate bonds are downgraded to a speculative grade (a rating of BB+ or below). To empirically test the fire sale hypothesis, we construct a dataset of all the corporate bond downgrades and insurance companies' transactions from 2001 to 2005. We find a striking pattern of large price drops and reversals around the downgrade, similar to the pattern of fire sales documented in other markets (see Coval and Stafford (2007), for example). This pattern suggests that there are periods over which transaction prices deviate significantly from fundamental values. Investors buying fallen angels soon after the downgrade, providing liquidity to forced sellers, earn abnormal returns.

We also document positive relationships between regulatory constraints and selling pressure and between regulatory constraints and price reversals, consistent with the fire sale hypothesis. First, we find that more constrained insurance companies, those with low risk-based capital (RBC) ratios for example, are more likely to sell the downgraded bonds immediately after the downgrade. Second, we show that price reversals are significantly larger for bonds held widely by regulatory-constrained insurance companies. The median cumulative abnormal returns in the first 5 weeks after the downgrade are over -14% for bonds held by insurance companies with low RBC ratios but less than -8% for bonds held by companies with high RBC ratios. This difference disappears by week +16 after the downgrade.

We do not find significant price reversals for corporate bonds that are downgraded but remain investment-grade; hence, we rule out the hypothesis that information content of the downgrade drives the price reversals we documented for the bonds that are downgraded to a speculative grade. We also don't find price reversals after large sell trades hit the market and therefore rule out the simple liquidity story. Our tests all point to one conclusion: regulatory constraints imposed on insurance companies are important in explaining fire sales in the corporate bond market.

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Appendix A: Descriptions of Insurance Company-Specific Variables

Variable	Definition
Capital and Surplus	The insurance company's statutory net worth (including paid-in capital or unimpaired surplus and additional funds in surplus) in millions of dollars through the most recent year end.
Capitalization Index; Risk-Adjusted Capitalization Indexes 1 and 2 *,**	The Street.com's indexes that measure the adequacy of the insurance company's capital resources to deal with a variety of business and economic scenarios (considering the investment and business risks that the company is taking). The indexes are converted from RACR1 and RACR2 below, with the ratio of 1 converted into the index value of 7.0. During the sample period 2001-2005, the (combined) Capitalization Index is available only for life and health companies; the counterparts for the property and casualty companies are the Risk-Adjusted Capitalization Indexes 1 and 2. Scores range from 0 to 10.
Holding of Non-Investment Grade Bonds	The percentage of investment assets invested in non-investment grade bonds (based on the lower of Moody's and S&P ratings).
Holding of Risky Assets	The percentage of investment assets invested in any of the following asset classes: non-investment grade bonds, common and preferred stocks, non-performing mortgages, real estate, and other investments. According to the Street.com and NAIC, the target capital percentages for these assets are greater than or equal to those of the least risky class of non-investment grade bonds (BB).
Invested Assets	The reported market value in millions of dollars of the insurance company's assets, admitted by the state insurance regulators, that are invested in the capital and money markets through the most recent year end.
Investment Safety Index *,**	The Street.com's index that gauges the insurance company's net exposure to default, market, and interest rate risks. Scores range from 0 to 10.
Liquidity Index *,**	The Street.com's index that measures the insurance company's ability to raise cash to settle claims. The inability to raise cash may arise when the company is owed a great deal of money from its agents or reinsurers, or it cannot sell its investments at the prices at which the investments are valued in the company's financial statements. Scores range from 0 to 10.
NAIC Risk-Based Capital Ratio (RBC Ratio)	The ratio of total adjusted capital (capital, surplus, and applicable valuation reserves) to NAIC risk-based capital (RBC). RBC is the *minimum* amount of capital that the insurance company must maintain based on the inherent risks in its operations. RBC is calculated based on the NAIC's formula which reflects its assessment of risks of different asset classes and businesses. For example, a company with RBC ratio of 1.0 has capital equal to its RBC. Insurance companies with higher RBC ratios are considered better capitalized. Insurance companies with RBC ratio below 2.0 are subject to supervisory interventions. The levels of supervisory actions depend on the level of RBC ratio.
Risk-Adjusted Capital Ratios 1 and 2 (RACR1 and RACR2) *	The ratios of capital base to target capitals (similar in spirit to the NAIC RBC ratio). Both the capital base and the target capitals are determined based on the Street.com's formula. Capital base measures the insurance company's resources that can be used to cover losses. These resources include capital, surplus, applicable valuation reserves, and other applicable provisions. Target capitals are the amount of capital resources that the Street.com feels the insurance company would need to cover potential losses. The target capitals for a moderate loss scenario and for a severe loss scenario are used in calculating RACR1 and RACR2, respectively.

* The Street.com may not evaluate some insurance companies for one or more of the following reasons: (i) total assets are less than $1 million, (ii) premium income for the current year is less than $100,000, (iii) the company functions almost exclusively as a holding company rather than as an underwriter, or (iv) the Street.com does not have enough information to reliably evaluate the company.
** Scores of 7 to 10, 5 to 6.9, 3 to 4.9, and 2.9 and below are considered "strong", "good", "fair", and "weak", respectively.

Appendix B: Descriptions of Other Variables

Variable	Definition
Affected Company Dummy	Dummy variable equal to 1 for companies (or group of companies) that hold downgraded bonds at the quarter end preceding the downgrade, and 0 otherwise.
Age in Years	Time since issuance measured in years.
BB- to BB+ Dummy	Dummy variable equal to 1 for bonds that are downgraded to BB-, BB, or BB+, and 0 for all other bonds.
Event Week Є [X, Y)	Dummy variable equal to 1 for trades during event weeks X (inclusive) and Y (exclusive), and 0 otherwise.
High-Yield Spread Return	Return on Barclays (formerly known as Lehman Brothers) High-Yield Bond Index, measured as the product of change in average credit spreads of bonds in the index (over yield of the 10-year Treasury note) from the previous trading day to the current trading day and maturity of the bond on the previous trading day.
% Holding by Property Insurance	Percentage of the bond issue held by property insurance companies.
Property Insurance Dummy	Dummy variable equal to 1 for property and casualty insurance companies, and 0 for life and health companies.
Investment-Grade Spread Return	Return on Barclays (formerly known as Lehman Brothers) Investment-Grade Bond Index, measured as the product of change in average credit spreads of bonds in the index (over yield of the 10-year Treasury note) from the previous trading day to the current trading day and maturity of the bond on the previous trading day.
Investment to Non-Investment Dummy	Dummy variable equal to 1 for bonds that are downgraded from an investment grade to a speculative grade, and 0 for other bonds included in the analysis.
Issue Size	Dollar offering amount of the bond.
Stock Market Return	Percentage change in the CRSP value-weighted total return index from the prior trading day.
Δ Trade Direction	Trade direction of the current trade minus trade direction of a trade in the prior trading day. Trade direction is an indicator variable, equal to 1 for a buy and -1 for a sell.
Treasury Bond Return	Return on a constant-maturity 10-year Treasury note, measure as the product of the change in yield from the previous trading day to the current trading day and maturity of the bond on the previous trading day. For variable-rate bonds, we use assume the maturity of 1 year in this calculation.
Years to Maturity	Maturity of the bond at the time of trade or at the time of downgrade depending on specifications, measured in years.

Table 1: Data Screening and Merging Process

This table describes how the data are screened and merged. The original sample is the NAIC transaction data for the period from 2001 to 2005. In the first step, data errors, non-secondary market transactions, and potential outliers are deleted. The cleaned transaction data is then merged with the rating and FISD bond characteristics data. In the next step, other non-secondary market transactions, non-standard bond types, and bonds that are too small in issue size are deleted. Finally, the remaining sample is then merged with the Street.com Ratings insurance company data. The final sample is the starting point for further sample screening for bonds that go through the events of interest during the sample period. The first three columns detail the numbers of remaining and deleted transactions in each step. The fourth column details the numbers of remaining and deleted bond issues. The fifth columns details the numbers of remaining and deleted issuers, based on the six-digit issuer CUSIP. The last column details the numbers of deleted and remaining insurance companies, who trade at least once during the sample period.

	Transactions					
	Life & Health	Property	Total	Bond Issues	Issuers (CUSIP)	Insurance Companies
(1) Raw sample (2001-2005)	**1,136,515**	**571,733**	**1,708,248**	**119,790**	**29,468**	**3,476**
- Negative or missing prices or par values	(311,481)	(97,475)	(408,956)	(9,805)	(2,528)	(83)
- Non-market transactions (based on counterparty names)*	(233,585)	(124,174)	(357,759)	(19,542)	(3,822)	(86)
- Transaction size larger than 99th percentile, or smaller than 1st percentile, or not in multiple of par	(82,570)	(36,196)	(118,766)	(27,966)	(5,981)	(37)
- Outliers detected by big spikes in price**	(2,465)	(1,015)	(3,480)	(10)	(5)	(0)
(2) Screened sample	**506,414**	**312,873**	**819,287**	**62,467**	**17,132**	**3,270**
(3) Merged with rating data	**399,470**	**264,976**	**664,446**	**23,276**	**6,040**	**3,166**
(4) Merged with FISD bond characteristics	**399,470**	**264,976**	**664,446**	**23,276**	**6,040**	**3,166**
- Non-secondary market transactions (based on maturity and offering dates)	(72,608)	(34,910)	(107,518)	(1,799)	(131)	(27)
- Bonds that are not "corporate debentures" or "corporate MTN"	(34,376)	(28,439)	(62,815)	(5,340)	(1,405)	(50)
- Bonds with issue size <= $50 million	(2,881)	(2,066)	(4,947)	(1,810)	(176)	(5)
- Bonds with sinking funds or denominated in foreign currencies	(1,279)	(473)	(1,752)	(237)	(100)	(0)
(5) Screened sample	**288,326**	**199,088**	**487,414**	**14,090**	**4,228**	**3,084**
(6) Merged with the Street data* **	**288,180**	**195,530**	**483,710**	**14,074**	**4,228**	**3,042**

* Examples of non-market counterparties include called, cancelled, conversion, direct, maturity, put, redemption, sinking fund, tax-free exchange, tendered etc.
** An outlier is defined as a transaction whose product of immediately preceding and subsequent returns is negative (price reversal) and greater than 0.09 in absolute value (overshoot and reversal greater than 30% each way).
*** The Street.com Ratings does not examine and rate insurance companies with less than $1 million in capital and surplus.

Table 2: Bond and Transaction Descriptive Information

This table provides descriptive information regarding the samples used in the empirical analyses. The sample period is from 2001 to 2005. The "total" sample includes all transactions and underlying bonds that pass the screening process in Table 1. The "downgrade from investment to non-investment" sample includes only transactions on bonds that are downgraded from an investment-grade rating (BBB- and above) to a non-investment grade rating (BB+ and below) during the sample period. The "control" sample includes only transactions on bonds that are downgraded from BBB or above to BBB- during the sample period. Panel A summarizes bond characteristics that do not change over the life of the bonds. Panel B summarizes information on insurance companies' holding of the bond. For each issue, insurance holding is the (quarterly time series) median holding of all insurance companies together, measured as a percentage of the issue size. Property insurance holding is the (quarterly time series) median holding of all property and casualty insurance companies, measured as a percentage of the bond's issue size. Panel C provides information about the transactions. Buy trades refer to transactions in which the reporting insurance companies buy (mostly from dealers). For the two downgrade samples, the holdings statistics and the transaction summary statistics are reported separately for the periods before and after the downgrade.

Panel A: Descriptive bond static information

	Total Sample					
	Always Investment Grade	Sample: Downgrade from Investment to Non-Investment	Always Non-Investment Grade	Not Rated	Total	Control: Downgrade from BBB and Above to BBB-
Number of issues	8,081	1,179	4,634	180	14,074	1,273
Number of trades per issue						
Mean	39	56	22	19	34	53
Median	16	27	12	5	15	20
Issue Size ($ million)						
Mean	381.15	416.88	277.17	303.71	348.92	449.05
Standard Deviation	413.12	502.01	225.16	352.69	374.25	567.19
Median	250.00	250.00	200.00	200.00	250.00	250.00
Maturity at Issuance (years)						
Mean	12.49	15.22	9.40	9.54	11.66	15.01
Standard Deviation	11.37	12.50	5.42	4.75	10.02	13.13
Median	10.00	10.02	9.59	9.58	9.97	10.02
% Callable	42.66	54.71	85.67	74.44	58.24	39.04
% Industrial	44.51	66.58	86.96	81.11	60.80	50.59
% Financial	43.74	14.25	8.92	13.33	29.41	33.39
% Utility	11.75	19.17	4.12	5.56	9.78	16.03

Table 2, Continued: Bond and Transaction Descriptive Information

Panel B: Descriptive statistics on insurance companies' holding

	Total Sample						Control: Downgrade from BBB and Above to BBB-	
		Sample: Downgrade from Investment-Grade to Non-Investment Grade						
	Always Investment Grade	Before Downgrade	After Downgrade	Always Non-Investment Grade	Not Rated	Total	Before Downgrade	After Downgrade
Insurance Holding (% of Issue)								
Mean	34.10	34.09	21.22	8.47	11.63	25.05	40.19	33.19
Standard Deviation	26.55	23.47	18.68	12.17	20.75	25.10	24.90	25.07
Median	31.12	32.33	16.19	4.24	4.53	16.72	39.51	28.66
Property Insurance Holding (% of Issue)								
Mean	4.78	4.28	2.55	1.18	1.36	3.44	4.96	3.36
Standard Deviation	6.28	6.67	4.10	2.39	2.31	5.49	7.19	4.23
Median	2.81	2.43	1.10	0.30	0.28	1.37	3.06	2.00

Panel C: Descriptive transaction information

	Total Sample						Control: Downgrade from BBB and Above to BBB-	
		Sample: Downgrade from Investment-Grade to Non-Investment Grade						
	Always Investment Grade	Before Downgrade	After Downgrade	Always Non-Investment Grade	Not Rated	Total	Before Downgrade	After Downgrade
Number of trades	311,699	42,181	23,840	102,503	3,487	483,710	40,557	29,288
Price ($)								
Mean	105.38	99.16	90.32	96.01	80.49	101.93	101.58	97.85
Standard Deviation	10.66	9.27	31.24	18.52	31.62	15.31	7.61	17.52
Median	104.10	100.45	96.25	100.96	94.23	102.70	101.64	100.99
Trade Size ($ million)								
Mean	3.22	3.11	2.32	1.55	1.97	2.80	3.41	2.83
Standard Deviation	4.77	4.75	4.00	2.89	3.55	4.44	4.95	4.48
Median	1.20	1.00	0.85	0.50	0.71	1.00	1.50	1.00
Trade Size (% of Issue Size)								
Mean	0.82	0.60	0.63	0.58	0.65	0.74	0.73	0.69
Standard Deviation	1.70	1.31	1.45	1.26	1.53	1.58	1.49	1.50
Median	0.25	0.15	0.17	0.17	0.16	0.20	0.20	0.17
Age (years)								
Mean	2.75	2.36	4.20	2.22	2.24	2.67	2.28	4.08
Standard Deviation	2.89	2.43	3.03	2.26	1.99	2.76	2.33	2.81
Median	1.85	1.70	3.64	1.56	1.73	1.86	1.69	3.64
Maturity (years)								
Mean	9.56	10.63	9.73	7.28	6.58	9.16	10.57	9.89
Standard Deviation	8.73	9.19	9.26	4.17	2.65	8.10	9.10	9.35
Median	7.42	7.84	6.52	6.97	6.47	7.22	7.96	6.63
% Buy Trades	59.95	52.67	41.67	49.16	41.76	56.00	56.63	44.72

Table 3: Ratings Before and After the Downgrade

This table presents the number of downgraded bonds categorized by the ratings before and after the downgrade event. The sample period is from 2001 to 2005. The sample includes only bonds that are downgraded from an investment-grade rating (BBB- and above) to a non-investment grade rating (BB+ and below) during the sample period.

Rating Before Downgrade	Rating After Downgrade: BB+	BB	BB-	B+	B	B-	CCC+	CCC	CCC-	CC	C&D	**Total**	**% of Total**
AAA	0	0	0	2	0	0	0	0	0	0	0	**2**	**0.2%**
AA+	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.0%**
AA	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.0%**
AA-	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.0%**
A+	2	1	0	0	0	0	0	0	0	0	0	**3**	**0.3%**
A	0	0	0	2	0	1	0	0	0	0	0	**3**	**0.3%**
A-	7	2	0	0	0	0	0	0	0	0	0	**9**	**0.8%**
BBB+	13	3	8	7	2	2	0	0	0	0	0	**35**	**3.0%**
BBB	144	45	7	6	0	0	0	4	0	0	3	**209**	**17.7%**
BBB-	510	270	68	31	3	22	1	5	0	8	0	**918**	**77.9%**
Total	**676**	**321**	**83**	**48**	**5**	**25**	**1**	**9**	**0**	**8**	**3**	**1,179**	
% of Total	**57.3%**	**27.2%**	**7.0%**	**4.1%**	**0.4%**	**2.1%**	**0.1%**	**0.8%**	**0.0%**	**0.7%**	**0.3%**		

Table 4: Insurance Company Descriptive Information

This table provides descriptive information about the insurance companies that trade the bonds in the total sample, the "downgrade from investment to non-investment" sample, and the control sample (bonds that are downgraded from BBB or above to BBB-). The sample period is from 2001 to 2005. The total number of trades only includes the trades that passed the screen described in Table 1. Other variables are from the Street.com. The frequency is annual and the variable values are for each year end. The statistics reported are cross-sectional statistics based on the median value of each variable from 2000 to 2005. The capitalization index and the investment safety index are available only for life and health insurance companies. The counterparts of the capitalization index for property and casualty insurance companies are the risk-adjusted capitalization indexes 1 and 2. The detailed description of each variable is in Appendix A.

	Total Sample											Sample	Control
	Life & Health Insurance (N=982)					Property & Casualty Insurance (N=2,060)					Total	Downgrade from Investment to Non-Investment	Downgrade from BBB and Above to BBB-
	Mean	Std. Dev.	10th Pct	50th Pct	90th Pct	Mean	Std. Dev.	10th Pct	50th Pct	90th Pct	Mean		
Measures of Size													
Total Number of Bond Trades (2001-2005)	293	595	5	73	795	95	199	3	34	218	159	195	182
Invested Assets ($ million)	2,536	10,426	7	128	4,818	448	2,300	7	48	755	1,122	1,367	1,275
Capital and Surplus ($ million)	270	847	3	31	589	187	1,130	4	24	303	214	251	235
Measures of Regulatory Constraint													
NAIC Risk-Based Capital Ratio (RBC Ratio)	25.63	73.12	4.21	8.28	40.19	39.75	138.68	3.00	7.40	70.20	35.13	22.30	26.50
Risk-Adjusted Capital Ratio 1 (RACR1)	2.28	1.73	0.86	1.93	3.92	8.29	32.08	0.59	1.80	9.80	6.35	4.21	5.03
Risk-Adjusted Capital Ratio 1 (RACR2)	1.65	1.24	0.64	1.30	3.08	5.14	17.95	0.40	1.29	7.66	4.02	2.75	3.22
Capitalization Index (Scale 1-10)	6.94	2.09	4.05	7.33	9.55						6.94	6.96	6.97
Risk-Adjusted Capitalization Index 1 (Scale 1-10)						7.49	2.55	3.40	8.00	10.00	7.49	7.41	7.45
Risk-Adjusted Capitalization Index 2 (Scale 1-10)						6.57	2.85	2.08	7.28	10.00	6.57	6.45	6.51
Liquidity Index (Scale 1-10)	7.08	1.70	5.40	6.95	9.40	6.98	1.38	5.88	6.90	8.83	7.02	6.90	6.94
Measures of Risk Appetite													
Holding of Non-Investment Grade Bonds (% of Invested Assets)	2.66	3.87	0.00	1.63	6.65	0.72	1.58	0.00	0.00	2.26	1.35	1.60	1.50
Holding of Risky Assets (% of Invested Assets)	15.56	17.04	0.35	11.41	34.87	14.99	16.87	0.00	9.43	37.82	15.18	16.06	15.57
Investment Safety Index (Scale 1-10)	6.42	1.94	3.80	6.55	8.80						6.42	6.23	6.30

Table 5: Weekly Cumulative Abnormal Returns of Downgraded Bonds

This table reports the median cumulative abnormal returns (*MCAR*s) for bonds that are downgraded from an investment-grade rating to a non-investment grade rating and those that are downgraded from BBB and above to BBB-. Week 0 denotes the downgrade announcement week. The abnormal return for a bond from *t*-1 to *t* is measured as the residual ε_t from the model:

$$\ln(P_{i,t} / P_{i,t-1}) \cong \alpha + \beta Z_{i,t-1,t} + \gamma_0 (Q_{i,t} - Q_{i,t-1}) + \gamma_1 (Q_{i,t} \ln(S_{i,t}) - Q_{i,t-1} \ln(S_{i,t-1})) + \varepsilon_{i,t-1,t}$$

where Z is a vector of information variables that impact the bond's fundamental value, including yield on 10-year Treasury note, Barclays investment-grade corporate bond yield spread, Barclays high-yield bond yield spread, and CRSP value-weighted return index. Q is an indicator variable equal to 1 if the transaction is a buy and -1 if it is a sell. S denotes transaction size (par value). The parts associated with Q are included to control for "normal" price impact of a trade. The above model is estimated using the data for the period up to 30 weeks before the downgrade to obtain the abnormal return from weeks -30 to -1. The model is then re-estimated using the data starting week 31 after the downgrade to obtain the abnormal return from weeks 0 to 30. The abnormal returns are accumulated over time. The cumulative abnormal return for each bond is normalized to 0 in week -20. *MCAR*s are measured as across-bond across-transaction medians of cumulative abnormal returns for each week. Panel A reports weekly *MCAR*s from weeks -20 to +20. Panel B reports the *MCAR*s for different 5-week periods relative to the event. The *z*-statistics in both Panels A and B are for the rank-sum tests of difference in abnormal returns between the two types of downgrade. Panel C reports changes in *MCAR* from the 5-week period immediately after the downgrade to the later periods. The *t*-statistics are based on median regression (or LAE) estimates of difference-in-difference models, in which the differences are between the two samples and between the two 5-week periods.

Panel A: Median cumulative abnormal returns by week relative to the downgrade

	(1) Investment to Non-Investment		(2) BBB and Above to BBB-			*z*-statistic
Week	*MCAR*	*N*	*MCAR*	*N*	(1) - (2) *MCAR*	(Rank-Sum Test)
-20	0.000	124	0.000	139		
-19	0.000	132	-0.061	109	0.061	(-1.122)
-18	-0.153	127	-0.177	140	0.024	(-0.306)
-17	-0.015	129	-0.459	147	0.444	(1.574)
-16	-0.584	120	-0.185	115	-0.399	(-1.484)
-15	-0.879	150	-0.435	126	-0.444	(-0.808)
-14	-1.818	123	-0.377	131	-1.440	(-3.234)
-13	-1.693	116	-0.640	129	-1.053	(-2.502)
-12	-1.519	127	-1.083	133	-0.436	(-1.317)
-11	-2.105	125	-0.777	104	-1.328	(-3.161)
-10	-3.295	115	-0.556	106	-2.740	(-2.407)
-9	-3.399	118	-0.648	120	-2.751	(-2.856)
-8	-3.353	128	-0.427	122	-2.926	(-4.129)
-7	-5.500	142	-1.314	127	-4.186	(-5.187)
-6	-6.241	132	-2.067	130	-4.174	(-3.927)
-5	-5.321	155	-2.081	121	-3.240	(-4.040)
-4	-7.974	126	-2.387	111	-5.587	(-4.386)
-3	-9.363	144	-1.044	125	-8.319	(-5.641)
-2	-10.144	141	-1.625	127	-8.519	(-5.165)
-1	-9.665	142	-3.573	138	-6.092	(-3.335)
0	-9.689	256	-2.299	186	-7.391	(-5.339)

Table 5, Continued: Weekly Cumulative Abnormal Returns of Downgraded Bonds

Panel A, Continued: Median cumulative abnormal returns by week relative to the downgrade

Week	(1) Investment to Non-Investment		(2) BBB and Above to BBB-		(1) - (2)	*z*-statistic (Rank-Sum
	MCAR	*N*	*MCAR*	*N*	*MCAR*	Test)
1	-10.947	220	-3.480	174	-7.467	(-5.239)
2	-9.324	178	-3.592	124	-5.732	(-3.577)
3	-11.308	151	-3.277	143	-8.031	(-3.528)
4	-9.082	165	-3.311	130	-5.771	(-2.091)
5	-6.738	133	-3.937	146	-2.802	(-1.168)
6	-7.712	146	-5.377	127	-2.335	(-2.113)
7	-9.497	152	-4.234	134	-5.263	(-2.186)
8	-6.039	103	-5.120	121	-0.918	(-1.638)
9	-6.074	131	-3.291	130	-2.783	(-1.388)
10	-7.542	119	-4.467	110	-3.075	(-1.374)
11	-7.074	138	-4.695	106	-2.379	(-1.596)
12	-7.469	134	-4.680	117	-2.789	(-1.925)
13	-7.663	119	-4.240	119	-3.423	(-0.856)
14	-5.046	85	-3.699	128	-1.348	(-0.208)
15	-4.401	95	-3.131	138	-1.270	(0.081)
16	-3.885	105	-4.532	126	0.647	(-0.935)
17	-4.064	108	-2.970	101	-1.094	(-0.721)
18	-1.378	91	-4.329	121	2.951	(2.175)
19	-3.676	114	-3.522	111	-0.154	(0.129)
20	-2.069	81	-3.846	107	1.777	(0.803)

Panel B: Median cumulative abnormal returns by 5-week period relative to the downgrade

5-Week Period	(1) Investment to Non-Investment *MCAR*	(2) BBB and Above to BBB- *MCAR*	(1) - (2) *MCAR*	*z*-statistic (Rank-Sum Test)
[-20, -16]	0.000	0.000	0.000	(0.038)
[-15, -11]	-1.519	-0.690	-0.829	(-4.736)
[-10, -6]	-4.071	-0.976	-3.095	(-8.214)
[-5, -1]	-8.150	-2.166	-5.983	(-9.941)
Week 0	-9.689	-2.299	-7.391	(-5.339)
[1, 5]	-9.682	-3.533	-6.149	(-7.101)
[6, 10]	-7.439	-4.687	-2.752	(-3.688)
[11, 15]	-6.314	-3.909	-2.405	(-3.153)
[16, 20]	-3.555	-3.855	0.300	(1.132)

Panel C: Changes in median cumulative abnormal returns from the 5-week period immediately after the downgrade to subsequent 5-week periods

Difference between Two Periods	(1) Investment to Non-Investment Δ*MCAR*	(2) BBB and Above to BBB- Δ*MCAR*	(1) - (2) Δ*MCAR*	Diff-in-Diff Median Regression *t*-statistic
[6-10] - [1-5]	2.243	-1.153	3.397	(3.210)
[11-15] - [1-5]	3.368	-0.375	3.743	(3.780)
[16-20] - [1-5]	6.127	-0.322	6.449	(6.740)

Table 6: Trading Volume of Downgraded Bonds

This table reports and compares the trading volume (by insurance companies as reported to NAIC) between the bonds that are downgraded from an investment-grade rating to a non-investment grade rating and those that are downgraded from BBB and above to BBB-. Volume statistics are reported by event week, with week 0 being the downgrade announcement week. For each bond in each event week, the total volume is calculated as the sum of the buy volume and the sell volume, while the net volume is calculated as the buy volume minus the sell volume. The means are calculated as the averages across all bond-weeks during the defined period. The *t*-tests and the rank-sum tests investigate the differences in volume and net volume between the investment to non-investment sample and the BBB and above to BBB- sample.

	Total Volume ($ Million/bond/week)				Net Volume ($ Million/bond/week)			
Period	Investment to Non-Investment Mean	BBB and Above to BBB- Mean	*t*-statistic (Mean Difference Test)	*z*-statistic (Rank-Sum Test)	Investment to Non-Investment Mean	BBB and Above to BBB- Mean	*t*-statistic (Mean Difference Test)	*z*-statistic (Rank-Sum Test)
[-30, -26]	1.019	1.126	(-1.132)	(-1.379)	0.020	0.182	(-2.169)	(-1.078)
[-25, -21]	0.901	0.908	(-0.098)	(-0.737)	0.043	0.090	(-0.735)	(-0.758)
[-20, -16]	0.925	1.015	(-1.050)	(-0.672)	-0.061	0.126	(-2.881)	(-3.059)
[-15, -11]	0.951	0.928	(0.301)	(0.381)	-0.180	0.035	(-3.495)	(-5.250)
[-10, -6]	0.959	0.990	(-0.362)	(0.495)	-0.307	0.049	(-5.014)	(-6.857)
[-5, -1]	0.993	1.068	(-0.922)	(1.979)	-0.433	0.062	(-7.080)	(-9.842)
Week 0	2.482	1.770	(2.388)	(4.707)	-1.344	-0.469	(-3.683)	(-4.715)
[1, 5]	1.062	1.138	(-0.880)	(4.000)	-0.492	-0.245	(-3.511)	(-5.173)
[6, 10]	0.883	0.889	(-0.076)	(1.410)	-0.460	-0.186	(-4.231)	(-4.464)
[11, 15]	0.646	0.972	(-4.751)	(-3.357)	-0.289	-0.318	(0.449)	(-2.339)
[16, 20]	0.597	0.772	(-3.020)	(-2.890)	-0.229	-0.189	(-0.741)	(-0.515)
[21, 25]	0.549	0.953	(-5.884)	(-6.106)	-0.315	-0.154	(-2.492)	(-2.895)
[26, 30]	0.509	0.717	(-3.713)	(-2.245)	-0.236	-0.164	(-1.389)	(-1.677)

Table 7: Probability of Selling during Weeks 0 and 5 after the Downgrade

This table reports probit estimates of the effects of regulatory constraints on the probability that an insurance company will sell the downgraded bonds during weeks 0 to 5 after the downgrade. The dependent variable is a dummy that equals one if the insurance company (holding the bond) sells the downgraded bond during weeks 0 and 5, and zero otherwise. Panel A reports the coefficient estimates. Panel B reports the corresponding marginal effect evaluated at the sample means of the explanatory variables. The downgrade is from investment grade to non-investment grade. In column "Life vs. Property", the difference in selling propensity between life and property companies is analyzed. In columns Life (1) to Life (4), only life companies are used in the estimation. In columns Property (1) to Property (4), only property companies are used in the estimation. All models include state and year-quarter dummies. White's robust standard errors are in parentheses. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels. Variable definitions are in Appendix A.

Panel A: Coefficient estimates

	Life vs. Property	Life (1)	Life (2)	Life (3)	Life (4)	Property (1)	Property (2)	Property (3)	Property (4)
Regulatory Constraints									
Property Insurance Dummy	0.1827***								
	(0.0276)								
ln(RBC Ratio)		-0.2622***				-0.2072***			
		(0.0597)				(0.0692)			
ln(RACR1)			-0.0746				-0.2447***		
			(0.0652)				(0.0713)		
Capitalization Index				0.0075					
				(0.0122)					
Liquidity Index					-0.0279**				0.0114
					(0.0111)				(0.0209)
Risk-Adjusted Capitalization Index 1								-0.0409***	
								(0.0120)	
Insurance Company Controls									
ln(Capital & Surplus)		-0.0097	-0.0096	-0.0121	-0.0070	0.0070	0.0186	0.0214	0.0120
		(0.0093)	(0.0094)	(0.0094)	(0.0094)	(0.0141)	(0.0141)	(0.0143)	(0.0141)
Risky Asset Holding (% of Portfolio)		0.0012	0.0007	0.0013	0.0012	-0.0066***	-0.0071***	-0.0068***	-0.0066***
		(0.0015)	(0.0016)	(0.0015)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
Bond Controls									
BB- to BB+ Dummy	-0.1216**	-0.1031*	-0.1015*	-0.1026*	-0.1010*	-0.1672*	-0.1700*	-0.1710*	-0.1625
	(0.0492)	(0.0572)	(0.0572)	(0.0572)	(0.0572)	(0.1014)	(0.1013)	(0.1013)	(0.1015)
ln(Age in Years)	-0.1196***	-0.1226***	-0.1240***	-0.1232***	-0.1235***	-0.1118***	-0.1145***	-0.1166***	-0.1165***
	(0.0142)	(0.0178)	(0.0177)	(0.0177)	(0.0177)	(0.0259)	(0.0259)	(0.0260)	(0.0260)
ln(Issue Size)	0.0892***	0.0847***	0.0847***	0.0850***	0.0852***	0.0828***	0.0818***	0.0805***	0.0834***
	(0.0157)	(0.0196)	(0.0195)	(0.0195)	(0.0195)	(0.0286)	(0.0287)	(0.0287)	(0.0286)
Observations	23,690	16,006	16,006	16,006	16,006	6,264	6,264	6,264	6,264
Pseudo R-squared	0.0536	0.0691	0.0671	0.0670	0.0677	0.0668	0.0676	0.0672	0.0648
Log Likelihood	-6,376	-4,082	-4,091	-4,091	-4,088	-2,049	-2,047	-2,048	-2,053

Table 7, Continued: Probability of Selling during Weeks 0 and 5 after the Downgrade

Panel B: Marginal effects

	Life vs. Property	Life (1)	Life (2)	Life (3)	Life (4)	Property (1)	Property (2)	Property (3)	Property (4)
Regulatory Constraints									
Property Insurance Dummy	0.0264***								
	(0.0043)								
ln(RBC Ratio)		-0.0312***				-0.0351***			
		(0.0072)				(0.0117)			
ln(RACR1)			-0.0089				-0.0415***		
			(0.0078)				(0.0121)		
Capitalization Index				0.0009					
				(0.0015)					
Liquidity Index					-0.0033**				0.0019
					(0.0013)				(0.0036)
Risk-Adjusted Capitalization Index 1								-0.0069***	
								(0.0020)	
Insurance Company Controls									
ln(Capital & Surplus)		-0.0012	-0.0011	-0.0014	-0.0008	0.0012	0.0032	0.0036	0.0020
		(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0024)	(0.0024)	(0.0024)	(0.0024)
Risky Asset Holding (% of Portfolio)		0.0001	0.0001	0.0002	0.0001	-0.0011***	-0.0012***	-0.0012***	-0.0011***
		(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Bond Controls									
BB- to BB+ Dummy	-0.0178**	-0.0131*	-0.0130*	-0.0131*	-0.0129*	-0.0312	-0.0317	-0.0319	-0.0303
	(0.0077)	(0.0078)	(0.0078)	(0.0078)	(0.0078)	(0.0206)	(0.0206)	(0.0206)	(0.0205)
ln(Age in Years)	-0.0162***	-0.0146***	-0.0148***	-0.0147***	-0.0148***	-0.0190***	-0.0194***	-0.0198***	-0.0198***
	(0.0019)	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0044)	(0.0044)	(0.0044)	(0.0044)
ln(Issue Size)	0.0121***	0.0101***	0.0101***	0.0102***	0.0102***	0.0140***	0.0139***	0.0137***	0.0142***
	(0.0021)	(0.0023)	(0.0023)	(0.0023)	(0.0023)	(0.0049)	(0.0049)	(0.0049)	(0.0049)

Table 8: Cumulative Abnormal Returns of Downgraded Bonds by Selling Pressure Group

This table reports the median cumulative abnormal returns (*MCAR*s) for the downgraded bonds grouped by the selling propensity of insurance companies holding the bonds. Week 0 denotes the downgrade announcement week. The bonds are grouped by (i) the average RBC ratio, or (ii) the average probability of selling during the first 5 weeks after the downgrade. For each bond, both measures are calculated by averaging the variables across all companies holding the bond at the end of the quarter preceding the downgrade. The low (high) RBC ratio group includes bonds with the average holders' RBC ratio below (above) the across-bond median. The probability of selling is calculated based on the models Life (1) and Property (1) in Table 7. The high (low) selling probability group includes bonds with the average holders' probability of selling above (below) the across-bond median. Panel A reports the *MCAR*s for the 5-week period immediately after the downgrade (weeks 1 to 5) and for later 5-week periods. The *z*-statistics are for the rank-sum tests of difference in abnormal returns. Panel B reports changes in *MCAR* from the period immediately after the downgrade to later periods. The *t*-statistics are based on median regression (or LAE) estimates of difference-in-difference models, in which the differences are across the two selling pressure groups and across the two event periods.

Panel A: Median cumulative abnormal returns by selling pressure group

	RBC Ratio				Sell Probability			
5-Week Period	Low Group *MCAR*	High Group *MCAR*	Low - High *MCAR*	*z*-statistic (Rank-Sum Test)	High Group *MCAR*	Low Group *MCAR*	High - Low *MCAR*	*z*-statistic (Rank-Sum Test)
[1, 5]	-14.108	-7.884	-6.223	(-7.789)	-13.815	-7.274	-6.541	(-10.582)
[6, 10]	-11.678	-5.696	-5.982	(-4.354)	-12.730	-6.908	-5.822	(-7.524)
[11, 15]	-6.968	-6.107	-0.861	(-1.501)	-7.111	-6.254	-0.857	(-3.363)
[16, 20]	-2.690	-2.855	0.166	(-1.195)	-4.254	-1.853	-2.401	(-4.585)

Panel B: Changes in median cumulative abnormal return from the 5-week period immediately after the downgrade to later 5-week periods, by selling pressure group

	RBC Ratio				Sell Probability			
Difference between Two Periods	Low Group Δ*MCAR*	High Group Δ*MCAR*	Low - High Δ*MCAR*	Diff-in-Diff Median Regression *t*-statistic	High Group Δ*MCAR*	Low Group Δ*MCAR*	High - Low Δ*MCAR*	Diff-in-Diff Median Regression *t*-statistic
[6-10] - [1-5]	2.430	2.189	0.241	(0.210)	1.085	0.366	0.719	(0.490)
[11-15] - [1-5]	7.140	1.777	5.363	(4.830)	6.704	1.020	5.684	(4.610)
[16-20] - [1-5]	11.418	5.029	6.389	(6.020)	9.561	5.421	4.139	(3.120)

Table 9: Regression of Price Reversals

This table reports coefficient estimates for the regression of price reversals on measures of regulatory constraint of an average insurance company holding the downgraded bonds. For each transaction executed during the period from weeks 0 to 5 after the downgrade, price reversal (the dependent variable) is measured as the logged benchmark price minus the logged transaction price. The benchmark price for each bond is measured as the average price of all transactions that are executed in or after event week 16. All other change and return variables are measured in the same fashion. Age and years to maturity are measured at the time of downgrade. Panel A reports OLS estimates for four models with different measures of regulatory constraints. White's robust standard errors are in parentheses. Panel B reports quantile regression estimates (.25, .50, and .75) for two models using two different measures of regulatory constraints, one using % holding by property insurance companies and the other using mean holders' log of RBC ratio. Bootstrapped standard errors are in parentheses. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels.

Panel A: OLS regressions

	Property Holding	RBC Ratio	RACR1	Liquidity Index
Regulatory Constraints				
% Holding by Property Insurance	0.0020***			
	(0.0005)			
Mean Holders' ln(RBC Ratio)		-0.1142***		
		(0.0368)		
Mean Holders' ln(RACR1)			-0.1189**	
			(0.0519)	
Mean Holders' Liquidity Index				-0.0040
				(0.0074)
Insurance Company Controls				
Mean Holders' ln(Capital & Surplus)		-0.0617***	-0.0595***	-0.0626***
		(0.0048)	(0.0051)	(0.0048)
Mean Holders' Risky Asset Holding		0.0024**	0.0021**	0.0028***
		(0.0010)	(0.0010)	(0.0010)
Market Movement Controls				
Stock Market Return	0.1935***	0.2286***	0.2146***	0.2273***
	(0.0238)	(0.0234)	(0.0240)	(0.0241)
Treasury Bond Return	0.2796***	0.1905***	0.1980***	0.1966***
	(0.0407)	(0.0394)	(0.0396)	(0.0395)
Investment-Grade Spread Return	-0.0032	0.0642	0.0455	0.0541
	(0.1045)	(0.0975)	(0.0983)	(0.0977)
High-Yield Spread Return	0.1291***	0.0965***	0.1066***	0.1056***
	(0.0300)	(0.0278)	(0.0279)	(0.0278)
Transaction Cost Controls				
Δ Trade Direction	0.0164	0.0231	0.0210	0.0214
	(0.0167)	(0.0160)	(0.0161)	(0.0160)
Δ (Trade Direction X ln(Trade Size))	-0.0006	-0.0011	-0.0010	-0.0010
	(0.0012)	(0.0012)	(0.0012)	(0.0012)
Bond Controls				
BB- to BB+ Dummy	-0.0143*	-0.0153*	-0.0113	-0.0085
	(0.0076)	(0.0080)	(0.0081)	(0.0079)
ln(Age in Years)	-0.0174***	-0.0287***	-0.0335***	-0.0342***
	(0.0038)	(0.0043)	(0.0041)	(0.0041)
ln(Issue Size)	-0.0056**	-0.0177***	-0.0201***	-0.0201***
	(0.0026)	(0.0029)	(0.0027)	(0.0028)
ln(Years to Maturity)	-0.0225***	-0.0072*	-0.0079*	-0.0087**
	(0.0043)	(0.0043)	(0.0043)	(0.0043)
Constant	0.1887***	1.7298***	1.6208***	1.5725***
	(0.0349)	(0.1184)	(0.1115)	(0.1195)
Observations	2,962	2,962	2,962	2,962
Adjusted R-squared	0.160	0.202	0.201	0.199

Table 9, Continued: Regression of Price Reversals

Panel B: Quantile regressions

	Property Holding			RBC Ratio		
	25%	50%	75%	25%	50%	75%
Regulatory Constraints						
% Holding by Property Insurance	0.0015***	0.0015***	0.0031**			
	(0.0003)	(0.0003)	(0.0012)			
Mean Holders' ln(RBC Ratio)				0.0113	-0.0499*	-0.2763***
				(0.0284)	(0.0263)	(0.0511)
Insurance Company Controls						
Mean Holders' ln(Capital & Surplus)				-0.0347***	-0.0537***	-0.0797***
				(0.0050)	(0.0034)	(0.0062)
Mean Holders' Risky Asset Holding				0.0026**	0.0055***	0.0035**
				(0.0010)	(0.0008)	(0.0014)
Market Movement Controls						
Stock Market Return	-0.0046	0.0291	0.2333***	0.0317	0.0460***	0.2382***
	(0.0227)	(0.0218)	(0.0426)	(0.0234)	(0.0174)	(0.0315)
Treasury Bond Return	0.1368***	0.3849***	0.4071***	0.1715***	0.2976***	0.2239**
	(0.0525)	(0.0501)	(0.1029)	(0.0463)	(0.0285)	(0.0897)
Investment-Grade Spread Return	-0.2091**	-0.4742***	0.1467	-0.2939***	-0.5381***	0.1515
	(0.0980)	(0.1463)	(0.1682)	(0.0962)	(0.1015)	(0.1769)
High-Yield Spread Return	0.1774***	0.2722***	0.1763***	0.1669***	0.2769***	0.1408***
	(0.0302)	(0.0418)	(0.0460)	(0.0292)	(0.0327)	(0.0394)
Transaction Cost Controls						
Δ Trade Direction	0.0029	-0.0021	0.0132	0.0009	0.0123	0.0219
	(0.0078)	(0.0108)	(0.0205)	(0.0115)	(0.0103)	(0.0178)
Δ (Trade Direction X ln(Trade Size))	0.0001	0.0006	-0.0002	0.0002	-0.0005	-0.0008
	(0.0006)	(0.0008)	(0.0015)	(0.0008)	(0.0007)	(0.0013)
Bond Controls						
BB- to BB+ Dummy	-0.0603***	-0.0361***	0.0289*	-0.0625***	-0.0264***	0.0066
	(0.0075)	(0.0046)	(0.0153)	(0.0092)	(0.0047)	(0.0111)
ln(Age in Years)	-0.0127***	-0.0119***	-0.0209***	-0.0233***	-0.0256***	-0.0341***
	(0.0026)	(0.0029)	(0.0076)	(0.0043)	(0.0027)	(0.0060)
ln(Issue Size)	0.0009	0.0012	-0.0198***	-0.0037	-0.0149***	-0.0294***
	(0.0021)	(0.0018)	(0.0035)	(0.0027)	(0.0023)	(0.0047)
ln(Years to Maturity)	-0.0228***	-0.0136***	-0.0090	-0.0157***	-0.0045	0.0038
	(0.0029)	(0.0050)	(0.0098)	(0.0035)	(0.0037)	(0.0073)
Constant	0.0783***	0.0721***	0.3599***	0.7570***	1.3300***	2.5558***
	(0.0261)	(0.0240)	(0.0483)	(0.1200)	(0.0809)	(0.1769)
Observations	2,962	2,962	2,962	2,962	2,962	2,962
Pseudo R-squared	0.0432	0.0959	0.1528	0.0557	0.1284	0.1957

Table 10: Price Reversals for Different Downgrade Samples

This table compares price reversals and the effects of regulatory constraints on price reversals between the bonds that are downgraded from an investment-grade rating to a non-investment grade rating and those that are downgraded from BBB and above to BBB- (as a control group). OLS coefficient estimates are reported for different conditional models of price reversals. Week 0 denotes the downgrade announcement week. For each transaction executed during the period from weeks 0 to 5 after the downgrade, price reversal (the dependent variable) is measured as the logged benchmark price minus the logged transaction price. The benchmark price for each bond is measured as the average price of all transactions that are executed in or after week 16. The models include, as explanatory variables, (i) an indicator for whether the observation is from the investment to non-investment sample, (ii) measures of regulatory constraint of an average insurance company holding the downgraded bonds, (iii) the interaction term of the investment to non-investment dummy and the measures of regulatory constraints, and (iv) other control variables as in Table 9. For brevity, only the coefficient estimates for (i), (ii), and (iii) are reported. White's robust standard errors are in parentheses. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels.

	No Constraint	Property Holding	RBC Ratio	RACR1	Liquidity Index
Sample Identifier					
Investment to Non-Investment Dummy	0.0221***	0.0237***	0.0277***	0.0265***	0.0229***
	(0.0033)	(0.0034)	(0.0034)	(0.0033)	(0.0035)
Regulatory Constraints					
% Holding by Property Insurance		0.0005			
		(0.0004)			
Mean Holders' ln(RBC Ratio)			-0.0037		
			(0.0296)		
Mean Holders' ln(RACR1)				0.2904***	
				(0.0356)	
Mean Holders' Liquidity Index					-0.0377***
					(0.0053)
Differential Effects of Regulatory Constraints					
[% Holding by Property Insurance] X [Investment to Non-Investment Dummy]		0.0012**			
		(0.0006)			
[Mean Holders' ln(RBC Ratio)] X [Investment to Non-Investment Dummy]			-0.0779*		
			(0.0450)		
[Mean Holders' ln(RACR1)] X [Investment to Non-Investment Dummy]				-0.4262***	
				(0.0583)	
[Mean Holders' Liquidity Index] X [Investment to Non-Investment Dummy]					0.0203**
					(0.0087)
Insurance Company Controls	NO	NO	YES	YES	YES
Market Movement Controls	YES	YES	YES	YES	YES
Transaction Cost Controls	YES	YES	YES	YES	YES
Bond Controls	NO	YES	YES	YES	YES
Observations	5,532	5,532	5,532	5,532	5,532
Adjusted R-squared	0.220	0.239	0.259	0.265	0.263

Table 11: Net Trading Volume of Other Bonds Held by Affected Insurance Companies

This table reports the net dollar volume of non-downgraded bonds that are held by insurance companies holding the downgraded bonds at the quarter end before the downgrade event. The downgrade is from an investment-grade rating to a non-investment grade rating. The net volume is calculated separately by rating group and for the group of "affected" insurance companies, i.e. those also holding the downgraded bonds, and for the group of other insurance companies not affected by the downgrade. The coefficient of each time period dummy represents the average dollar volume per bond per insurance company per week, conditional on at least one company (affected or not affected) trading the bond in the period. The interaction terms represent the difference in net dollar volume between the groups of companies affected and not affected by the downgrade. Standard errors clustered by year-quarter of the downgrade event are in parentheses. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels.

	Average Net Volume ($ per bond per company per week)		
	Non-Investment	BBB	A and Above
Event Week Є [-20, -15)	13,519***	35,685***	27,525***
	(988)	(1,337)	(1,032)
Event Week Є [-15, -10)	13,937***	36,030***	27,848***
	(1,680)	(1,779)	(1,461)
Event Week Є [-10, -5)	-2,254	13,112***	11,121***
	(2,410)	(2,999)	(2,446)
Event Week Є [-5, 0)	-14,754***	-6,543*	-5,992**
	(2,663)	(3,393)	(2,390)
Event Week = 0	-71,024***	-65,003***	-53,666***
	(7,819)	(11,626)	(7,283)
Event Week Є (0, 5]	-21,806***	-21,161***	-17,366***
	(2,310)	(3,418)	(2,344)
Event Week Є (5, 10]	-20,718***	-20,486***	-16,741***
	(2,161)	(3,489)	(2,352)
Event Week Є (10, 15]	-19,372***	-19,826***	-16,040***
	(2,527)	(3,829)	(2,617)
Event Week Є (15, 20]	-18,886***	-19,335***	-15,460***
	(2,570)	(3,587)	(2,400)
[Event Week Є [-20, -15)] X [Affected Company Dummy]	12,685***	26,305***	27,233***
	(1,790)	(1,714)	(2,505)
[Event Week Є [-15, -10)] X [Affected Company Dummy]	10,659***	22,823***	23,625***
	(1,640)	(2,231)	(2,900)
[Event Week Є [-10, -5)] X [Affected Company Dummy]	4,569**	17,740***	15,879***
	(2,173)	(2,341)	(3,136)
[Event Week Є [-5, 0)] X [Affected Company Dummy]	-3,192	6,834*	3,236
	(3,128)	(3,813)	(3,831)
[Event Week = 0] X [Affected Company Dummy]	-30,880**	-7,340	-21,232
	(12,625)	(14,340)	(14,333)
[Event Week Є (0, 5]] X [Affected Company Dummy]	-7,810**	-328	-5,062
	(3,375)	(3,384)	(3,611)
[Event Week Є (5, 10]] X [Affected Company Dummy]	-6,275**	-607	-4,926
	(2,836)	(3,339)	(3,517)
[Event Week Є (10, 15]] X [Affected Company Dummy]	-6,448	-184	-2,916
	(4,002)	(4,607)	(4,228)
[Event Week Є (15, 20]] X [Affected Company Dummy]	-5,778	288	-2,759
	(4,481)	(4,447)	(4,085)
Estimation Includes Dummies for Event Weeks in [-40,-30), [-30,-25), [-25,-20), (+20,+25], (+25,+30], (+30,+40]	YES	YES	YES
Observations	1,450,704	2,494,972	2,445,574
Adjusted R-squared	0.0339	0.0388	0.0351

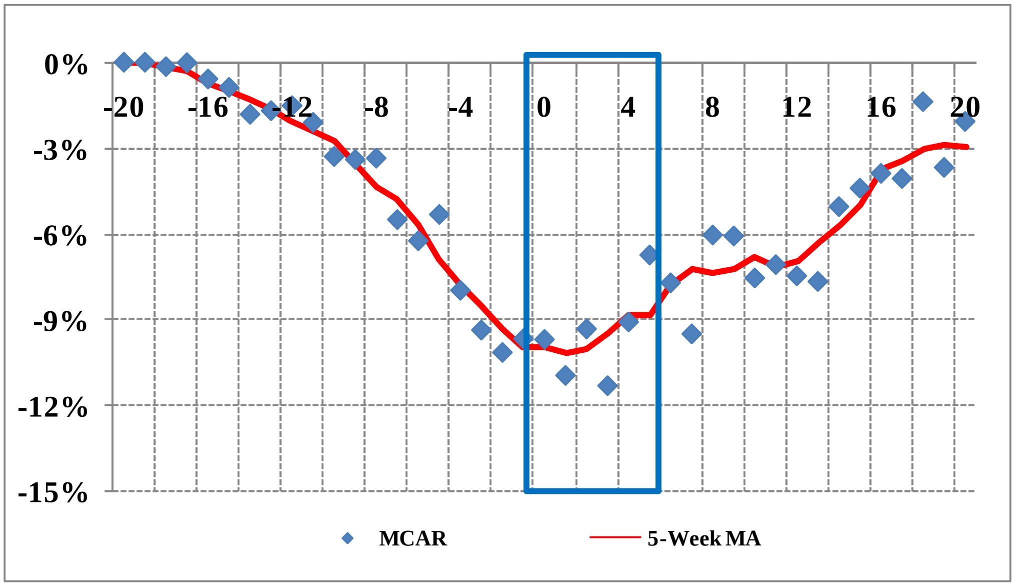


Figure 1: Median Cumulative Abnormal Returns of Downgraded Bonds

This figure plots the median cumulative abnormal returns (*MCAR*s) by event week for the bonds that are downgraded from an investment-grade rating to a non-investment grade rating. Week 0 is the downgrade announcement week. The abnormal returns are measured as the residuals from estimating the model in Table 4. The period up to 30 weeks before the downgrade is used as an estimation period to obtain the abnormal return from weeks -30 to -1. The period starting week 31 after the downgrade is used as an estimation period to obtain the abnormal return from weeks 0 to 30. The abnormal returns are accumulated over time. The cumulative abnormal return for each bond is normalized to 0 in week -20. *MCAR*s are measured as across-bond across-transaction averages medians of cumulative abnormal returns for each week. The blue diamond-shaped markers represent the *MCAR*s. The red solid line represents the 5-week centered moving averages of the *MCAR*s.

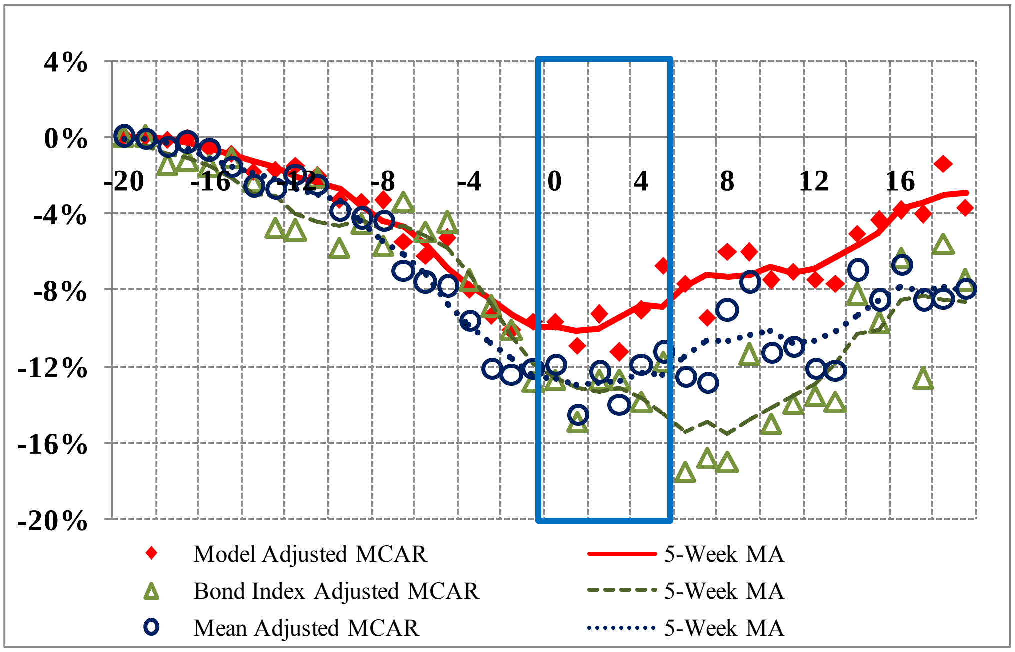


Figure 2: Median Cumulative Abnormal Returns by Different Methodologies

This figure compares the median cumulative abnormal returns (*MCAR*s) based on three methodologies of measuring abnormal returns: (i) model adjustment, (ii) mean adjustment, and (iii) bond index adjustment. The calculation of model adjusted abnormal returns is as described in Figure 1. Mean adjusted abnormal returns are calculated as actual bond returns minus the mean return during the estimation period. Bond index adjusted returns are calculated as actual bond returns minus rating-matched Barclays bond index (price) return. The estimation period, accumulation of abnormal returns, and calculation of the *MCAR*s from abnormal returns are as described in Figure 1.

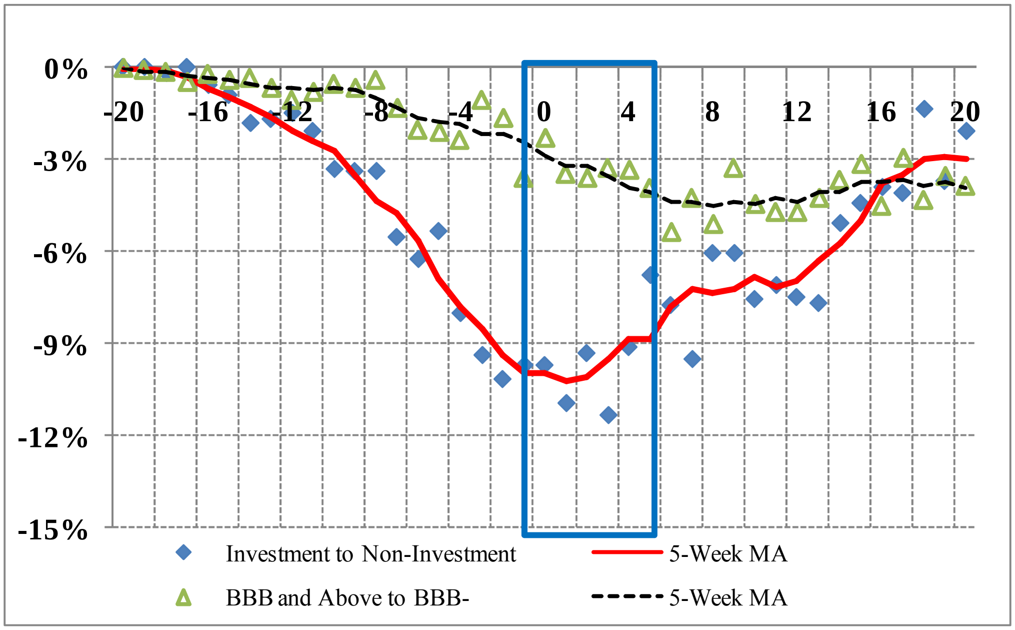


Figure 3: Median Cumulative Abnormal Returns by Type of Rating Downgrade

This figure compares the median cumulative abnormal returns (*MCAR*s) and the net trading volume between the bonds that are downgraded from an investment-grade rating to a non-investment grade rating and those that are downgraded from BBB and above to BBB-. Week 0 is the downgrade announcement week as applicable to each sample. The diamond-shaped (triangle) markers represent *MCAR*s for the investment grade to non-investment grade (BBB and above to BBB-) bond sample. The lines represent the corresponding 5-week centered moving averages.

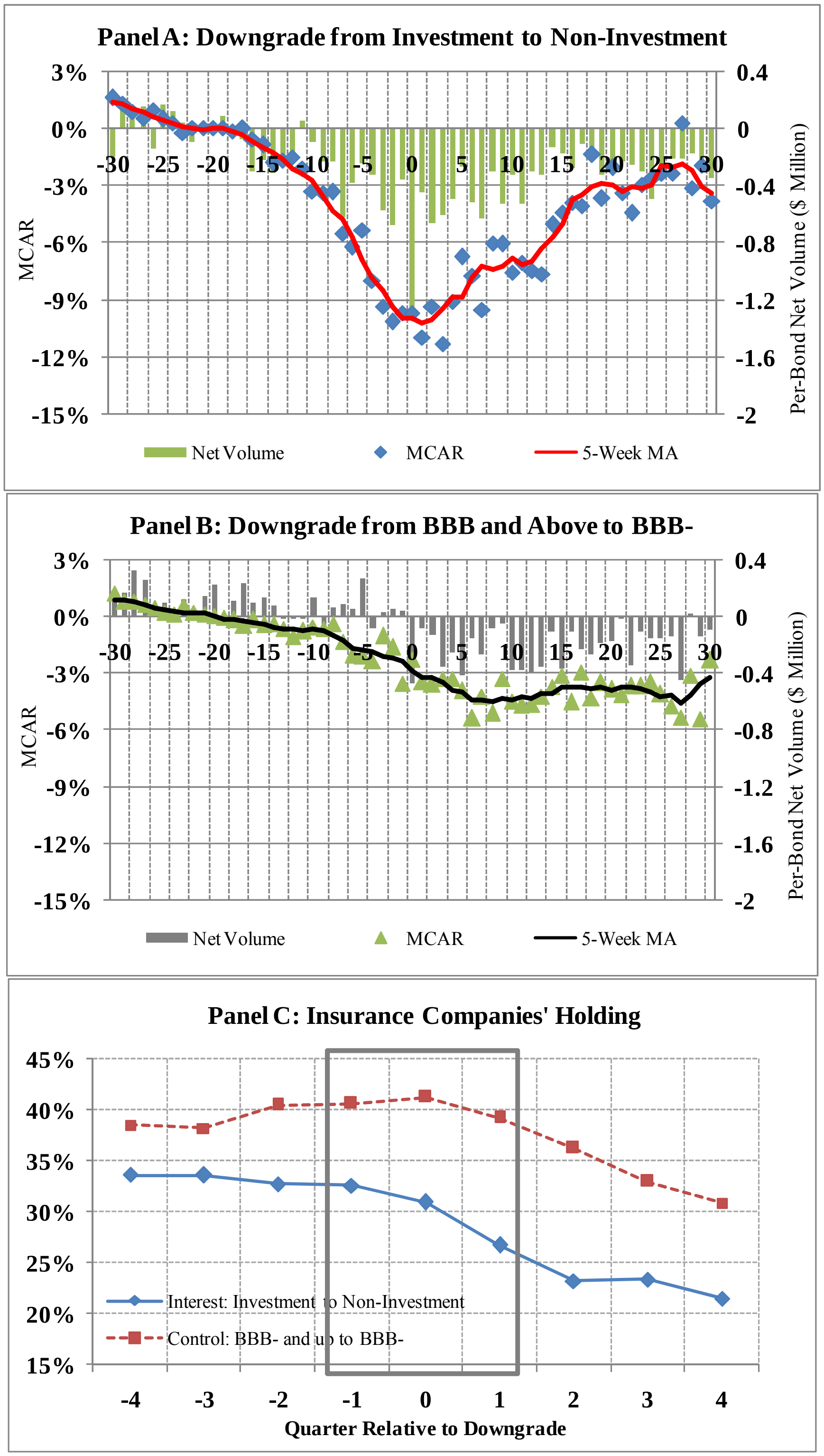
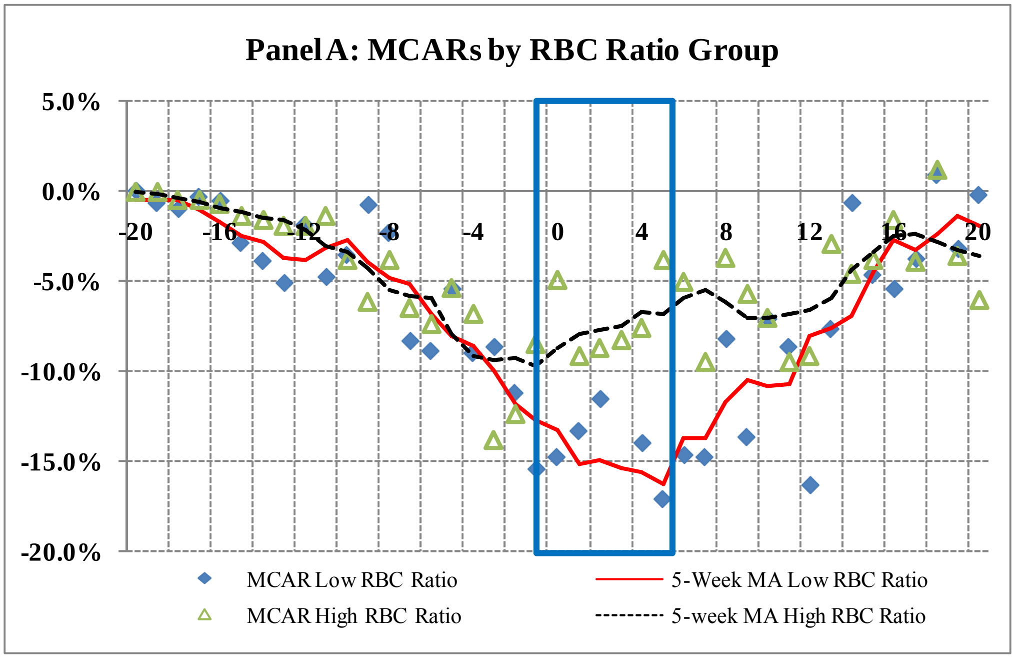


Figure 4: Insurance Companies' Net Trading Volume and Positions in Downgraded Bonds

This figure illustrates insurance companies' trading activity and positions in the bonds that are downgraded from an investment-grade rating to a non-investment grade rating and those that are downgraded from BBB and above to BBB-. Panels A and B plot the per-bond net trading volume by event week, along with the median cumulative abnormal returns (*MCAR*s) for the two samples. The bars represent the average per-bond net volume. The right vertical axis applies. For each bond, the net volume is calculated as the buy volume minus the sell volume in each event week. Week 0 is the downgrade announcement week. The net volume plotted here is the average net volume across all the downgraded bonds that remain outstanding for each sample in each week. The blue markers represent the model-adjusted *MCAR*s. The solid line represents the 5-week centered moving average of the *MCAR*s. The left vertical axis applies to *MCAR*s. Panel C plots insurance companies' holdings of the downgraded bonds at the end of each calendar quarter. Quarter 0 is the quarter in which the downgrade is announced. The holdings are measured as percentage of the issue size. The plots represent the median holdings across all downgraded bonds in each sample that remain outstanding at quarter end.



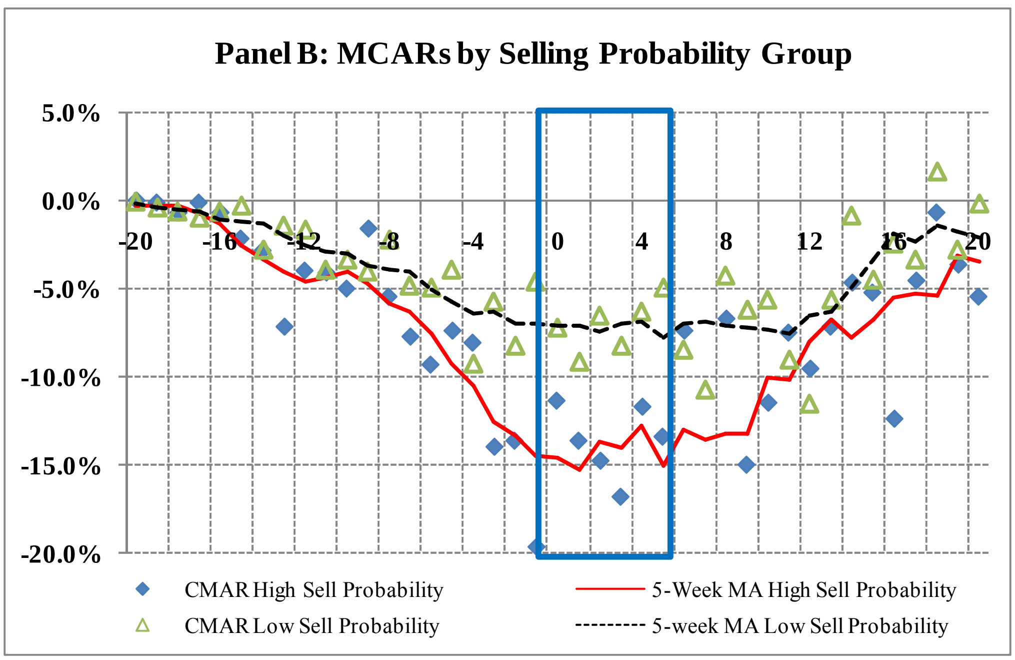


Figure 5: Median Cumulative Abnormal Returns by Selling Pressure Group

This figure plots the median cumulative abnormal returns (*MCAR*s) for downgraded bonds grouped by the selling propensity of insurance companies. *MCAR*s are calculated as described in Figure 1 and Table 5. In Panel A, the bonds are grouped by the average RBC ratio across all insurance companies holding the bonds at the end of the quarter preceding the downgrade. The low (high) RBC ratio group includes bonds with the average holders' RBC ratio below (above) the median. In Panel B, the bonds are grouped by the average probability of selling based on the models Life (1) and Property (1) in Table 7. The high (low) selling probability group includes bonds with the average holders' selling probability above (below) the median. The markers represent the *MCAR*s and the lines represent the corresponding 5-week centered moving averages.

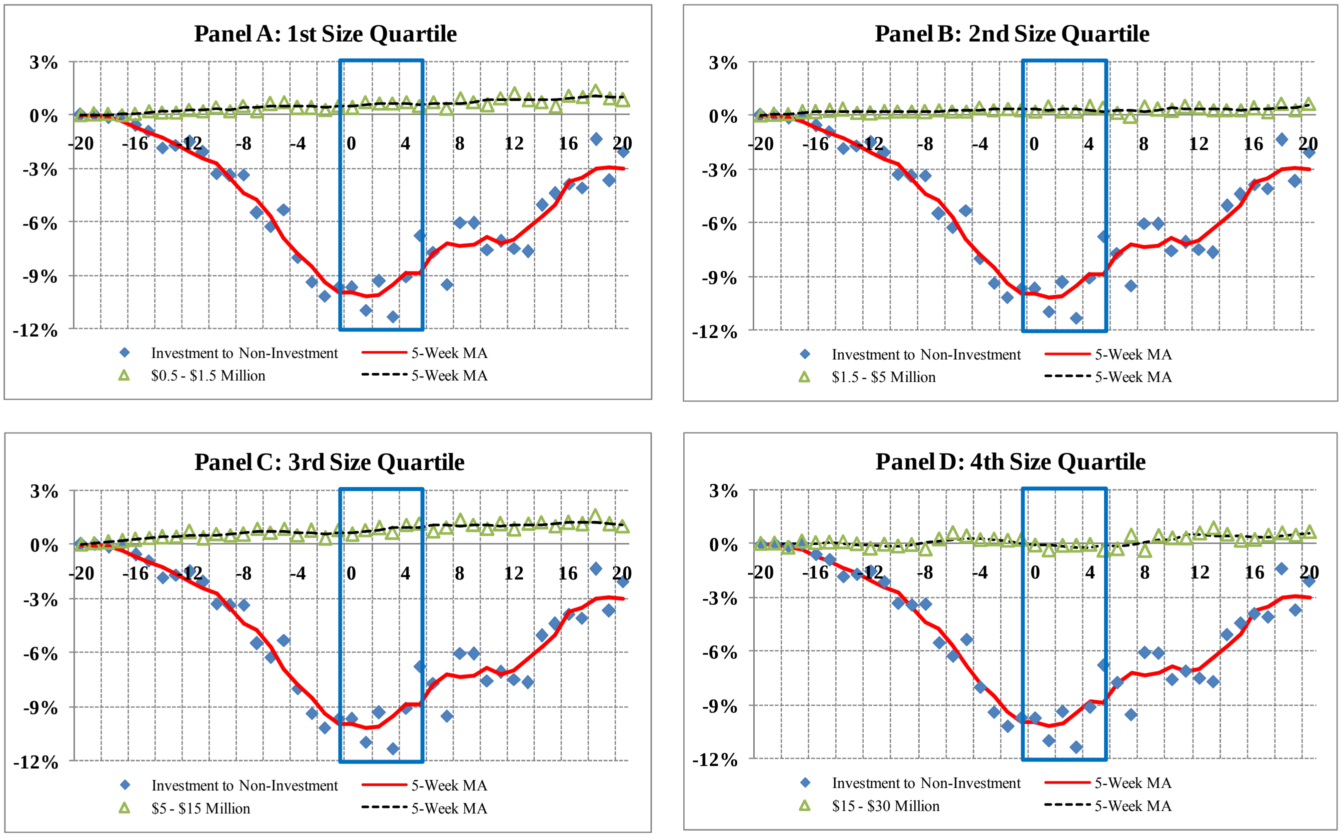


Figure 6: Median Cumulative Abnormal Returns of Downgraded Bonds vs. Bonds Experiencing Sell Trade in Different Sizes.

This figure compares the median cumulative abnormal returns (*MCAR*s) between the bonds that are downgraded from an investment-grade rating to a non-investment grade rating and those that experience sell trades in four different size groups corresponding to four quartiles of selling volume of downgraded corporate bonds during weeks 0 and 5. The size of trade in each group is comparable to the net selling volume in each quartile. The sell trade event sample includes only investment-grade bonds with maturity between 8 and 12 years when the sell trades take place. Only the largest trade in each size group for each bond is used. Week 0 is the downgrade announcement week for the downgraded bond sample or the week of a qualified sell trade for the sell trade event sample. The diamond-shaped markers represent *MCAR*s for the downgraded bond sample. The solid red line represents the corresponding 5-week centered moving averages. The triangle markers represent *MCAR*s for the sell trade event sample. The dashed black line represents the corresponding 5-week centered moving averages. Panels A to D plot *MCAR*s around sell trade events defined as sell trades of size between (i) \$0.5 to \$1.5 million, (ii) \$1.5 to \$5 million, (iii) \$5 to \$15 million, and (iv) \$15 to \$30 million, respectively. These size definitions correspond to (i) the 10^{th} to 25^{th} percentiles, (ii) the 25^{th} to 50^{th} percentiles, (iii) the 50^{th} to 75^{th} percentiles, and (iv) the 75^{th} to 90^{th} percentiles of the total selling volume of downgraded corporate bonds during weeks 0 and 5.

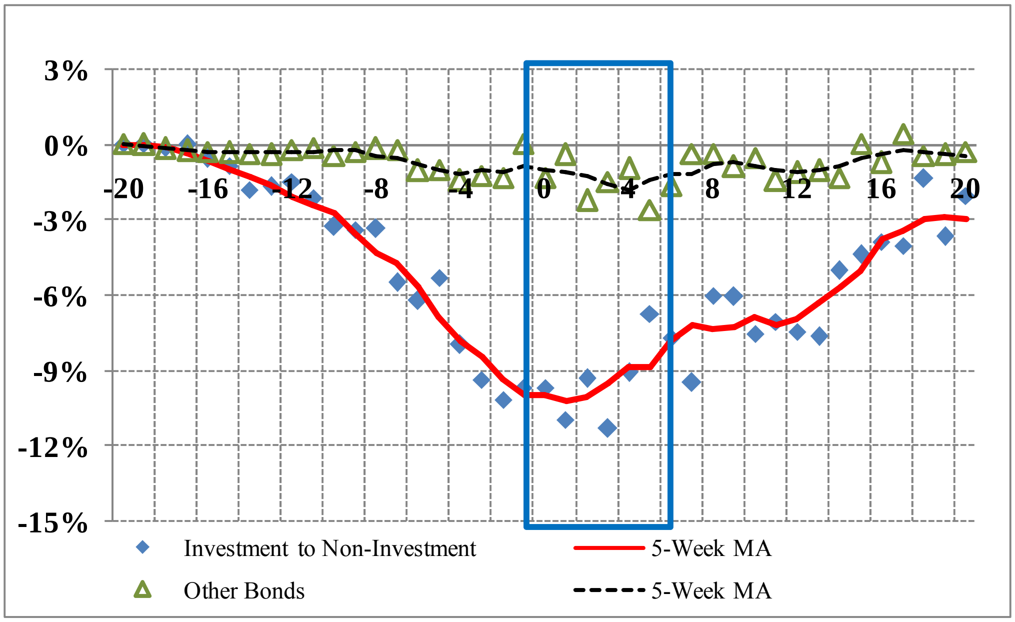


Figure 7: Median Cumulative Abnormal Returns of Downgraded Bonds vs. Other Non-Investment Grade Bonds Held by Insurance Companies (That Hold Downgraded Bonds).

This figure compares the median cumulative abnormal returns (*MCAR*s) between (i) the bonds that are downgraded from an investment-grade rating to a non-investment grade rating and (ii) other non-investment grade bonds that are held by the insurance companies holding the downgraded bonds. Week 0 is the downgrade announcement week, which applies to both samples. The other non-investment grade bond sample includes only the bonds that are rated between BB+ and BB- by S&P or between Ba+ and Ba- by Moody's, whichever is lower, and are net sold by insurance companies between weeks 0 and 5. The diamond-shaped markers represent *MCAR*s for the downgraded bond sample. The solid red line represents the corresponding 5-week centered moving averages. The triangle markers represent *MCAR*s for the other non-investment grade bond sample. The dashed black line represents the corresponding 5-week centered moving averages.