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The role of institutional investors in propagating the crisis of 2007–2008 ☆

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ABSTRACT

Using novel data on investors' bond portfolios, we study the contagion of the crisis from securitized bonds to corporate bonds. When securitized bonds became "toxic" in August 2007, mutual funds retained the now illiquid securitized bonds and sold corporate bonds. Funds with negative flows or high liquidity needs liquidated more than others. Yield spreads increased more for corporate bonds whose pre-crisis bondholders were more heavily exposed to securitized bonds, compared to *same-issuer* bonds held by unexposed investors. The findings suggest that liquidity-constrained investors with exposure to securitized bonds played a role in propagating the crisis from securitized to corporate bonds.

1. Introduction

By August 2007, what had begun as some bad news about the souring of the subprime mortgage market had spread into a full-fledged financial crisis encompassing wide-ranging and seemingly unrelated markets.[3] "Liquidity abruptly dried up for many firms and securities

[3] See Gorton (2008, 2009), Gorton and Metrick (this issue), and Brunnermeier (2009) for informative readings.

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markets" (Getter, Jickling, Labonte, and Murphy, 2007, p. 9), as the resale value of securitized bonds – mortgage-backed securities (MBS), asset-backed securities (ABS), collateralized debt obligations (CDO), and so forth – plummeted and the whole asset class became "toxic."[4] While much analysis has focused on how these assets impaired banks and left them staggering, less attention has been paid to the role of nonbank, institutional investors – e.g., bond mutual funds and insurance companies – in the crisis. In this paper we study a transmission mechanism that explains the contagion of the crisis from the securitized bond market to the corporate bond market. Using a novel data set of institutional investors' bond holdings, we will argue that, when the crisis hit the securitized bond market, the shock was transmitted by the portfolio decisions of institutional investors, which held both securitized bonds and corporate bonds and had to liquidate portions of their portfolios due to their liquidity needs.

The focus on these institutional investors seems warranted, not only because of the role they may have played in the propagation of the crisis but also because of their role in the economic recovery. By the time of the crisis, bond financing had become a more common source of external financing for corporations than bank borrowing, especially for large corporations.[5] Institutional investors (such as mutual bond funds and insurance companies) increasingly supplied the majority of capital, either directly, through bond financing, or indirectly, through investing in securitized loans. In fact, some argue that these investors' strong demand for relatively safe debt instruments fueled the credit expansion and securitization boom in the U.S. in 2003–2006.[6] Thus, as the economy recovers, the financial conditions and constraints of these institutional investors could become financial bottlenecks that are as important as those of traditional banks. To the best of our knowledge, there is very little evidence on this side of the equation.[7]

The specific purpose of our study is to examine how one asset class (securitized bonds) that experiences extreme market turmoil affects the portfolio decisions of institutional investors holding this and other classes of assets. We are among the first to provide evidence for such a transmission mechanism. We also provide the first detailed empirical analysis of professional investor behavior in the securitized bond market.

We focus on a potential transmission mechanism based on the effect of liquidity shocks on "open-end" institutional investors investing in securitized bond markets. Institutional investors that grant withdrawal rights to clients (e.g., mutual funds) are subject to runs, much like traditional banks (see, e.g., Bernardo and Welch, 2004). The desire of these investors to hold liquid – and potentially high-return – assets together with the widespread belief that the secondary markets for securitized bonds would remain liquid induced them to acquire large amounts of these securitized bonds prior to the onset of the crisis.[8] Indeed, one private estimate puts these institutional investors' collective exposure higher than that of banks.[9] With the onset of the crisis, these investors, left with significant exposure to the now more illiquid asset class, would have to decide how to rebalance their portfolios. Mutual funds would have to liquidate some of their assets if they either face current redemption claims or anticipate claims in the future. Reluctant to sell the more illiquid, "toxic" assets and book losses at fire sale prices (thereby exacerbating the investor flight), they would instead sell other, more liquid assets, such as corporate bonds.

In contrast, another class of institutional investors (e.g., insurance companies and pension funds) – which face longer-term end investors and are equipped with long lock-ups, penalties for early withdrawals, and predictable payout schedules – would be less pressed to sell than mutual funds, especially in the event of temporary deviations of prices from fundamentals. However, for these institutional investors, capital regulations made it expensive to hold lower-rated bonds.

Thus, we expect that, while the actual and anticipated liquidity needs influence the reaction of mutual funds, regulatory capital constraints influence the portfolio decisions of insurance companies when/if downgrades occur.

The key questions are: (1) Which types of assets would the institutional investor choose to sell? (2) Which types of institutional investors would sell more than others? (3) Would the selling pressure from institutional investors have negative effects on the performance of the sold assets? On the first question, we posit that institutional investors who face a liquidation problem would not sell the now illiquid securitized bonds, but, instead, would sell the more liquid corporate bonds, as suggested by Scholes (2000) and others. On the second question, we expect mutual funds that experience the most negative flows at the onset of the crisis to sell more than other funds. We also draw on the theory of sorting between fund managers and fund investors along the dimension of liquidity risk[10] and posit that funds with higher turnover or flow

[4] There is no exact agreed-upon definition of what constitutes a "toxic" asset in discussions of crisis. We use the definition "no-agency, securitized bonds" to capture a class of assets that became impaired during the crisis.

[5] For large representative firms, about two-thirds of their total debt is attributable to corporate bonds and less than one-third to bank loans (Massa, Yasuda, and Zhang, 2011).

[6] See Holmström (2008), Caballero, Farhi, and Gourinchas (2008), and Nini (2009).

[7] For studies that examine whether skewed incentives of originators or sellers (e.g., banks, mortgage banks, and investment banks) contributed to the unsustainable boom and the subsequent collapse of the market for securitized bonds, see Mian and Sufi (2009, forthcoming), Keys, Mukherjee, Seru, and Vig (2010), Griffin and Tang (2009), and Jiang, Nelson, and Vytlacil (2009).

[8] Shleifer and Vishny (2010), Gorton and Metrick (this issue), and others describe the so-called "shadow banking system," where broker-dealer banks actively supported the liquidity of securitized bonds by acting as market makers, while, at the same time, they funded their own balance sheets in the repo market using the same bonds as collateral.

[9] Blundell-Wignall (2007) quotes the following private investment bank estimate of delta-adjusted exposure to CDOs as of November 2007: 28.6% for insurance companies and asset managers together, 46.5% for hedge funds, and 24.9% for banks.

[10] Chordia (1996).

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volatility are matched with investors with greater liquidity risk. These funds are therefore expected to sell more of their corporate bonds to recover the desired liquidity level in their portfolio after the securitized bonds become illiquid. Similarly, we expect mutual funds in general to sell greater portions of their corporate bonds than insurance companies. Finally, on the third question, we posit that, ceteris paribus, corporate bonds held by investors with high exposure to securitized bonds and liquidity needs experience greater selling pressure and price declines (yield increases) compared with corporate bonds held by unexposed investors.

We first establish that institutional investors had significant exposure to the securitized bond market before the crisis. We find that institutional investors' holdings of securitized bonds increased fourfold between 1998 and 2007, totaling nearly $2 trillion (measured in par value) in 2007. While asset holdings grew steadily for both classes of institutional investors over most of the pre-crisis period, mutual funds' holdings of securitized bonds in the 2004–2007 period grew particularly rapidly, doubling in just three years; in contrast, insurance companies' holdings grew more gradually.

We then focus on the investors' liquidation problem once the crisis had impaired liquidity and the resale values of their holdings. We show that, in the last quarter of 2007, mutual funds collectively reduced the holdings of corporate bonds in their portfolios by 15% (6% of total holdings), while they reduced their holdings of securitized bonds by 9% (1.9% of total holdings). During the same period, insurance companies were small net purchasers, increasing their holdings of corporate bonds and securitized bonds by just 1.9% and 0.3% of their total holdings, respectively.

In the cross-section analysis of mutual funds, we find a monotonically negative relation between contemporaneous fund flows and their sales of corporate bonds. After establishing that our measures of funds' liquidity needs (fund turnover and fund flow volatility) are positively correlated with the funds' pre-crisis holdings of securitized bonds, we examine the relation between these fund attributes and their portfolio choices and find that high-turnover/high flow-volatility mutual funds indeed liquidated greater portions of their corporate bond holdings than funds with lower liquidity needs. We further find that the average investor tended to sell more junk bonds than investment-grade bonds. In contrast, among insurance companies, only firms close to or below the risk-based capital threshold engaged in selling securitized bonds.

Next we turn to measuring the effects of selling by institutional investors on the performance of sold assets. We show that bond yield spreads widened more and net sales were larger for those corporate bonds whose holders' portfolios were more heavily exposed to securitized bonds, and particularly more so for lower-rated corporate bonds. A cross-section analysis of individual corporate bonds' yield spread changes between the 2nd and 4th quarters of 2007 indicates that an increase in the portfolio weight of securitized bonds from 0% to 50% for the average investor holding a given corporate bond translates to a 70 bps greater increase in the bond's yield spread. The effect is sharper for lower-rated bonds. Selling pressure on these lower-rated corporate bonds came primarily from mutual fund investors with high exposure to securitized bonds, while insurance company investors contributed to a lesser degree to the trading volumes during the second-half of 2007. Our findings suggest that the sharp increase in yield spreads of lower-rated bonds at the start of the crisis is at least partly due to the contagion of the shock from the (mostly AAA-rated) securitized bond market to the lower-rated corporate bond market via the ownership of both securities by mutual funds.

In our analysis of corporate bond performances, we include bond issuer fixed effects, a crucial element for identification. Effectively, we compare a bond held by exposed investors to another bond *issued by the same firm* but held by non-exposed investors, holding constant any issuer-specific characteristics, including unobservable firm quality. This addresses the endogeneity concern that the inclusion of a bond in the exposed investors' portfolios could be correlated with some unobserved characteristics about the issuing firm.

Overall our results show that mutual funds with high liquidity needs (which have incentives to hold liquid assets) acquired large amounts of securitized bonds during the boom years. When faced with liquidity shocks at the onset of the crisis, these funds sold corporate bonds, thereby transmitting the crisis from securitized bonds to corporate bonds.[11] In the clearest evidence of the transmission channel, we find greater spread increases for individual corporate bonds that are held by investors with heavy exposure to securitized bonds, compared to same-issuer bonds held by unexposed investors. Fig. 3 illustrates this point.

The remainder of the paper is organized as follows. Section 2 discusses the hypotheses. Section 3 describes the data and presents sample summary statistics. Section 4 presents the analysis of the mutual fund flows and their portfolio decisions in the crisis. Section 5 presents the cross-section analysis of mutual funds' liquidity needs and their portfolio decisions. Section 6 presents the bond-level analysis of the effects of investors' exposure to securitized bonds on corporate bonds' yields and trading volumes. Section 7 concludes the paper.

2. Hypotheses

To state our research hypotheses, we first need to define the problem (or "toxic") assets and the shock event that hit institutional investors' portfolios. We focus on the entire class of non-agency, securitized bonds as "toxic assets." This is for two reasons. First, Gorton and Metrick (this issue, 2010) provide evidence showing that the shock spread from subprime to all other securitized bonds

[11] Longstaff (2010) finds that declines in subprime-related asset values forecast widening of corporate bond spreads with a lag after the onset of the crisis, especially in 2007. The result is consistent with a liquidity channel of contagion. Our results suggest that portfolio holdings of institutional investors provide one such channel.

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(but not to corporate bonds) starting in August 2007. This suggests considerable uncertainty among market participants about the precise location and extent of the negative shock. Second, information about collateral types is opaque in our data set in that we cannot separate out, for example, residential mortgage-backed securities that contain subprime mortgages from those that do not contain any subprime mortgages. Also, it is not possible to classify CDOs and collateralized loan obligations (CLOs) into those that contain subprime mortgages and those that do not.[12] This opacity might indeed be the cause of the market participants' broad negative reactions to the entire class of securitized bonds. Thus, we posit that the investors' exposure to the entire securitized bond market matters.

We define the shock (the onset of the crisis) as the arrival of negative news about subprime housing, which caused securitized bonds to become illiquid and their trades to collapse in August 2007. Dang, Gorton, and Holmström (2010) propose a utility-based tail risk measure, information sensitivity, defined as the value (in utility terms) of producing private information about the security payoff. Securitized bonds at origination were designed to be "information-insensitive" – i.e., designed so that skilled investors were made just indifferent between incurring the acquisition cost of becoming informed and staying uninformed about the final payoffs of securitized bonds, thus allowing unskilled investors (such as insurance companies and pension funds) to hold the bonds without fear of adverse selection. This resulted in high trading volumes and liquidity levels of securitized bonds in the pre-crisis period. Dang, Gorton, and Holmström (2010) further describe the crisis shock as the arrival of sufficiently negative public information about subprime housing, which rendered the securitized bonds information-sensitive, leading to the result that the only possible equilibria were those in which trades collapsed and sales would occur only at fire sale prices, for fear of adverse selection.

We take this definition of the shock and the collapse in liquidity of securitized bonds as givens and build hypotheses based on the three key questions posed in Section 1: (1) Which types of assets would the institutional investor choose to sell? (2) Which types of institutional investors would sell more than others? (3) Would the selling pressure from institutional investors have negative effects on the performance of the sold assets?

On the first question, Scholes (2000, p. 19) posits that "….[i]n an unfolding crisis, most market participants respond by liquidating their most liquid investments first to reduce exposure….". Brown, Carlin, and Lobo (2009) build on Scholes and analyze the roles of permanent and transitory price impacts of trades in a multi-period liquidation problem. A permanent change in the asset price is associated with a change in its perceived intrinsic value, and is dependent on the amounts of both informed and uninformed trading (e.g., Kyle, 1985). In contrast, a transitory price change is related to how thinly an asset is traded, and is considered non-informational. One implication of Brown, Carlin, and Lobo's (2009) model is that an asset with a high permanent price impact (of trades) – for example, an asset with a high degree of information asymmetry – will not be liquidated first in a crisis. As described above, securitized bonds became both illiquid and subject to adverse selection (a form of information asymmetry) in the crisis. Thus, both Scholes and Brown, Carlin, and Lobo predict that investors will retain the securitized bonds and sell other, more liquid bonds that are less subject to adverse selection (such as corporate bonds). The prediction is also consistent with the model of Dang, Gorton, and Holmström (2010), which implies the collapse of trades of securitized bonds in a crisis. This leads to our first hypothesis:

Hypothesis 1a. Securitized bonds will not be the first asset class to be sold at the onset of the crisis.

As for which type of corporate bonds the investors would sell more, we hypothesize that investors with liquidity needs tend to sell junk bonds more than investment-grade bonds, a hypothesis that is subject to multiple explanations. First, according to Brown, Carlin, and Lobo (2009), investors facing a multi-period liquidation problem value keeping some liquidity cushion in their portfolios against future liquidity needs. In other words, they want to retain some assets that are not difficult to dispose of if they are hit with another negative shock tomorrow. So they sell junk bonds today and retain investment-grade bonds. Second, Gorton and Metrick (2010) compare the distinction between information-sensitive and information-insensitive debt with the distinction between junk and investment-grade debt. Junk bonds are information-sensitive, meaning investors holding them must always be informed, whereas uninformed investors can hold investment-grade bonds without fear of adverse selection. However, at the onset of the crisis, if some investment-grade bonds (particularly those below AAA) were hit with negative news and became information-sensitive, they may have become harder to sell. Junk bonds, on the other hand, experienced no such "regime switch" (Gorton and Metrick, 2010, p. 12), and thus were easier to sell than investment-grade bonds. Third and finally, it is also possible that mutual funds seek to maintain a certain ratio of high-quality bonds to low-quality bonds in their portfolios.[13] When the shock hit the securitized bonds, these funds may have realized that their holdings of AAA-rated securitized bonds were now equivalent to junk bonds (even though there were few immediate downgrades), and found that their portfolios

[12] In addition to showing a broad transmission of the shock from subprime to other types of securitized bonds, Gorton and Metrick (2010) use proprietary data obtained from a dealer bank that allows them to separate subprime-related securitized bonds from those that are unrelated, and show that subprime-related bonds suffered more than other securitized bonds. To the extent that we are lumping subprime and non-subprime-related securitized bonds together, we lose this cross-sectional variation across securities that we could exploit otherwise.

[13] In informal discussions with fund managers, we heard anecdotal examples where such internal requirements for maintaining risk threshold, even in the absence of immediate withdrawal requests, prompted selling during the crisis.

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were overexposed to low-quality bonds. These funds would therefore sell junk bonds to restore their optimal ratio of high-quality to low-quality bonds.[14] Drawing on these considerations, we formulate our second hypothesis:

Hypothesis 1b. Investors tend to liquidate more junk bonds than investment-grade corporate bonds.

On the question of which types of institutional investors would sell more than others, we test three related cross-sectional predictions. First, we posit that mutual funds with higher immediate liquidity needs – withdrawals – will liquidate more corporate bonds than others. This prediction is straightforward and intuitive. Second, we draw on existing literature (e.g., Chordia, 1996), which argues that in equilibrium, mutual fund investors with high liquidity risk are matched with mutual funds that impose the weakest redemption restrictions and hold the most liquid assets. We will use fund turnover and fund flow volatility as the two proxies to measure the underlying liquidity risk of end investors, which in turn is matched (in equilibrium) with the liquidity needs of mutual funds. Since securitized bonds were liquid prior to the crisis (Loutskina, 2010), we expect funds with high turnover and high flow volatility to hold large amounts of securitized bonds before the crisis. Once the crisis hits and liquidity dries up for securitized bonds, we expect these funds more than others to liquidate more corporate bonds to meet their liquidity needs. Third, we posit that mutual funds, which in general are matched with end investors with greater liquidity risk, will sell more than insurance companies. A possible exception to this prediction is a case of insurance companies constrained by their capital requirements, which we will examine separately. To summarize:

Hypothesis 2a. The contemporaneous fund flows of mutual funds are negatively associated with the amount of corporate bonds liquidated.

Hypothesis 2b. The turnover and flow volatility of mutual funds (as proxies for funds' liquidity needs) are positively associated with the amount of corporate bonds liquidated.

Hypothesis 2c. Mutual funds liquidate more corporate bonds than insurance companies upon the arrival of the crisis shock.

Finally, on the question of how the institutional investors' behavior would impact the performance of liquidated assets, we posit that, ceteris paribus, corporate bonds whose pre-crisis bondholders' portfolios were more heavily exposed to securitized bonds experience greater selling pressure and yield increases. We examine this hypothesis by constructing holders' exposure to securitized bonds, yield spread changes, and trading volumes at the individual asset (i.e., corporate bond) level. Thus, the main hypothesis on this question is:

Hypothesis 3a. For a given corporate bond, mutual fund investors' portfolio exposure to securitized bonds is positively associated with yield spread changes (negatively associated with asset price changes) and positively associated with trading volumes.

Hypothesis 1b also suggests a specific transmission of the shock from securitized bonds to the lower-rated corporate bonds. That is, among the corporate bonds held by high-exposure investors, junk bonds would be sold more and the impact on their yield spreads would be greater. Thus:

Hypothesis 3b. Holding constant the mutual fund investors' exposure to securitized bonds, the impact of exposure on yield changes and trading volumes is greater for junk bonds than for investment-grade bonds.

3. Data

3.1. Data sources

We construct our sample by merging a number of different data sources: the Lipper eMAXX institutional bond holdings database, Thomson Financial's 13f Institutional Holdings, CDA/Spectrum, the Center for Research in Security Prices (CRSP) Mutual Funds Database, and the Mergent Fixed Investment Securities Database (FISD).

The Lipper eMAXX database contains details of corporate bond and securitized bond (mortgage- or asset-backed securities, collateralized debt, mortgage, or loan obligations, and their variants) holdings for nearly 20,000 U.S. and European insurance companies, U.S., Canadian, and European mutual funds, and leading U.S. public pension funds. It provides information on quarterly ownership of more than 50,000 fixed-income issuers with over $7 trillion in total par amount from 1998Q1 to 2008Q1. Holdings are recorded in units of $1,000 in par amounts, not in market values; this allows us to accurately measure quarterly quantity changes (as opposed to market value changes) in holdings of individual bonds. We focus on U.S. institutional investors in the eMAXX database, and their holdings of corporate bonds and structured products (about 15,000 institutional investors every quarter, holding in aggregate a total face value of about $300 million per institution, on average, in any given quarter). For these institutions, Lipper eMAXX reports the holdings based on regulatory disclosure to the National Association of Insurance Commissioners (NAIC) for insurance companies, the Securities and Exchange Commission (SEC) for mutual funds, and on voluntary disclosure by the major pension funds.[15] Thomson Financial's 13f database contains information on the equity positions of investment companies holding U.S. equities.

[14] For related studies that examine the role of international investors in spreading crises through rebalancing of their cross-country asset holdings, see, e.g., Boyer, Kumagai, and Yuan (2006) and the papers cited therein.

[15] Our sample of mutual funds does not include money market funds.

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3.2. Empirical proxies for funds' liquidity needs

To conduct our analyses with respect to Hypothesis 2b, we need empirical proxies for mutual funds' liquidity needs. A mutual fund has more liquidity needs if its investors have higher liquidity demands, which would require the fund to engage in more flow-induced, liquidity-motivated trading. Chordia (1996) argues that, in equilibrium, funds and end investors sort along this dimension and that high liquidity risk investors are matched with funds that engage in significant amounts of liquidity-motivated trading and, thus, hold more liquid assets, and vice versa. Edelen (1999) finds evidence that flow-induced trading imposes significant costs on mutual funds' performance. Thus, the more volatile the fund flows, the higher the liquidity needs of such a fund will be. Therefore, our first proxy of the fund's liquidity needs is the volatility of flows.

An alternative way to measure the fund's liquidity needs is by focusing on the actual trades by the investors. Standard literature (e.g., Chen, Goldstein, and Jiang, 2010; Gaspar, Massa, and Matos, 2005) suggests that funds that turn over their portfolios more rapidly are matched with investors with shorter investment horizons and higher redemption needs. This could be due to tax considerations. Long-term investors dislike high turnover portfolios as they can result in undesirable short-term taxable capital gains (Jin, 2006). Therefore, portfolio turnover is our second proxy for the fund's liquidity needs.

We measure flow volatility as the standard deviation of the fund's flow over the previous 12 months. We use the CRSP Mutual Funds turnover ratio as the fund's turnover measure. To verify that these proxies behave as expected, in Section 5.1 we examine the relation between these measures of funds' liquidity needs and their pre-crisis holdings of securitized bonds.

3.3. Affiliation with financial institutions

We also construct variables for funds' affiliation with other financial institutions. Affiliations could affect investors' portfolio decisions through either additional incentive effects or pure information effects. The first affiliation variable, *Affiliated with commercial banks*, measures the affiliation with financial conglomerates that also own the banks that participate in the securitized debt markets and perform due diligence on the instruments. This implies that these investors have an informational advantage over unaffiliated investors. This variable could also capture the fact that affiliated investors are less risk averse than unaffiliated investors, as they receive implicit buyback guarantees from their affiliate banks in the event of market turmoil. It could also capture any pressure the funds receive from originating affiliate banks to buy their securitized bonds, especially if the banks, unable to sell the bonds to third parties, used their affiliate funds as dumping grounds.

The second affiliation variable (*Log*(*Family size*)) measures affiliation with large asset management groups. In contrast to the first measure, this is a pure information measure.

3.4. Descriptive statistics

We report summary statistics in Fig. 1 and Table 1. In Fig. 1, Panel A reports the securitized bond and corporate bond holdings by mutual funds and insurance companies. Institutional investors' holdings of securitized bonds increased fourfold during the sample period, totaling nearly $2 trillion in 2007. While asset holdings grew steadily for both classes of institutional investors over most of the pre-crisis period, mutual funds' holdings of securitized bonds in the 2004–2007 period grew particularly rapidly, doubling in just three years; in contrast, insurance companies' holdings grew more gradually. There was also a large contraction in the mutual funds' holdings of corporate bonds in the last quarter of 2007.

Panel B reports the securitized bond and corporate bond holdings of mutual funds by ratings. It is striking that nearly 80% of the securitized bonds with known ratings held by the sample mutual funds are AAA-rated, with just a handful of non-AAA, investment-grade tranches, and virtually no junk-rated tranches (statistics for insurance companies are similar). In contrast, the majority of corporate bonds held by mutual funds are investment-grade but lower than AAA-rated. This is not surprising, as the number of AAA-rated corporate issuers steadily dwindled over the years, from more than 60 in the 1980s to just six by 2008. As we argued above, institutional investors had a great appetite for securitized bonds because the securitization methodology enabled the creation of information-insensitive, highly rated debt in vast quantities. The summary statistics reported here corroborate this view. Mutual funds also hold a higher percentage of their corporate bond portfolios in junk-rated bonds than insurance companies. This is consistent with the fact that risk-based capital regulation makes it expensive for insurance companies to hold low-rated bonds (see, for example, Herring and Schuermann, 2005).

Panel C shows AAA-rated bond holdings as a percentage of the total portfolio. For both classes of institutional investors, holdings of AAA-rated bonds grew sharply, both as percentage of their total portfolios and in absolute value, during the sample period. For mutual funds, they grew from about 3% of the total to 12%, and for insurance companies they grew from about 6% to 16%. In both cases, that growth was disproportionately in securitized bond holdings.

Panel D presents securitized bond holdings by collateral type (residential mortgage-backed securities (RMBS), commercial mortgage-backed securities (CMBS), other asset-backed securities (ABS), and government agency-backed securities (Agency)). Panels D-1 and D-3 show all securitized bonds, and Panels D-2 and D-4 show AAA-rated bonds only. In general, RMBS is the most common collateral type throughout the sample period, though the portfolios become more diversified among the four collateral types over time. CMBS appears to be more popular among the insurance companies than among mutual funds.[16] The opposite is true for ABS, which can be backed

[16] Stanton and Wallace (2010) argue that changes in risk-based capital regulation led to ratings arbitrage by regulated financial firms, including insurance companies.

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by a wide variety of assets, including credit card debt, student loans, auto loans, etc. Finally, Agency is not a dominant fraction of portfolios; i.e., investors primarily invested in privately issued securitized bonds.

Table 1 reports the summary statistics for the main variables used in the analysis. Note that the unit of observations for Table 2 (Panel A) and Tables 3 and 4 is a fund-quarter, whereas the unit of observations for Table 2 (Panel B) and Tables 5–7 is a corporate bond. For example, *Turnover ratio* and *Flow volatility* in Panel A report the sample statistics (across fund-quarters) for the two proxies of liquidity needs for our sample of mutual

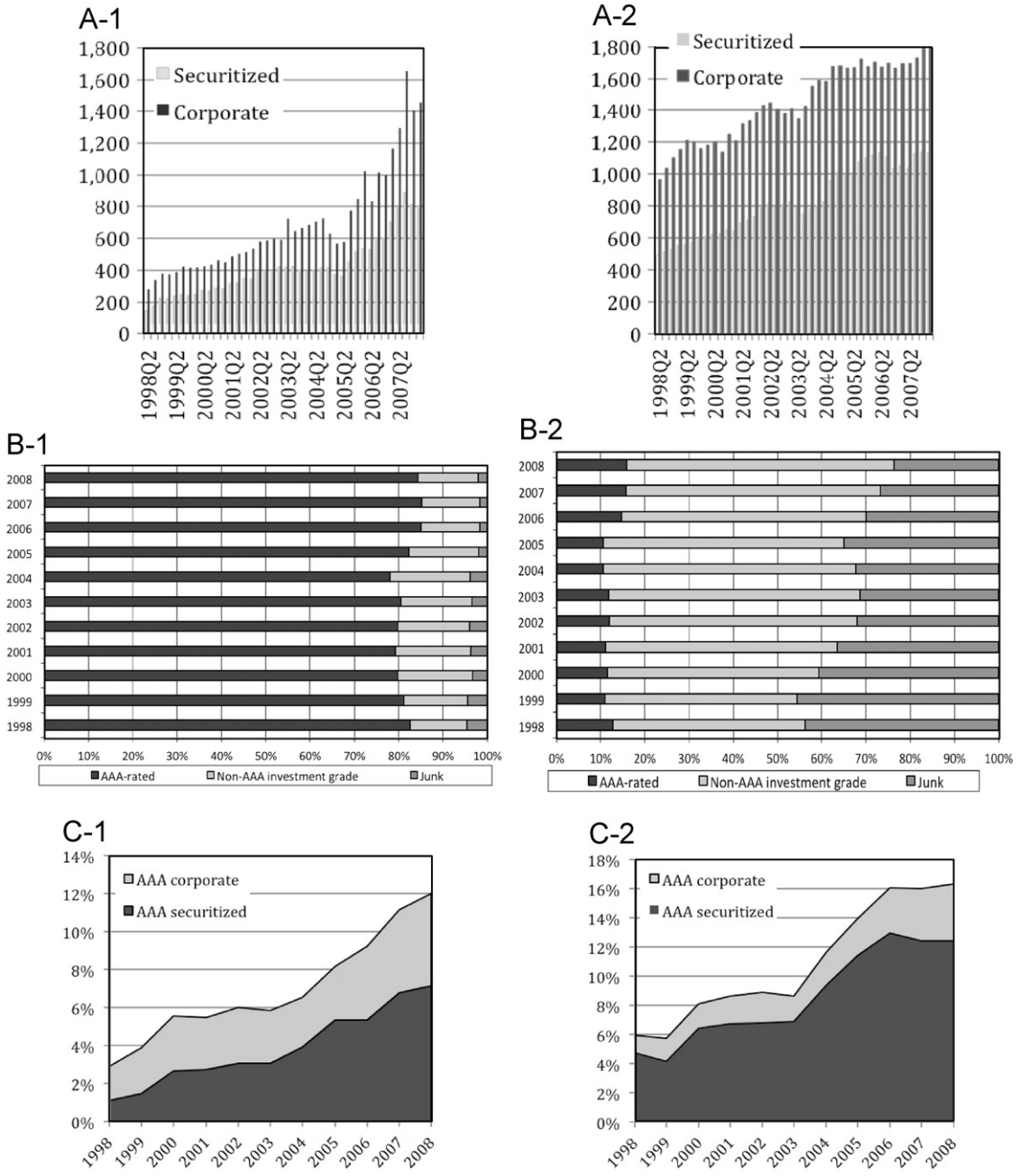

Fig. 1. Sample summary statistics. Panel A reports the securitized bond and corporate bond holdings by mutual funds and insurance companies (A-1: Mutual funds ($bn) and A-2: Insurance companies ($bn)). Panel B reports the corporate bond and securitized bond holdings of mutual funds by ratings (for bonds with known ratings only) (B-1: Securitized bonds (%) and B-2: Corporate bonds (%)). Panel C reports AAA-rated bond holdings as % of the total portfolio (C-1: Mutual fund portfolio and C-2: Insurance company portfolio). Panel D reports the breakdown of securitized bond holdings by collateral type (residential mortgage-backed securities (RMBS), commercial mortgage-backed securities (CMBS), other asset-backed securities (ABS), and government agency-backed securities (Agency)) (D-1: Mutual fund portfolio–all ratings, D-2: Mutual fund portfolio–AAA-rated only and D-3: Insurance company portfolio–all ratings and D-4: Insurance company portfolio–AAA-rated only).

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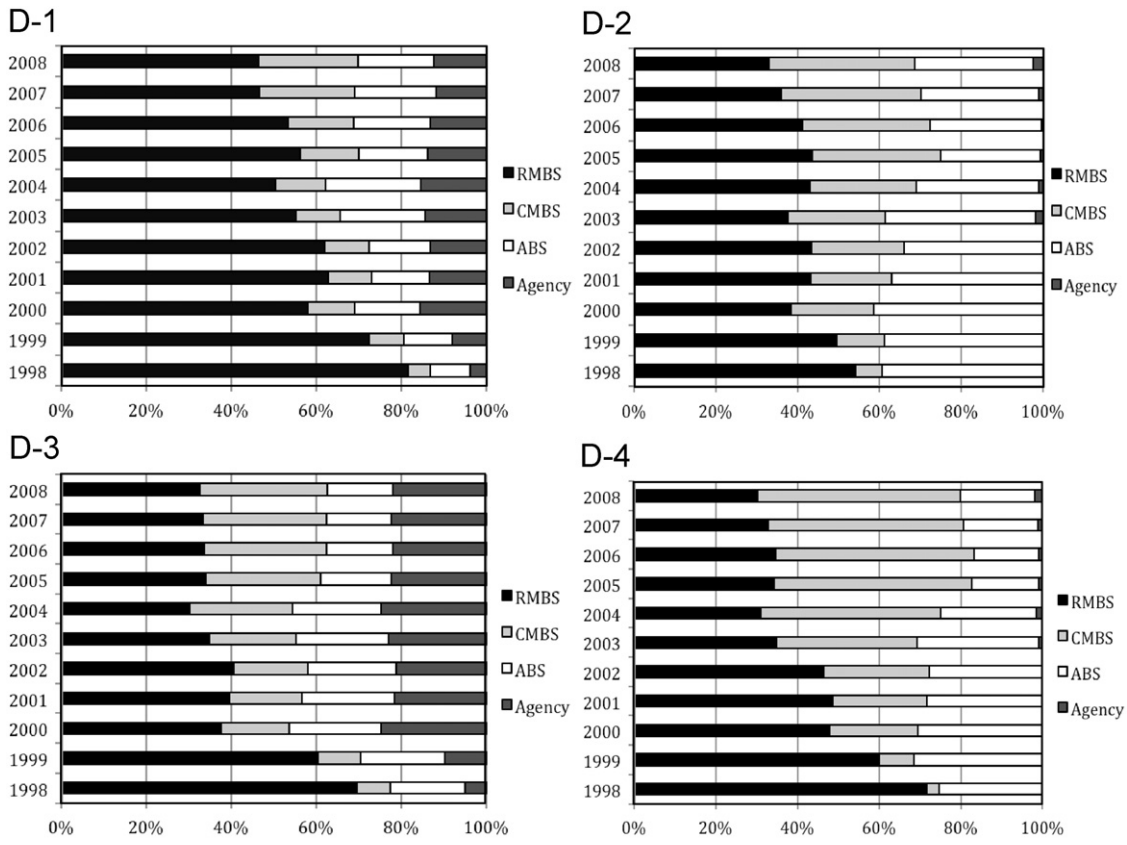

Fig. 1. (*continued*)

funds. There is a great amount of variability in these measures; e.g., flow volatility ranges from 0 to 0.3733.

Another variable in Panel A, *Affiliated with commercial bank*, indicates that about one-quarter of the sample funds are affiliated with banks. The variable *No equity* (which equals one if the fund does *not* hold equity), indicates that about four-fifths of our sample mutual funds are pure bond funds that hold no equity, while the remaining one-fifth are blend funds with some equity holdings. Other variables are standard mutual fund characteristics used in the literature (for definitions see Appendix A).

In contrast to Panel A, in which the variables are defined at the fund level, the variables in Panel B are defined at the level of individual corporate bonds. For example, the first variable, *LogSale (July–December 2007)*, measures the log of net sales of a given corporate bond by the sample mutual funds. The next two variables, ΔYS, measure the change in yield spreads of corporate bonds between the pre-crisis 2007 Q2 and the crisis periods of 2007 Q3 and 2007 Q4, respectively. On average, bond yield spreads increase by approximately 1% in the first three months of the crisis, and nearly 2% in the first six months, as indicated by the mean of these variables.

The variable *Holders' exposure* (*to securitized bonds*) is of significant interest. We empirically gauge the magnitude of selling pressure on a given corporate bond i by creating $HoldersExposure_i$, a weighted-average exposure measure of all mutual fund investors who held bond i before the crisis. This measure is constructed by first calculating the fractional exposure to the securitized bonds of the portfolio (e.g., 30%) of each mutual fund investor $n=1, \ldots, N_i$ holding bond i, and then obtaining a weighted average of this exposure across all N_i funds using par amounts of bond i held as weights. The sample statistics indicate that investors' exposure varies widely from none to very high (over 90%). We similarly measure and report the exposure of the average insurance firm investor holding corporate bond i to securitized bonds. It appears that the average exposure is higher for insurance company investors than for mutual funds, but the variance is not larger. In Section 6, we will examine whether the exposure of existing investors to securitized bonds explains some of the increases in corporate bond yields at the onset of the crisis. Other variables are standard bond characteristics used in the literature (for definitions see Appendix A).

4. Who sells and what gets sold after the onset of the crisis?

Our first hypothesis regarding the mutual funds' liquidation problem is that they will sell corporate bonds first while retaining securitized bonds (Hypothesis 1a). We also expect those funds with greater liquidity needs to sell more. We test these predictions by focusing on the sales of securitized bonds and corporate bonds around the time

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Table 1
Sample summary statistics.
This table reports the sample summary statistics for the main variables used in the analysis. The variables in Panel A are defined at the fund-quarter level and used in Tables 2–4; the variables in Panel B are defined at the level of individual corporate bonds and used in Tables 2 and 5–7. See Appendix A for variable definitions.

	Mean (1)	Median (2)	St. dev. (3)	Min (4)	Max (5)	No. obs (6)
Panel A: Variables defined at the fund level						
Excess fractional holdings of corporate bonds	0.0335	0.0667	0.2813	−0.8756	0.9862	17,038
Excess fractional holdings of securitized assets	0.0252	−0.0237	0.2498	−0.6290	0.9976	17,038
Turnover ratio (as fraction of TNA)	0.0125	0.0088	0.0103	0.0000	0.0378	16,948
Flow volatility (over 12 monthly flows)	0.0710	0.0326	0.0951	0.0000	0.3733	16,910
Log(Family size) (size in $100M)	3.1136	3.1339	1.8743	0.0000	7.3502	17,038
Affiliated with commercial bank [1=YES]	0.2867	0.0000	0.4522	0.0000	1.0000	17,038
Past flow	0.0160	−0.0002	0.0626	−0.0552	0.2782	16,911
Fund return	0.0133	0.0107	0.0426	−0.3982	0.7702	17,038
Family fractional equity holdings	0.1548	0.0000	0.2718	0.0000	1.0000	17,038
Mgmt fee (%)	0.4923	0.5000	0.2473	0.0000	2.2210	17,038
Expense ratio	0.0105	0.0092	0.0067	0.0000	0.1877	17,038
Actual 12b1	0.0025	0.0000	0.0036	0.0000	0.0103	17,038
Average maturity of holdings (months)	42.7778	37.4805	21.2881	0.0000	196.0000	17,038
No equity [1=NO]	0.8191	1.0000	0.3849	0.0000	1.0000	17,038
Fund's equity holdings return	0.0109	0.0000	0.1029	−0.8961	2.8805	17,038
Panel B: Variables defined at the bond level						
LogSale (July–December 2007) (sale in $K)	4.2004	0.0000	4.7330	0.0000	13.893	9,201
ΔYS(July–October 2007) (%)	0.8151	0.5376	1.2439	−3.998	13.191	7,348
ΔYS(July–December 2007) (%)	1.9650	1.2949	2.0580	−11.310	19.965	8,148
ΔTr(July–October 2007)	0.0375	0.0000	0.0903	0.0000	0.3426	9,133
ΔTr(July–December 2007)	0.0353	0.0000	0.0846	0.0000	0.4997	8,728
Holders' exposure (between 0 and 1)	0.0944	0.0000	0.1472	0.0000	0.9050	9,598
High-turnover holders [1=YES]	0.3113	0.0000	0.4631	0.0000	1.0000	8,728
High-flow volatility holders [1=YES]	0.3291	0.0000	0.4699	0.0000	1.0000	8,728
InvRating	−2.6509	−3.0445	1.0272	−3.3322	0.0000	9,598
Yield spread in 2007Q2 (%)	1.3392	1.1010	1.4089	0.3530	9.4245	9,598
No rating [1=NO]	0.1267	0.0000	0.3327	0.0000	1.0000	9,598
Bond face value (Log($K))	11.275	12.067	2.0613	7.0553	15.425	9,598
Covenants [1=YES]	0.4974	0.0000	0.5000	0.0000	1.0000	9,598
CovIndex (between 0 and 1)	0.1673	0.0000	0.2004	0.0000	0.6667	9,598
Log(Months to maturity)	4.1110	4.2627	1.1467	0.0000	6.9903	9,598
Insurance co.'s exposure (between 0 and 1)	0.2182	0.2761	0.1751	0.0000	0.9716	9,598
Bond is not held by mutual funds [1=NO]	0.4359	0.0000	0.4959	0.0000	1.0000	9,598
Amihud's illiquidity proxy	0.4466	0.4095	0.2848	0.0433	1.5162	9,598
InvTrades	−0.9774	−0.8544	0.5011	−4.0012	−0.2231	9,598

of the onset of the crisis and relate them to the liquidity needs of investors.

As described in the Introduction, the crisis started in August 2007. Since our observations are quarterly, we examine changes between (i) the second quarter of 2007 ending in June and the third quarter of 2007 ending in September, and also between (ii) the second quarter of 2007 ending in June and the fourth quarter of 2007 ending in December. Unreported statistics show that, on average, securitized bonds were not sold and that most of the sales took place in corporate bonds. The mutual funds reduced the holdings (measured in par value) of corporate bonds in their portfolios by $253B (15%) in the last quarter of 2007, while they reduced their holdings of securitized bonds only by $82B (9%). This is consistent with Hypothesis 1a. During the same period, insurance companies were small net purchasers, increasing their holdings (again measured by par value) of corporate bonds by $60B (3%) and securitized bonds by $10B (1%). The contrast between mutual funds and insurance companies is also consistent with Hypothesis 2c, namely that investors with greater liquidity needs (mutual funds) liquidated greater portions of their portfolios.

Next we examine whether the net sales of corporate bonds and securitized bonds are related to contemporaneous fund flows.[17] While hedge funds and investment banks were highly leveraged and therefore forced to de-leverage when the securitized bonds that they posted as collateral plunged in value, mutual funds were generally unleveraged. Thus, the posited propagation of shocks from securitized bonds to corporate bonds (via liquidity-motivated trades) by mutual funds that held both assets must come from either contemporaneous or future expected fund flows.[18] Given our data

[17] We thank Ken French for suggesting this exercise.

[18] As discussed in Section 2, funds could decide to sell corporate bonds for allocation reasons even in the absence of contemporaneous outflows. Mutual funds seek to maintain relatively stable risk and style characteristics to satisfy their objectives. The "shock" to the securitized bond market has left the funds with "toxic" holdings that are riskier and less liquid than they had anticipated. To reduce the risk level, so as to avoid future outflows, the funds with securitized bond holdings would liquidate (particularly low-grade) corporate bonds.

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Table 2
Mutual fund flows and bond sales after the onset of the crisis.

In Panel A, we examine the relation between contemporaneous fund flows and net position changes. In columns 1–4 the dependent variable is the percentage net purchases of corporate bonds (odd-numbered columns) and securitized bonds (even-numbered). In columns 5–8 the dependent variable is the negative of Log-$ Sales, columns are organized analogously, and the model is estimated with a Tobit regression. The cross section of sample funds are sorted by their contemporaneous fund flows into four bins (*VeryLowFlow*, *LowFlow*, *HighFlow*, and *VeryHighFlow*). In columns 1–2 and 5–6, the net position changes are regressed on just the four category dummies; in columns 3–4 and 7–8, the model also includes additional fund characteristics (see Appendix A for variable definitions). The standard errors are italicized and appear below coefficients. The row labeled *F*-stat reports the *F*-test statistics for the hypothesis that the paired coefficients (corporate bonds vs. securitized bonds) on the most negative flow group (*VeryLowFlow)* are equal. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel B reports the estimates of a model:

$$LogSale_{ij} = \alpha + \beta\, BondType_{ij} + \delta\, LogHold_{ij} + \gamma' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (1)$$

where each observation corresponds to a corporate bond. The dependent variable is *LogSale*, the log-net sales (in thousands of dollars) of the bond by institutional investors between July 2007 and December 2007. *LogHold* denotes the log-dollar holding of the bond by institutional investors as of June 2007, μ_j is an issuer-fixed effect for issuer *j*, and *x* is a vector of standard bond characteristics, including offering year fixed effects. *BondType* denotes one of three variables of interest: *InvRating* (the natural logarithm of the inverse of 1+the numerical value of the bond's Standard & Poor's (S&P) rating, which ranges from zero (no rating) to 24 (AAA rating or higher)), the bond's *Amihud* illiquidity ratio, and *InvTrades* (the natural logarithm of the inverse of the average number of daily trades of the bond over the period January–June 2007). In all specifications, the standard errors are clustered around bond issuers and appear italicized. The sample includes all bonds in the FINRA TRACE Corporate Bond Data with available data on bond characteristics from the Mergent FISD Database. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Fund flows and bond sales (fund-level analysis)

	Percentage net purchases				Log-$ sales			
	(1) Corporate	(2) Securitized	(3) Corporate	(4) Securitized	(5) Corporate	(6) Securitized	(7) Corporate	(8) Securitized
VeryLowFlow	−0.0461**	−0.0126	−0.1039***	−0.0017	−5.5307***	−0.5190	−5.0510***	0.3837
	−2.30	*−0.40*	*−3.10*	*−0.04*	*−3.49*	*−0.36*	*−3.17*	*0.28*
LowFlow	0.0061	0.0278	−0.0559*	0.0342	−3.5071**	0.9564	−3.1398*	1.5937
	0.40	*1.32*	*−1.81*	*1.08*	*−2.14*	*0.66*	*−1.92*	*1.16*
HighFlow	0.0584***	0.0339	−0.0033	0.0395	−1.4884	2.6290*	−1.3548	3.5581**
	3.22	*1.18*	*−0.11*	*1.08*	*−0.87*	*1.71*	*−0.80*	*2.45*
VeryHighFlow	0.1149***	0.0740***	0.0443	0.0732**	2.0973	3.6415**	2.2739	4.0179***
	5.68	*2.70*	*1.36*	*2.17*	*1.22*	*2.46*	*1.33*	*2.90*
Secur. holdings 2007Q2				−0.1326**				−10.7325***
				−2.17				*−6.14*
Corp. holdings 2007Q2			0.0601*				−4.7101***	
			1.81				*−2.64*	
Affil. comm. bank			−0.0640***	−0.0420*			−1.8665*	−0.0802
			−3.47	*−1.67*			*−1.90*	*−0.08*
Log(Family size)			0.0022	0.0101*			0.0872	0.1491
			0.65	*1.76*			*0.46*	*0.84*
Fam. equity hold.			−0.1076***	−0.0077			−5.7572***	−0.5048
			−3.68	*−0.19*			*−3.71*	*−0.28*
Av. maturity of holdings			0.0009***	0.0004			−0.0047	0.0702***
			2.76	*0.60*			*−0.20*	*3.35*
F-stat (*p*-value)	1.06 (0.3035)		5.06** (0.0245)		6.58** (0.0103)		8.45*** (0.0037)	
St. error	White	White	White	White	White	White	White	White
No. obs.	546	546	546	546	546	546	546	546
(Pseudo-)R^2	0.09	0.02	0.14	0.04	0.02	0.01	0.03	0.02

Panel B: Determinants of corporate bond sales (bond-level analysis)

	(1)	(2)	(3)	(4)
InvRating	1.0496**			1.0712**
	2.14			*2.25*
Amihud		−0.9552***		−0.7488***
		−4.54		*−3.56*
InvTrades			−0.4114***	−0.2938***
			−5.26	*−3.72*
No rating [1=NO]	−3.1242**	0.0897	0.0967	−3.2439**
	−2.01	*0.95*	*1.02*	*−2.15*
Bond is not held by institutional investors [1=NO]	4.8895***	4.6887***	4.7389***	4.6379***
	25.10	*24.01*	*25.04*	*24.34*
LogHold (2007Q2)	1.0148***	0.9738***	0.9840***	0.9647***
	33.00	*31.90*	*32.83*	*31.98*
Bond face value (orthogonalized)	0.1919***	0.1640***	0.1756***	0.1492***
	5.99	*4.76*	*5.27*	*4.29*
Covenants [1=YES]	1.1209***	1.0253***	1.0170***	1.0459***

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Table 2 (*continued*)

Panel B: Determinants of corporate bond sales (bond-level analysis)

	(1)	(2)	(3)	(4)
	4.61	*4.33*	*4.37*	*4.36*
CovIndex	−0.1055	0.0722	0.0346	−0.1165
	−0.25	*0.20*	*0.09*	*−0.27*
Log(Months to maturity)	−0.3952***	−0.3226***	−0.3886***	−0.3348***
	−9.23	*−8.39*	*−9.58*	*−8.78*
Issuer fixed effects	Yes	Yes	Yes	Yes
Offering year fixed effects	Yes	Yes	Yes	Yes
Standard error cluster	Issuer	Issuer	Issuer	Issuer
No. obs.	9,201	9,078	9,113	9,078
R^2	0.91	0.88	0.91	0.91

constraints, we examine this question using contemporaneous flows only.[19] We predict that funds with the most negative flows are the main sellers of corporate bonds, and that their sales of corporate bonds dominate their trades of securitized bonds.

The results are reported in Table 2, Panel A. The sample consists of just the pure bond funds that held both corporate bonds and securitized bonds in their portfolios prior to the crisis and we use their portfolio changes in the last two quarters of 2007 as the dependent variable. In columns 1–4 the dependent variable is the percentage net purchases of corporate bonds (odd-numbered columns) and securitized bonds (even-numbered). In columns 5–8 the dependent variable is the (negative of) *Log-$ Sales* and columns are organized analogously. The cross section of sample funds is then sorted by their contemporaneous fund flows into four bins. In columns 1–2 and 5–6, the net position changes are regressed on just the four category dummies; in columns 3–4 and 7–8, the model also includes additional fund characteristics, such as *Affiliated with commercial bank* and *Log*(*Family size*).

As expected, there is a monotonic relation between the flows and net sales: funds with the most negative flows have significantly more negative net position changes, and vice versa. Importantly, funds that experience the most negative flows significantly reduce corporate bond holdings but retain securitized bonds, consistent with their needing to meet liquidity needs and deciding to sell the more liquid parts of their portfolios. The *F*-stat for the hypothesis that the funds with the most negative flows sold as much corporate funds as securitized bonds is rejected at 5% significance level in three out of the four specifications. Interestingly, funds affiliated with banks also reduce corporate bond holdings significantly but retain securitized bonds. Overall, these results support Hypothesis 2a, i.e., that the liquidity-motivated trades by funds most desperate to raise cash contributed to the propagation of shocks from securitized bonds to corporate bonds.

We further investigate which types of bonds are sold more by estimating the following multivariate regressions for a cross-sectional sample of corporate bonds:

$$Log\,Sale_{ij} = \alpha + \beta\, BondType_{ij} + \delta\, Log\,Hold_{ij} + \gamma' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (1)$$

where $LogSale_{ij}$ is the log-net sales (in thousands of dollars) of corporate bond i (issued by firm j) by institutional investors between July 2007 and December 2007, $LogHold_{ij}$ denotes the log-dollar holding of corporate bond i by institutional investors as of June 2007, μ_j is an issuer fixed effect for issuer j, and x_{ij} is a vector of standard bond characteristics, which are: the logarithm of the number of months to maturity [*Log*(*Months to maturity*)], an indicator variable for whether the bond has covenants (*Covenants*), a covenant protection index (*CovIndex*),[20] the logarithm of the amount outstanding (*Bond face value* (*orthogonalized*)), an indicator variable equal to one when the bond does not have a rating, and zero otherwise, an indicator variable equal to one when the bond is not held by institutional investors in our data set as of June 2007, as well as issuance year fixed effects. Including issuer fixed-effects, μ_j, implies that we control for any unobserved firm characteristics that could affect the sales of all bonds issued by a given issuer j.

$BondType_{ij}$ denotes one of three variables of interest, which we include one at a time (in specifications (1)–(3)), as well as all three (in specification (4)). The first variable is the *InvRating*, defined as $\log(1/1+Rating)$, where *Rating* is a numerical variable measuring the bond's rating, ranging from zero (no rating) to 24 (AAA rating or above); the lower the rating, the larger *InvRating*.

The other two variables of interest are related to how thinly traded the bond is. They are constructed by actual transactions from Financial Industry Regulatory Authority (FINRA) Trade Reporting and Compliance Engine® (TRACE®) Corporate Bond Data. The first is *InvTrades*, the natural logarithm of the inverse of the number of trades from TRACE. For each bond, we consider the mean

[19] Ideally, we would also like to run experiments where we would observe the impact of *not* rebalancing funds' portfolios in response to the crisis shock on their *future* outflows. However, this is not observable for two reasons. First, in equilibrium, rational fund managers would avoid such outcomes by rebalancing their portfolios. Second, we are limited by our data, which last only until the first quarter of 2008.

[20] The construction of the covenant index follows Billet, King, and Mauer (2007).

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Table 3
Funds' liquidity needs and pre-crisis holdings.
The table reports the estimates of a model:

$$H_{it} = \alpha + \beta \text{ Flow volatility(or turnover)}_{it} + \gamma' x_{it} + \varepsilon_{it}, \quad (2)$$

where each observation represents the portfolio composition of a given mutual fund in a given quarter. The dependent variable H is the excess percentage ownership of the fund's portfolio represented by securitized bonds (Panel A) or corporate bonds (Panel B). *Turnover ratio* and *Flow volatility* are as defined in Section 3.2. x is a set of standard control variables (see Appendix A for variable definitions). In both panels, in columns 1–2 the model is estimated using the Fama-MacBeth procedure. The standard errors are italicized, appear below coefficients, and are Newey-West, with lag length parameter equal to four. In columns 3–4, the model is estimated as a pooled OLS with quarter fixed effects, and standard errors (also shown italicized) are clustered around each fund. The sample includes all the mutual funds belonging to the merged Lipper eMAXX-CDA/Spectrum data set, over the period 1998Q1–2007Q2. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: Holdings of securitized bonds

	Fama-MacBeth		Pooled OLS	
	(1)	(2)	(3)	(4)
Turnover ratio	2.7576***		2.8124***	
	6.26		*4.94*	
Flow volatility		0.1125**		0.0676
		2.44		*1.12*
Log(family size)	0.0060**	0.0088***	0.0055	0.0079**
	2.44	*3.37*	*1.5*	*2.15*
Affiliated with commercial bank	0.0269***	0.0286***	0.0257*	0.0275*
	2.92	*3.19*	*1.75*	*1.87*
Past flow	−0.0803	−0.1966**	−0.1050*	−0.1655**
	−1.26	*−2.64*	*−1.74*	*−2.07*
Fund return	−0.4052	−0.3836	−0.1813***	−0.1919***
	−1.6	*−1.49*	*−3.68*	*−3.84*
Family equity holdings	−0.0339***	−0.0378***	−0.0376**	−0.0440***
	−4.55	*−5.06*	*−2.35*	*−2.75*
Mgmt fee	−0.0507***	−0.0572***	−0.0774***	−0.0831***
	−5.13	*−5.9*	*−3.07*	*−3.34*
Expense ratio	−4.2264***	−3.9102***	−3.5381**	−3.1500**
	−3.86	*−3.76*	*−2.39*	*−2.19*
Actual 12b1	−1.3601	−1.8687	−2.0375	−2.7213
	−0.85	*−1.28*	*−0.89*	*−1.21*
Av. maturity of holdings	0.0002	0.0004	0.0008**	0.0010***
	0.5	*0.84*	*2.06*	*2.71*
No equity	0.1232***	0.1336***	0.1385***	0.1500***
	10.81	*11.51*	*10.75*	*11.71*
Fund's equity hold. return	0.0224	0.0257	−0.0036	−0.0029
	1.1	*1.18*	*−0.31*	*−0.24*
Quarter fixed effects	No	No	Yes	Yes
Standard error	Newey-West	Newey-West	Clustered by fund	Clustered
by fund				
No. obs.	16,294	16,293	16,294	16,293
(Average) R^2	0.17	0.16	0.14	0.13

Panel B: Holdings of corporate bonds

	Fama-MacBeth		Pooled OLS	
	(1)	(2)	(3)	(4)
Turnover ratio	−2.9380***		−3.1865***	
	−5.66		*−4.94*	
Flow volatility		−0.0599		−0.0018
		−1.04		*−0.03*
Log(family size)	0.0006	−0.0023	0.0017	−0.001
	0.25	*−0.87*	*0.41*	*−0.22*
Affiliated with commercial bank	−0.0267***	−0.0295***	−0.0243	−0.0271
	−2.90	*−3.25*	*−1.45*	*−1.62*
Past flow	0.1538**	0.2125**	0.1564**	0.1459
	2.61	*2.29*	*2.22*	*1.56*
Fund return	0.331	0.3041	0.1666**	0.1797***
	1.04	*0.94*	*2.55*	*2.73*
Family equity holdings	−0.0393***	−0.0341***	−0.0356	−0.0274
	−3.39	*−2.83*	*−1.49*	*−1.15*
Mgmt fee	0.0276**	0.0352**	0.0559**	0.0628**
	2.22	*2.60*	*2.00*	*2.28*
Expense ratio	6.1217***	5.7437***	5.1174***	4.6354***

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Table 3 (*continued*)

Panel B: Holdings of corporate bonds

	Fama-MacBeth		Pooled OLS	
	(1)	(2)	(3)	(4)
	4.64	*4.62*	*3.43*	*3.20*
Actual 12b1	−0.1937	0.3661	0.8121	1.5681
	−0.10	*0.21*	*0.32*	*0.63*
Av. maturity of holdings	−0.0010*	−0.0012**	−0.0018***	−0.0020***
	−1.89	*−2.11*	*−4.36*	*−5.00*
No equity	0.1028***	0.0913***	0.0603***	0.0466**
	3.45	*2.99*	*2.90*	*2.24*
Fund's equity hold. return	−0.0143	−0.0186	0.0402**	0.0396*
	−0.21	*−0.27*	*1.98*	*1.92*
Quarter fixed effects	No	No	Yes	Yes
Standard error	Newey-West	Newey-West	Clustered by fund	Clustered by fund
No. obs.	16,294	16,293	16,294	16,293
(Average) R^2	0.10	0.09	0.06	0.05

number of trades per day between January 2007 and June 2007; the more illiquid, the larger this variable. The second is the bond's Amihud illiquidity ratio.[21] The Amihud ratio is defined as the average daily 1000 $\sqrt{|\Delta P|/\$V}$, where ΔP is the daily percentage change in price ("return") and $\$V$ is the bond's dollar volume of trade. This most directly measures the price impact of daily trading, as normalized by trade volume; again, the more illiquid the bond, the larger this variable. We compute the average ratio over the period January 2007–June 2007.

The results are reported in Table 2, Panel B. They show that the sales by institutional investors are concentrated in bonds with lower ratings, as well as in the more liquid (in the sense of ease of trading) bonds. One standard deviation increase (decrease) in the bond's *InvRating* (Amihud ratio, *InvTrades*) is associated with a 22% (5%, 3%) higher sale.

The results on bond ratings are consistent with Hypothesis 1b, i.e., investors tend to liquidate more junk bonds than investment-grade corporate bonds. The results on the ease of trading measures are both intuitive and broadly consistent with Scholes' (2000) conjecture. The economic magnitudes are larger for bond ratings than for ease-of-trading measures.

5. Funds' liquidity needs and their selling

5.1. Funds' liquidity needs and their pre-crisis holdings of securitized bonds

As defined in Section 3.2, we use fund turnover and fund flow volatility as two proxies for funds' liquidity needs. In equilibrium, these funds cater to end investors with higher liquidity demands, and therefore need to hold more liquid assets than other mutual funds. Before we examine our Hypothesis 2b, we first verify that these proxies behave as expected by examining their pre-crisis holdings of securitized bonds. As argued in Dang, Gorton, and Holmström (2010) and empirically shown in Loutskina (2010), securitized bonds were liquid, owing to their information insensitivity, which allowed dispersed ownership by uninformed institutional investors in the pre-crisis period. We therefore expect that, *among mutual funds*, the funds with high liquidity needs would hold more securitized debt in the pre-crisis period.[22]

We examine the relation between mutual funds' liquidity need measures (flow volatility or turnover) and their pre-crisis portfolio holdings by estimating the following equation:

$$H_{it} = \alpha + \beta\ \text{Flow volatility(or turnover)}_{it} + \gamma' x_{it} + \varepsilon_{it}, \qquad (2)$$

where each observation represents the portfolio composition of a given mutual fund in a given quarter. The dependent variable H is alternatively the fraction of the fund's portfolio invested in either securitized bonds or corporate bonds.[23] Flow volatility and turnover are as defined in Section 3.2, and x is a set of fund characteristics (*Affiliated with commercial bank*, *Log*(*Family size*), the fund's flow in the previous year (*Past flow*), the fund's return in the previous quarter (*Fund return*), the equity holdings of the fund's family (*Family equity holdings*), management fees (*Mgmt fee*), *Expense ratio*, *Actual 12b1*, *Average maturity* (of the fund's fixed-income holdings), an indicator variable for whether the fund holds equity or not, and the return on the fund's equity holdings (*Equity return*)).

We estimate the model using both Fama-MacBeth cross-sectional regression (with Newey-West standard

[21] Amihud (2002).

[22] Note that we do not expect mutual funds to hold more securitized bonds than insurance companies, since the mechanism governing insurance companies' decisions to hold securitized bonds is expected to be distinct from that governing mutual fund decisions, as we posit above. Thus, we examine the relation between fund turnover and fund flow volatility and their holdings using only the mutual fund sample. Indeed, as shown in Table 1, insurance companies in the aggregate held a higher percentage of their portfolios in securitized bonds than did mutual funds.

[23] They are not mere complements of each other, because there is a third component, namely, equity.

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Table 4
Changes in mutual fund holdings of securitized and corporate bonds at the onset of the crisis.

Panel A reports the estimates of a model:

$$\Delta B_i = \alpha + \beta \text{Flow volatility(orturnover)}_i + \gamma' x_i + \varepsilon_i. \quad (3)$$

The dependent variable ΔB is the change, between 2007Q2 and 2007Q4, in the fraction of the fund's portfolio represented by securitized bonds (columns 1–2) or corporate bonds (columns 3–4), in excess of the fund sector average. *Turnover ratio* (odd-numbered columns) and *Flow volatility* (even-numbered columns) are as defined in Section 3.2. x is a set of standard mutual fund characteristics (see Appendix A for variable definitions). All explanatory variables are expressed in their values as of June 2007. The standard errors are italicized and appear below coefficients.

Panel B reports the estimates of a model:

$$\Delta C_i = \alpha + \beta \text{ Flow volatility(or turnover)}_i + \gamma' x_i + \varepsilon_i.$$

In the odd-numbered columns, the dependent variable ΔC is defined analogously to ΔB for investment-grade bonds (*High*). In the even-numbered columns, the dependent variable is analogously defined for junk bonds (*Low*). *Turnover ratio* (odd-numbered columns) and *Flow volatility* (even-numbered columns) are as defined in Section 3.2. x is a set of standard control variables as in Panel A. *F*-test statistics and *p*-values for the difference between the *Flow volatility* or *Turnover* coefficients for investment-grade and junk bonds are provided in the row labeled "*F*-stat (*p*-value)." The sample includes all the mutual funds belonging to the merged Lipper eMAXX-CDA/Spectrum data set, over the period 2007Q2–2007Q4. The standard errors are italicized and appear below coefficients. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Changes in holdings of corporate bonds and securitized bonds

	Securitized bonds		Corporate bonds	
	(1)	(2)	(3)	(4)
Turnover ratio	−3.4498***		−2.8097***	
	−4.25		*−5.95*	
Flow volatility		−0.1144		−0.3682***
		−0.95		*−3.37*
Secur. holdings 2007Q2	−0.3858***	−0.3969***		
	−10.4	*−10.86*		
Corp. holdings 2007Q2			−0.2664***	−0.2736***
			−10.23	*−10.46*
Affiliated to commercial bank	0.0028	−0.0022	−0.0189	−0.0217*
	0.17	*−0.14*	*−1.63*	*−1.78*
Log(family size)	−0.0017	−0.0029	−0.0006	−0.0003
	−0.51	*−0.9*	*−0.24*	*−0.12*
Past flow	0.2640*	0.3139*	0.2693*	0.5939***
	1.74	*1.7*	*1.89*	*3.62*
Fund return	0.4722	0.4932	0.3035	0.1715
	1.36	*1.45*	*1.32*	*0.71*
Family equity holdings	0.0103	0.0165	−0.0153	−0.0104
	0.4	*0.66*	*−0.7*	*−0.47*
Mgmt fee	−0.0515	−0.0673*	0.0339	0.0236
	−1.4	*−1.87*	*0.81*	*0.54*
Exp. ratio	1.312	2.6289	−6.3101*	−1.8736
	0.39	*0.88*	*−1.79*	*−0.44*
Actual 12b1	−0.8002	−1.5201	6.5211	1.7917
	−0.18	*−0.4*	*1.53*	*0.34*
Av. maturity of holdings	0.0007	0.0004	−0.0010***	−0.0012***
	1.6	*0.93*	*−2.78*	*−3.13*
No equity	0.0183	0.0097	0.0092	0.0002
	0.87	*0.46*	*0.53*	*0.01*
Fund's equity return	−0.0602	−0.0531	−0.0368	0.0055
	−0.31	*−0.28*	*−0.22*	*0.03*
Standard error	White	White	White	White
No. obs.	561	578	561	578
R^2	0.38	0.35	0.3	0.28

Panel B: Sales of corporate bonds, by ratings

Rating	Low	High	Low	High
	(1)	(2)	(3)	(4)
Turnover ratio	−1.4581***	−1.2381***		
	−3.78	*−5.59*		
Flow volatility			−0.2789***	−0.0838*
			−3.34	*−1.92*
[Control variables suppressed]				
F-stat (*p*-value)	0.25 (0.6193)		5.94** (0.0148)	
Standard error	White	White	White	White
No. obs.	561	561	578	578
R^2	0.33	0.1	0.33	0.06

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Table 5
Changes in corporate bonds' yield spreads after the onset of the crisis.

Panel A of this table reports the estimates of a model:

$$\Delta YS_{ij} = \alpha + \beta\, HoldersExposure_{ij} + \gamma\, InvRating_{ij} + \delta(HoldersExposure_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (4)$$

where each observation is a corporate bond with data in the FINRA TRACE Corporate Bond Data. The dependent variable ΔYS is the change in bond *i*'s yield spread, defined as the difference between bond *i*'s yield on the secondary market, as reported by TRACE, and the yield on a Treasury bond of comparable maturity. Data on Treasury bond yields are from the Federal Reserve Statistical Release. In columns 1–4, ΔYS is defined as the change in the bond's yield spread over the period from June to October 2007, while in columns 5–8 it is the change in the bond's yield spread over the period from June to December 2007. The explanatory variables are: *HoldersExposure* (the weighted-average fraction of securitized bonds in the portfolio of the mutual funds that hold bond *i*, averaged across each investor holding bond *i* and using par amount of bond *i* held as weights), *InvRating* (the natural logarithm of the inverse of 1 + the numerical value of the bond's S&P rating, which ranges from zero (no rating) to 24 (AAA rating or higher)), the interaction term between these two variables, and a standard set of bond characteristics *x* (see Appendix A for variable definitions), issuer fixed effects for issuer *j* (μ_j), and offering year fixed effects.

Panel B of this table reports the estimates of a model:

$$\Delta YS_{ij} = \alpha + \beta\, HighExposed_{ij} + \gamma\, InvRating_{ij} + \delta(HighExposed_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (5)$$

where each observation is a corporate bond *i*. The dependent variable ΔYS is defined as in Panel A. *HighExposed* is an indicator equal to one if bond *i*'s high-liquidity-need mutual fund holders' exposure to securitized bonds is above the sample median. We use two proxies for mutual funds' liquidity needs as before (turnover ratio and flow volatility) and obtain one indicator *HighExposed* for each proxy. *InvRating* is defined as in Panel A. We further include the interaction term between these two variables, along with a standard set of bond characteristics *x* (see Appendix A for variable definitions), issuer fixed effects for issuer *j* (μ_j), and offering year fixed effects. For brevity, only the key coefficients are shown. In both panels and in all specifications, the standard errors are shown italicized below coefficients and clustered around bond issuers. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: The baseline model

	Change in yield spread—July–October 2007				Change in yield spread—July–December 2007			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Holders' exposure (to securitized bonds)	0.7885**	0.6659*	0.5762	0.3936	1.2900*	1.4210**	1.4042*	1.2581*
	2.02	*1.80*	*1.45*	*1.01*	*1.87*	*2.04*	*1.92*	*1.74*
InvRating	0.8066*	0.9079**	0.8497**	0.8048**	1.8664**	1.6608**	1.6482**	1.6086**
	1.84	*2.47*	*2.28*	*2.14*	*2.96*	*2.61*	*2.54*	*2.47*
Holders' exposure × InvRating	0.2911**	0.2576**	0.2988**	0.2568**	0.4836**	0.5349**	0.5438**	0.5311**
	2.48	*2.16*	*2.53*	*2.18*	*2.26*	*2.43*	*2.51*	*2.43*
Yield spread in 2007Q2	−0.1909**	−0.2689***	−0.2717***	−0.2731***	−0.4174***	−0.4134***	−0.4147***	−0.4157***
	−2.48	*−2.89*	*−2.98*	*−2.99*	*−6.70*	*−6.40*	*−6.34*	*−6.37*
No rating [1 = NO]	−2.6943*	−3.0231***	−2.8370**	−2.6829**	−6.0739***	−5.4002***	−5.3617***	−5.2271**
	−1.92	*−2.60*	*−2.41*	*−2.24*	*−3.05*	*−2.70*	*−2.63*	*−2.55*
Bond is not held by mutual funds [1 = NO]	0.0720	0.1387*	0.1188	0.1086	−0.1198	−0.1244	−0.1311	−0.1434
	0.79	*1.95*	*1.57*	*1.56*	*−0.95*	*−0.99*	*−1.11*	*−1.16*
Bond face value	−0.0012	−0.0082	0.0028	0.0120	−0.0372	−0.0333	−0.0302	−0.0225
	−0.07	*−0.60*	*0.19*	*0.79*	*−1.53*	*−1.44*	*−1.01*	*−0.95*
Covenants [1 = YES]	0.1651	0.0267	0.0311	0.0358	−0.1065	−0.0979	−0.0958	−0.0900
	1.37	*0.34*	*0.39*	*0.46*	*−0.73*	*−0.70*	*−0.68*	*−0.65*
CovIndex	−0.2727	−0.1518	−0.1218	−0.1090	0.1924	0.1865	0.1925	0.2066
	−0.87	*−0.73*	*−0.59*	*−0.52*	*0.49*	*0.48*	*0.50*	*0.53*
Log(Months to maturity)	−0.1016***	−0.1039***	−0.1154***	−0.1048***	−0.2147***	−0.2215***	−0.2251***	−0.2220***
	−3.20	*−2.94*	*−3.09*	*−2.85*	*−3.17*	*−3.25*	*−3.14*	*−3.22*
Insurance holders' exposure		0.2657	0.2632	0.2573		−0.2643	−0.2645	−0.2641
		0.75	*0.74*	*0.72*		*−0.52*	*−0.51*	*−0.52*
Insurance holders' exposure × InvRating		0.0374	0.0286	0.0266		−0.0635	−0.0628	−0.0676
		0.33	*0.25*	*0.23*		*−0.37*	*−0.37*	*−0.40*
Amihud			0.1525				0.0468	
			0.94				*0.14*	
Holders' exposure × Amihud			0.6232				0.1272	
			1.35				*0.21*	
InvTrades				0.1873***				0.1088
				2.91				*0.98*
Holders' exposure × InvTrades				−0.2203				−0.1274
				−1.22				*−0.44*
Issuer fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Offering year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table 5 (*continued*)

Panel A: The baseline model

	Change in yield spread—July–October 2007				Change in yield spread—July–December 2007			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standard error cluster	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer
N. obs.	7,348	7,348	7,348	7,348	8,148	8,148	8,148	8,148
R^2	0.65	0.70	0.70	0.70	0.74	0.75	0.75	0.75

Panel B: High-liquidity-need funds with exposure to securitized bonds

	Change in yield spread—July–October 2007		Change in yield spread—July–December 2007	
	(1)	(2)	(3)	(4)
HighExposed (turnover)	0.3324*		0.7222***	
	1.71		*2.71*	
HighExposed (flow volatility)		0.2429		0.4700**
		1.26		*1.99*
InvRating	0.9439***	0.9231***	1.8800***	1.8093***
	2.79	*2.74*	*3.67*	*3.55*
HighExposed (turnover) × InvRating	0.1181*		0.2083**	
	1.87		*2.54*	
HighExposed (flow vol.) × InvRating		0.1228**		0.1476**
		2.01		*2.09*
Issuer fixed effects	Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes
Offering year fixed effects	Yes	Yes	Yes	Yes
Standard error cluster	Issuer	Issuer	Issuer	Issuer
No. obs.	7,302	7,302	8,136	8,136
R^2	0.66	0.66	0.76	0.76

errors with lag length parameter equal to four), and a pooled ordinary least squares (OLS) with quarter fixed effects and standard errors clustered around each fund (Petersen, 2009). The sample includes all the mutual funds belonging to the merged Lipper eMAXX-CDA/Spectrum data set over the period 1998Q1–2007Q2.[24,25]

The results are reported in Table 3. In Panel A, the dependent variable is the fraction of the fund's portfolio represented by securitized bonds. In Panel B, the dependent variable is the fraction of the fund's portfolio represented by corporate bonds. In columns 1–2 the model is estimated using the Fama-MacBeth regression; in columns 3–4, it is estimated as a pooled OLS.

The results show a strong correlation between the mutual funds' liquidity needs and their pre-crisis investments in securitized bonds.[26] All else equal, a fund in the top decile of *Turnover* holds 46% of its portfolio in securitized bonds, while a fund in the bottom decile holds only 28%. The fund's affiliation with banks is also associated with higher holdings of securitized bonds.

Among the control variables, it is interesting to note that funds with higher expense ratios hold more in corporate bonds and less in securitized bonds. One possible interpretation is that a corporate bond is considered more information-sensitive than a securitized bond because its default risk contains more idiosyncratic risk about the firm. Therefore, funds with more active investment strategies (and higher expenses) gravitate towards corporate bonds, whereas funds with lower expenses choose to hold securitized bonds. The equity focus of fund families is negatively associated with portfolio weights of both corporate bonds and securitized bonds. This could be because prominent pure bond funds tend to be part of fund families that are focused on fixed-income securities (e.g., Pacific Investment Management Company, LLC (PIMCO)).

[24] The merged data set consists of both pure bond funds (about 80% of the sample) and blend funds, which hold some equity (about 20%). In unreported analysis, we re-estimate the models reported in Tables 3 and 4 using only pure bond funds and find that the results are qualitatively unchanged.

[25] While many observers of the crisis point to August 2007 as the first month in which financial contagion or systemic risk surfaced (as reflected, e.g., in the sharp rise in the London Interbank Offered Rate-overnight indexed swap (LIBOR-OIS) spread, shown in Fig. 2), subprime market indicators (e.g., ABX) exhibited localized disruptions as early as 2007Q1. Thus, as a robustness check, we also re-run the model using data up to 2006Q4 rather than 2007Q2 and find that results are qualitatively unchanged.

[26] Some funds in our original data set had extremely high flow volatility *and* also held very high portions of their portfolios in securitized bonds (e.g., 90%) prior to the crisis. While these funds appear to hold large amounts of securitized bonds precisely to meet their high liquidity demands from their end investors (as we hypothesize), we nonetheless winsorize both *Flow volatility* and *Turnover* at the top 5% to ensure that results are not driven by a few outliers. If we do not winsorize these high volatility funds, the coefficient for *Flow volatility* in column 4 of Panel A is highly positive and significant, and the coefficient in Panel B is also negative and significant for column 2.

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Table 6
Corporate bond selling pressure by mutual funds.

Panel A reports the estimates of a model:

$$\Delta Tr_{ij} = \alpha + \beta HoldersExposure_{ij} + \gamma InvRating_{ij} + \delta(HoldersExposure_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (6)$$

where each observation is a corporate bond with data in the FINRA TRACE Corporate Bond Data. The dependent variable ΔTr_i is defined as the total net sales of bond i by mutual funds divided by the total trading volume on the bond, over the crisis period. In columns 1–4, ΔTr_i is defined over the period from July to October 2007, while in columns 5–8 it is defined over the period from July to December 2007. The explanatory variables are: *HoldersExposure* (the weighted-average fraction of securitized bonds in the portfolio of the mutual funds that hold bond i, averaged across each investor holding bond i and using par amount of bond i held as weights), *InvRating* (the natural logarithm of the inverse of 1 + the numerical value of the bond's S&P rating, which ranges from zero (no rating) to 24 (AAA rating or higher)), the interaction term between these two variables, and a standard set of bond characteristics x (see Appendix A for variable definitions), issuer fixed effects for issuer j (μ_j), and offering year fixed effects.

Panel B reports the estimates of a model:

$$\Delta Tr_{ij} = \alpha + \beta HighExposed_{ij} + \gamma InvRating_{ij} + \delta(HighExposed_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (7)$$

where each observation is a corporate bond. The dependent variable ΔTr is defined as in Panel A. *HighExposed* is an indicator equal to one if the bond is held by high-liquidity-need mutual funds with exposure to securitized bonds above the median. We use two proxies for mutual funds' liquidity needs (turnover ratio and flow volatility) and obtain one indicator *HighExposed* for each proxy. *InvRating* is defined as in Panel A. We further include the interaction term between these two variables, along with a standard set of bond characteristics x (see Appendix A for variable definitions), issuer fixed effects for issuer j (μ_j), and offering year fixed effects. For brevity, only the key coefficients are shown. In both panels and in all specifications, the standard errors are shown italicized below coefficients and clustered around bond issuers. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Baseline model

	Trading pressure of mutual funds—July–October 2007				Trading pressure of mutual funds—July–December 2007			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Holders' exposure	0.0056	0.0199	0.0198	0.0176	0.0312	0.0412	0.0506	0.0552
	0.21	*0.65*	*0.68*	*0.52*	*0.99*	*1.20*	*1.55*	*1.46*
InvRating	0.0151	0.0148	0.0163	0.0176	0.0102	0.0105	0.0127	0.0093
	0.78	*0.77*	*0.84*	*0.93*	*0.55*	*0.57*	*0.69*	*0.51*
Holders' exposure × InvRating	0.0105	0.0154	0.0065	0.0118	0.0238**	0.0273**	0.0189*	0.0251**
	1.10	*1.39*	*0.65*	*1.25*	*2.37*	*2.44*	*1.82*	*2.49*
2007Q2 Log-volume	0.0022**	0.0024**	0.0015	0.0006	0.0014**	0.0013**	0.0012**	0.0014*
	2.03	*2.16*	*1.11*	*0.54*	*2.13*	*2.08*	*2.36*	*1.90*
No rating [1 = NO]	−0.0518	−0.0495	−0.0552	−0.0601	−0.0352	−0.0351	−0.0430	−0.0325
	−0.84	*−0.81*	*−0.89*	*−0.98*	*−0.59*	*−0.60*	*−0.73*	*−0.55*
Bond is not held by mutual funds [1 = NO]	−0.0461***	−0.0465***	−0.0469***	−0.0462***	−0.0562***	−0.0559***	−0.0555***	−0.0566***
	−9.25	*−9.27*	*−9.43*	*−9.22*	*−12.01*	*−12.07*	*−11.81*	*−11.88*
Bond face value	0.0006	0.0006	0.0005	0.0002	0.0015**	0.0014**	0.0010*	0.0016**
	0.86	*1.00*	*0.74*	*0.23*	*2.44*	*2.22*	*1.66*	*2.39*
Covenants [1 = YES]	0.0104	0.0115	0.0109	0.0095	0.0079	0.0086	0.0073	0.0086
	1.14	*1.26*	*1.21*	*1.06*	*0.80*	*0.88*	*0.76*	*0.87*
CovIndex	−0.0012	−0.0056	−0.004	−0.0019	0.0140	0.0104	0.0107	0.0150
	−0.05	*−0.24*	*−0.17*	*−0.08*	*0.54*	*0.41*	*0.42*	*0.58*
Log(months to maturity)	−0.0018**	−0.0018**	−0.0015*	−0.0018**	−0.0052***	−0.0052***	−0.0044***	−0.0052***
	−2.21	*−2.21*	*−1.67*	*−2.23*	*−5.09*	*−5.11*	*−4.12*	*−5.09*
Insurance holders' exposure		−0.022				−0.0090		
		−1.44				*−0.50*		
Insurance holders' exposure × InvRating		−0.0064				−0.0048		
		−1.19				*−0.75*		
Amihud			−0.0013				−0.0059*	
			−0.28				*−1.85*	
Holders' exposure × Amihud			−0.0738**				−0.0946**	
			−1.98				*−2.51*	
InvTrades				−0.0106***				0.0001
				2.83				*0.03*
Holders' exposure × InvTrades				0.0062				−0.0205
				0.39				*−1.35*
Issuer fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Offering year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard error cluster	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer

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Table 6 (*continued*)

Panel A: Baseline model

	Trading pressure of mutual funds—July–October 2007				Trading pressure of mutual funds—July–December 2007			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No. obs.	9,042	9,042	9,005	9,042	8,728	8,728	8,728	8,728
R^2	0.69	0.69	0.69	0.69	0.68	0.68	0.68	0.68

Panel B: High-liquidity-need funds with exposure to securitized bonds

	Mutual fund selling pressure—July–October 2007		Mutual fund selling pressure—July–December 2007	
	(1)	(2)	(3)	(4)
HighExposed (turnover)	0.0383***		0.0490***	
	2.86		*4.02*	
HighExposed (flow volatility)		0.0375***		0.0436***
		2.82		*2.98*
InvRating	0.0200	0.0188	0.0197	0.0183
	0.77	*0.73*	*1.08*	*1.01*
HighExposed (turnover) × InvRating	0.0096**		0.0073*	
	2.14		*1.84*	
HighExposed (flow vol.) × InvRating		0.0079*		0.0067
		1.86		*1.52*
Issuer fixed effects	Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes
Offering year fixed effects	Yes	Yes	Yes	Yes
Standard error cluster	Issuer	Issuer	Issuer	Issuer
No. obs.	8,666	8,666	8,728	8,728
R^2	0.58	0.58	0.69	0.68

Overall, these results show that high-turnover and high-flow-volatility mutual funds acquired proportionately larger amounts of securitized bonds prior to the crisis. Thus, our measures of funds' liquidity needs behave as expected.

5.2. Funds' liquidity needs and their selling after the onset of the crisis

We now link sales during the crisis to the liquidity needs of mutual funds and test whether investors with more liquidity needs liquidate more corporate bonds (Hypothesis 2b) and also whether they sell more lower-rated bonds (Hypothesis 1b). Recall that Hypothesis 2b predicts a positive relation between funds' liquidity needs and the amount of corporate bonds they liquidate. We therefore relate the changes in holdings of mutual fund investors around the onset of the crisis to our proxies for their liquidity needs. We estimate for a cross-sectional sample of mutual funds:

$$\Delta B_i = \alpha + \beta\ \text{Flow volatility(or turnover)}_i + \gamma' x_i + \varepsilon_i, \qquad (3)$$

where ΔB_i is the change, between 2007Q2 and 2007Q4, in the fraction of the fund's portfolio represented by either securitized bonds or corporate bonds. Flow volatility and Turnover are as defined in Section 3.2.[27] x is a set of fund characteristics including the control variables from Eq. (2), as well as the fraction of securitized (or corporate) bonds in the fund's portfolio as of 2007Q2. All explanatory variables are expressed in values as of June 2007 in columns 1–4 of Panel A, Table 4.

The results are reported in Table 4, Panel A. In columns 1–2, the dependent variable is the change in the fraction of the fund's portfolio represented by securitized bonds, while in columns 3–4, the dependent variable is the change in the fraction of the fund's portfolio represented by corporate bonds. The results show a significantly negative correlation between the liquidity needs of the investor and the net change in the representation of corporate bonds in the portfolio. That is, the greater the liquidity needs, the more the institutional investor reduces his stake in corporate bonds. Funds that are affiliated with commercial banks also tend to sell more corporate bonds. This finding is consistent with both (i) inside/higher-quality information received by the funds thanks to their affiliation and (ii) implicit guarantees by their affiliate banks to effectively bail out these funds in the event of market turmoil. The anecdotal evidence about Citigroup's and other banks'

[27] Our results reported in Tables 4–6 are robust to using the flow performance sensitivity as a third proxy of liquidity needs. We are, however, concerned with two potential issues. First, the extreme performance may be more likely for equity than bonds, and more likely

(*footnote continued*)
for lower-grade corporate bonds than AAA-rated securitized bonds. Second, the sensitivity could also capture how well fund manager incentives are aligned with fund investors. These concerns make clean interpretations of results using the sensitivity proxy difficult. Thus, we rely instead on the turnover and flow-volatility proxies for our inferences. The results are available from the authors upon request.

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Table 7
Corporate bond trading volume after the onset of the crisis.
The table reports the estimates of a model:

$$LogVol_{ij} = \alpha + \beta HoldersExposure_{ij} + \gamma InvRating_{ij} + \delta(HoldersExposure_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij},$$

where each observation is a corporate bond with data in the FINRA TRACE Corporate Bond Data. The dependent variable *LogVol* is the natural logarithm of bond *i*'s average daily trading volume (expressed in number of trades) over the crisis period. In columns 1–4, *LogVol* is defined over the period from July to October 2007, while in columns 5–8 it is defined over the period from July to December 2007. The explanatory variables are: *HoldersExposure* (the weighted-average fraction of securitized bonds in the portfolio of the mutual funds that hold the bond *i*, averaged across each investor holding bond *i* and using par amount of bond *i* held as weights), *InvRating* (the natural logarithm of the inverse of 1+the numerical value of the bond's S&P rating, which ranges from zero (no rating) to 24 (AAA rating or higher)), the interaction term between these two variables, and a standard set of bond characteristics *x* (see Appendix A for variable definitions), issuer fixed effects for issuer $j(\mu_j)$, and offering year fixed effects. In all specifications, the standard errors are shown italicized below coefficients and clustered around bond issuers. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Trading volume—July–October 2007				Trading volume—July–December 2007			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Holders' exposure (to securitized bonds)	0.8778***	0.9275***	1.3250***	0.5752	0.6254***	0.6348**	1.0685***	−0.0996
	2.73	*2.63*	*3.49*	*1.34*	*2.96*	*2.49*	*3.75*	*−0.33*
InvRating	−1.5356***	−1.5018***	−1.4736***	−1.4969***	−0.6168***	−0.5842***	−0.5456***	−0.5862***
	−4.38	*−4.37*	*−4.35*	*−4.36*	*−2.96*	*−2.88*	*−2.78*	*−2.92*
Holders' exposure × InvRating	0.2382**	0.2686**	0.1395	0.2664**	0.1564**	0.1718*	0.0253	0.1594*
	2.28	*2.21*	*1.11*	*2.21*	*2.18*	*1.89*	*0.30*	*1.76*
2007Q2 Log−volume	0.4286***	0.4152***	0.4076***	0.4176***	0.5093***	0.4963***	0.4588***	0.5088***
	10.44	*10.50*	*11.02*	*11.08*	*18.22*	*18.03*	*17.28*	*19.98*
No rating [1=NO]	4.8706***	4.7862***	4.7075***	4.7739***	2.0144***	1.9284***	1.8119***	1.9423***
	4.46	*4.46*	*4.44*	*4.45*	*3.11*	*3.05*	*2.95*	*3.10*
Bond is not held by mutual funds [1=NO]	−0.6231***	−0.5944***	−0.6176***	−0.5910***	−0.4955***	−0.4686***	−0.4976***	−0.4627***
	−6.10	*−5.89*	*−6.03*	*−5.83*	*−6.63*	*−6.37*	*−6.65*	*−6.37*
Bond face value	0.2756***	0.2649***	0.2636***	0.2653***	0.1389***	0.1289***	0.1260***	0.1317***
	7.62	*7.37*	*7.25*	*7.07*	*8.74*	*8.28*	*8.12*	*8.07*
Covenants [1=YES]	0.0862	0.1031	0.1084	0.0931	0.1788*	0.1914**	0.1942**	0.1773*
	0.64	*0.78*	*0.83*	*0.70*	*1.90*	*2.08*	*2.18*	*1.94*
CovIndex	0.6117**	0.5301*	0.4661	0.5293*	0.4216**	0.3590*	0.2972	0.3563*
	2.07	*1.81*	*1.60*	*1.81*	*2.27*	*1.94*	*1.64*	*1.93*
Log(Months to maturity)	−0.0981***	−0.0958***	−0.0928***	−0.0954***	−0.1056***	−0.1035***	−0.0869***	−0.1028***
	−4.57	*−4.42*	*−3.88*	*−4.44*	*−8.47*	*−8.32*	*−5.97*	*−8.47*
Insurance holders' exposure		0.3089	0.3357	0.3042		0.3452*	0.3919**	0.3325*
		0.97	*1.07*	*0.95*		*1.77*	*2.09*	*1.65*
Insurance holders' exposure × InvRating		−0.0785	−0.0612	−0.0796		−0.0552	−0.0302	−0.0589
		−0.69	*−0.54*	*−0.70*		*−0.88*	*−0.50*	*−0.93*
Amihud			0.0632				−0.1411	
			0.33				*−1.50*	
Holders' exposure × Amihud			−2.2277**				−2.4864***	
			−2.46				*−4.18*	
InvTrades				−0.0400				−0.1293**
				−0.50				*−2.50*
Holders' exposure × InvTrades				0.3435				0.6824***
				1.41				*4.17*
Issuer fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Offering year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard error cluster	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer	Issuer
No. obs.	9,598	9,598	9,598	9,598	9,573	9,573	9,573	9,573
R^2	0.80	0.80	0.80	0.80	0.88	0.88	0.88	0.88

infusion of cash into its own money market funds to keep them afloat is consistent with this latter interpretation.[28]

We further examine whether the funds with high liquidity needs sell more lower-rated bonds by examining their sales of corporate bonds separately for investment-grade and sub-investment-grade corporate bonds (Hypothesis 1b). We repeat the specification presented in Eq. (3) and simply replace the dependent variable with ΔC, defined analogously to ΔB_i for (i) investment-grade corporate bonds and (ii) sub-investment-grade corporate bonds, respectively.

The results are reported in Table 4, Panel B. In the odd-numbered columns, the dependent variable ΔC is the fund's sales of junk bonds, as a fraction of the value of the fund's portfolio as of June 2007. In the even-numbered

[28] Jewell (2010) reports that a study by Moody's concluded that "[a]ll told, companies with … money market funds that were at risk spent about $12.1 billion … to prop them up." Tangentially, we examine fund performance following the onset of the crisis and find that bank-affiliated funds underperform because their portfolios are heavy in securitized bond holdings. This result is more consistent with the bailout explanation than with the superior information explanation; however, the sample period is quite short after the onset of the crisis, and we stress the need for caution in drawing definitive conclusions from this evidence.

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columns, the dependent variable is the fund's sales of investment grade bonds. The impact of funds' liquidity needs on the sales of corporate bonds is stronger (significantly so in case of flow volatility) for the below-investment-grade bonds than for the investment-grade bonds (*F*-stat *p*-values for the statistical significance of the two coefficients are provided at the bottom of the table). Note also that *R*-squared is three to five times larger for the junk bonds (odd-numbered columns) than for investment-grade bonds (even-numbered columns).

Overall, the results in Tables 3 and 4 show that (i) mutual funds with high liquidity needs acquired proportionately larger amounts of securitized bonds prior to the crisis, and (ii) when the crisis hit in August 2007 and securitized bonds became illiquid, they liquidated more than other funds in the first months of the crisis, and, in particular, they reduced their holdings of lower-rated corporate bonds. The result on lower-rated corporate bonds being sold more is open to multiple interpretations, as discussed in Section 2.

As described earlier, there were some signs of disruptions in the subprime-mortgage markets as early as 2007Q1. Hence, it is possible that funds that held more securitized bonds experienced disruptions in their performance and flows in the first two quarters of 2007. Thus, to ensure that our measures of fund liquidity needs are not driven by these early episodes of the crisis, we repeat our analysis using flow volatility and turnover measured as of December 2006, instead of June 2007 (as is done in Table 4). The results (unreported) are qualitatively unchanged.[29]

As reported earlier, we find that the insurance companies overall were small net purchasers of both asset classes at the onset of the crisis. The only exception is a small subset of insurance companies whose risk-based capital ratios (RBC ratio) were below the threshold level of 2.0 as of 2007Q2—these insurance companies sold securitized bonds.[30] Given that downgrades did ***not*** occur for most of these bonds until after our sample period, this behavior is consistent with the view that insurance companies' portfolio decisions are based on capital regulation constraints.

6. Effects of investors' exposure to securitized bonds on corporate bonds

The previous sections show that, as the crisis hits the market, institutional investors faced with liquidity needs retain their (now) most illiquid assets – the securitized bonds – and sell the others. In particular, they prioritize the sale of junk bonds. We now examine whether corporate bonds that are held by investors with heavy exposure to securitized bonds experience negative shocks at the onset of the crisis. We start by focusing on changes in corporate bond yield spreads (prices) and trading volumes (Hypothesis 3a). We then test whether the size of the impact is related to the bond rating (Hypothesis 3b). Finally, we examine whether insurance companies act as strategic liquidity providers to offset the liquidity-motivated sales by mutual funds.

6.1. Effects on corporate bond yields

For a cross-sectional sample of corporate bonds, we estimate the following model:

$$\Delta YS_{ij} = \alpha + \beta\, HoldersExposure_{ij} + \gamma\, InvRating_{ij} + \delta(HoldersExposure_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (4)$$

where each observation corresponds to corporate bond *i* issued by issuer *j* with data in TRACE Corporate Bond Data. The dependent variable ΔYS_{ij} is the change in the yield spread of corporate bond *i* (issued by issuer *j*) between the pre-crisis 2007Q2 and post-crisis 2007Q3 (2007Q4 for columns 5–8). The yield spread is defined as the difference between the bond's yield in the secondary market, as reported by TRACE, and the yield of a Treasury bond of comparable maturity. Data on Treasury bond yields are from the Federal Reserve Statistical Release.

We empirically gauge the magnitude of selling pressure on a given corporate bond *i* by creating $HoldersExposure_{ij}$, a weighted-average exposure measure of all mutual fund investors who held bond *i* before the crisis. This measure is constructed by first calculating the fractional exposure to the securitized bonds of the portfolio (e.g., 30%) of each mutual fund investor $n=1,\ldots,N_i$ holding bond *i*, and then obtaining a weighted average of this exposure across all N_i funds using par amounts of bond *i* held as weights.[31] The larger the exposure of the mutual fund investors holding bond *i*, the more bond *i* is expected to be sold today.

What about insurance company investors? We expect the mechanism governing their portfolio decisions to be distinct. As we argued, they are not subject to runs like mutual funds, because they have longer lock-up periods and heftier early withdrawal penalties. This makes them less subject to selling pressure in the initial period of the crisis. At the same time, they are subject to rating-based capital regulation.[32] Downgrades of securitized bonds would thus predict sales by insurance companies. However, in the second-half of 2007 – the focus of our analysis – there were only a very small number of downgrades of securitized bonds. Thus, we do not expect insurance companies to liquidate as much as mutual funds during this period. To verify this prediction (Hypothesis 2c), we also construct an analogous *HoldersExposure* measure

[29] We thank Kent Daniel for suggesting this exercise.

[30] The NAIC states that insurance companies with an RBC ratio below 2.0 are subject to supervision by state regulators.

[31] In the results reported in Tables 5–7, the exposure measures are as of June 2007. In unreported analyses, we re-estimate the models in Tables 5–7 with exposure measures as of December 2006 and find that the results are qualitatively unchanged.

[32] Asset risk (called C1) makes up the bulk of insurance risk-based capital in the United States, as discussed in Herring and Schuermann (2005, Table 1.3). "In spirit, C1 [asset risk] is closer to the Basel risk-adjusted assets for credit risk. For example, risk weights for C1 are 30 basis points…for cash…0% for government bonds…0.3% for AAA- to A-rated bonds; then increasing for lower rated bonds (there are six risk bands in total)…" (pp. 38–39). Notably, the low 0.3% risk weights for AAA- to A-rated bonds apply to securitized bonds.

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separately for insurance companies holding bond i and include this variable in one of the specifications.

We further interact the exposure measure ($HoldersExposure_{ij}$) with $InvRating_{ij}$ (as defined earlier) and include this interaction term as well as $InvRating_{ij}$ itself in the model. The lower the rating, the higher the $InvRating_{ij}$, and the more the bond is expected to be sold as a function of the bondholders' exposure to securitized bonds, according to Hypothesis 1b.

There may be concerns that the association of a given corporate bond i with high-exposure investors picks up some unobserved quality about its issuer j and is thus endogenous. The inclusion of an issuer firm dummy μ_j (firm fixed effect) allows us to mitigate these concerns. Effectively, the use of a firm fixed-effect model enables us to compare the yield spread change of bond i issued by firm j and held by exposed investors to another bond k *issued by the same firm* j but held by non-exposed investors, holding any issuer-specific characteristics (both observable traits, such as credit ratings, as well as unobservable traits) constant.

Further, since we calculate a given bond's yield spread as the yield of the bond in excess of the Treasury bond of the same term structure, we are also able to control for any term spread difference that might be present between the exposed and non-exposed bonds of a given issuer. That is, we are able to isolate the within-firm variations in spread changes and selling pressures across bonds (holding issuer risk and term structure constant) as functions of bond-specific exposure measures.

We also include a standard set of bond characteristics x_{ij}, which includes the level of the yield spread of bond i as of June 2007, the bond's liquidity measures (*Amihud ratio* or *InvTrades*, as defined earlier), an interaction term between *HoldersExposure* and bond liquidity, as well as issuance year fixed effects. Finally, ε_{ij} is an error term with the mean zero. To allow for heteroskedasticity and to control for the fact that ε_{ij} is potentially correlated across bonds issued by the same issuer, we use standard errors clustered around bond issuers.

Treasury yields went down during the crisis as a result of investors' flight to liquidity and safety (e.g., Krishnamurthy and Vissing-Jorgensen, 2010). This phenomenon does not confound our cross-sectional analysis, since we use Treasury yields only as benchmarks. Specifically, to the extent that yield spreads increased for *all* corporate bonds during this period, the constant term in Eq. (4) picks up the aggregate-level increase. Furthermore, to the extent that lower-rated bonds' yield spreads increased by more than those for high-rated bonds (due to the investors' flight to safety), *InvRating* picks up the effect. The variables of our interest, $HoldersExposure_{ij}$ and $HoldersExposure_{ij} \times InvRating_{ij}$, pick up any residual effects of bondholders' exposure to securitized bonds *over and above* these macro effects.

We report the results in Table 5. In columns 1–4 ΔYS is defined as the change in the bond's yield spread over the period from the last week of June through the last week of October 2007, while in columns 5–8 it is the change in the bond's yield spread over the period from the last week of June through the last week of December 2007. The sample includes all bonds in the TRACE Corporate Bond Data with available data on bond characteristics from the Mergent FISD Database.

The first coefficient, *HoldersExposure*, is positive and significant, which means that the higher the exposure of the mutual fund investors holding bond i, the more the yield spread goes up in the months after the onset of the crisis. Comparing the coefficients on *HoldersExposure* between the left- and the right-hand side panel, we also note that they are two to three times larger in the

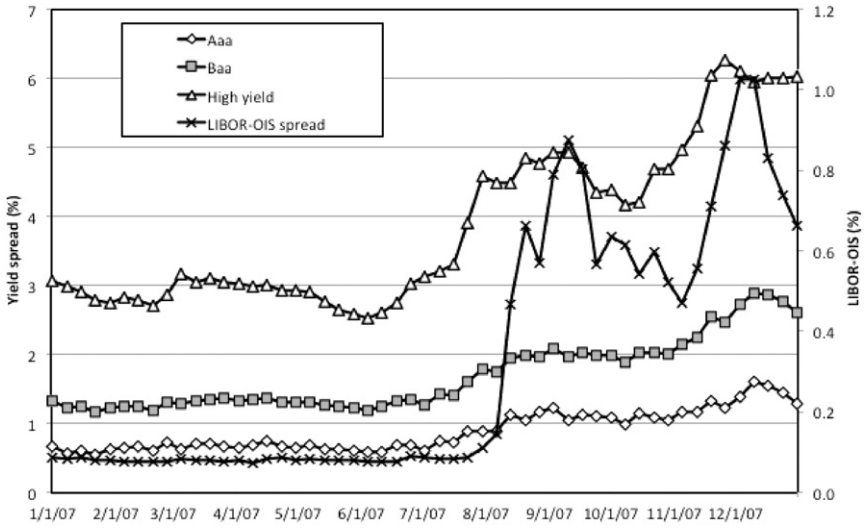

Fig. 2. Corporate bond yield spreads and LIBOR-OIS spread. This figure plots weekly average yield spreads on corporate bonds in 2007, for Aaa, Baa, and high yield corporate bonds, as well as the spread between the LIBOR rate and the Overnight Index swap rate (LIBOR-OIS Spread, secondary axis). The yield spread is defined as the difference between a bond's yield on the secondary market and the yield on a Treasury bond of comparable maturity. Data on Treasury yields are retrieved from the Federal Reserve Statistical Release; corporate bond index yield data used are the Barclays US Aggregate Indexes and are retrieved from Datastream; and the LIBOR-OIS data are retrieved from Bloomberg.

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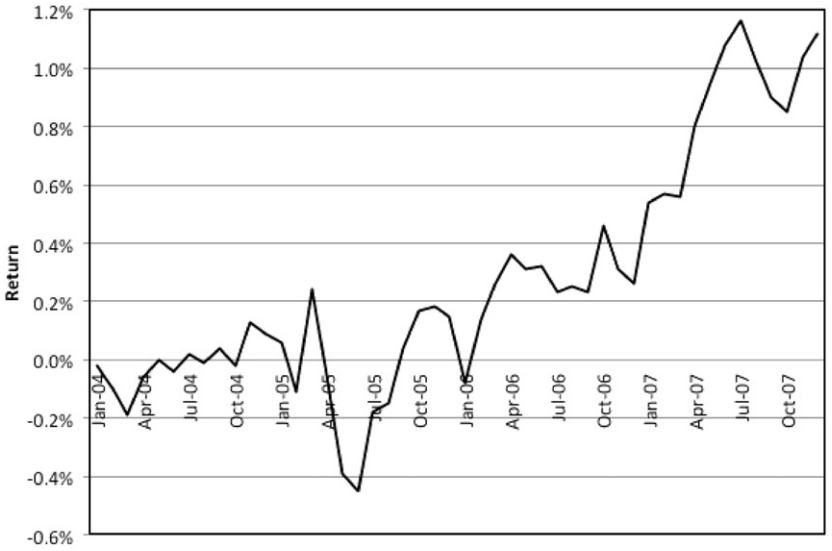

Fig. 3. Cumulative return of a long-short portfolio of low-rated corporate bonds with and without exposure. This figure plots the cumulative monthly return on a portfolio that is *short* on the below-investment-grade bonds whose mutual fund holders have high exposure to securitized bonds, and *long* on a set of issuer- and duration-matched bonds without the exposure, over the period 2004–2007. We define "high exposure" as those corporate bonds whose average mutual fund holder's exposure to securitized bonds is in the top 30% in either of the previous two quarters. We place these bonds in the short portfolio if and only if it has a matching bond without a high exposure satisfying the following criteria: (i) the matching bond is issued by the same issuer firm; and (ii) the time to maturity of the matching bond is between 50% and 150% of the time to maturity of the shorted bond. We place these matching bonds in the long portfolio. The long-short portfolio's monthly return is then the long portfolio's monthly return (rebalanced to be equal-weighted each month) minus the short portfolio's monthly return (similarly rebalanced). Returns on individual corporate bonds are constructed from the secondary market prices, as reported by TRACE. In each period, bond returns are also winsorized at 1%.

right-hand side panel, which is consistent with the worsening effect of investors' exposure on yields over time. The results are consistent with Hypothesis 3a. An increase in *HoldersExposure* from 0% to 50% is associated with a 70 bps higher increase in the yield spread in the first two quarters of the crisis. Recall that (Table 1) corporate bond yield spreads increased by approximately 100 bps, on average, in the first quarter of the crisis, and about 200 bps in the first two quarters of the crisis. This suggests that our findings are large but reasonable.

The third coefficient, the interaction term of *HoldersExposure* and *InvRating*, is also positive and significant. This implies that the lower the rating of the bond, the more its yield increased as a function of its holders' exposure to securitized bonds. The result is consistent with Hypothesis 3b and suggests that the sharp increase in yield spreads of lower-rated bonds at the start of the crisis, as depicted in Fig. 2, is at least partly due to the contagion of the shock from the (mostly AAA-rated) securitized bond market to the lower-rated corporate bond market via the portfolio decisions of mutual funds which owned both types of securities.

We separately control for the effect of a rating itself on the change in yield spreads by including *InvRating* in the model (second row). The positive and significant coefficient suggests that the lower the rating of the bond, the more the bond yield increased during this period independent of the investors' exposure to securitized bonds. This could be due to overall increased fear of risk or investor panic that is unrelated to the transmission mechanism we examine here. The interaction term between *HoldersExposure* and the bond's overall liquidity measures (Amihud ratio, *InvTrades*), on the other hand, is generally insignificant.

We also augment specification (4) by adding the fraction of securitized bonds held by the insurance companies and the corresponding interaction term with the ratings. Neither coefficient is significant (though they are positive). This is in line with our expectations, since insurance companies are not expected to be under pressure in the initial period of the crisis when bond ratings are still largely intact.

Overall, these results show that there is an incremental effect that comes from the transmission channel that we identify over and above the general unconditional increase in corporate bond yields during this period. The increase in bond yield spreads around the 2007 crisis is most pronounced among the low-rated bonds held by mutual funds with heavy exposure to securitized bonds.

In Panel B, we estimate an alternative model specification:

$$\Delta YS_{ij} = \alpha + \beta HighExposed_{ij} + \gamma InvRating_{ij} + \delta(HighExposed_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (5)$$

where $HighExposed_{ij}$ is an indicator equal to one if bond i's high-liquidity-needs mutual fund holder's exposure to securitized bonds is above the sample median. The idea is to isolate the effect on high-liquidity-need funds' exposure (to securitized bonds) on yield spread changes, rather than the average fund's exposure. We use turnover and flow volatility as before, and examine the model using both the change in yield spread between July and October 2007 (columns 1–2), as well as between July and December 2007 (columns 3–4). Positive coefficients on $HighExposed_{ij}$ itself as well as positive coefficients on its interaction term with $InvRating_{ij}$ indicate that presence of high exposure for these investors with

liquidity needs is associated with greater yield spread changes, and this is especially so for lower-rated bonds.[33]

In Fig. 3, we further provide a "portfolio" illustration of the firm-fixed effect model results presented in Table 5. We plot the cumulative monthly return on a portfolio that is short on corporate bonds whose mutual fund holders have "high exposure" to securitized bonds, and long on a set of issuer- and duration-matched bonds without the exposure. We place a "high exposure" bond in the short portfolio if and only if it has a matching bond without a high exposure satisfying the following criteria: (i) the matching bond is issued by the same issuer firm; and (ii) the time to maturity of the matching bond is between 50% and 150% of the time to maturity of the shorted bond. These matched bonds are then placed in the long portfolio. We then construct the return of a portfolio based on the difference between the long portfolio's monthly return minus the short portfolio's monthly return.

The cumulative return on the long-short portfolio hovers around zero from 2004 to 2006, but rises sharply in 2007. Given that the return on this portfolio is, by construction, independent of changes in firm-specific risk, we can interpret this sharp rise as a result of selling pressure on the exposed bonds by their investors.[34] While this plot is for illustrative purposes only, the issuer-fixed effect models presented in Tables 5–7 allow us to draw inferences about the statistical significance of this effect.

6.2. Effects on corporate bond trades

While the positive relation between investors' exposure to securitized bonds and yield increase is consistent with selling pressure being exerted on the bond by mutual funds in need of liquidation, we have so far not directly studied whether individual bond sales by mutual funds are a direct function of their exposure. Therefore, we now focus on whether mutual funds' relative trading impact increased after the onset of the crisis and whether this increase was related to the fraction of securitized bonds they held. We estimate

$$\Delta Tr_{ij} = \alpha + \beta HoldersExposure_{ij} + \gamma InvRating_{ij} + \delta(HoldersExposure_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij}, \quad (6)$$

where the dependent variable is defined as

$$\Delta Tr_{ij} = \frac{\text{Net sales by mutual funds}}{\text{Total trading volume from TRACE}}$$

for corporate bond i issued by firm j, over the periods July–October 2007 and July–December 2007. This variable measures the weight of the mutual funds' sales out of all the trades for bond i. We hypothesize that the selling pressure from mutual funds on a bond is higher the more the funds are exposed to securitized bonds *and* the lower the bond rating is. The other variables are defined as in the previous specification.

The results are reported in Table 6, Panel A. The interaction term coefficient is positive and significant in columns 5–8. Thus, the lower the rating of bond *i and* the higher the exposure of its investors to securitized bonds, the higher the mutual funds sales as a percentage of the total trading volume for the bond in the first six months of the crisis. One standard deviation increase in *HoldersExposure* is associated with a 26% higher increase in mutual funds' selling pressure for a junk bond (rated BBB- or below) than for an AAA-rated bond.

In Panel B, we estimate an alternative model specification based on the following:

$$\Delta Tr_{ij} = \alpha + \beta HighExposed_{ij} + \gamma InvRating_{ij} + \delta(HighExposed_{ij} \times InvRating_{ij}) + \varphi' x_{ij} + \mu_j + \varepsilon_{ij}. \quad (7)$$

This specification is analogous to Eq. (5) in Table 5, Panel B.

We find a positive relation between trading volume and both *HighExposed* itself as well as its interaction with *InvRating*. This indicates that the presence of high exposure for the investors with liquidity needs is associated with more selling pressure, and especially for lower-rated bonds.[35]

Finally, as a robustness check, we re-estimate specification (6) using as a dependent variable *LogVol*, defined as: $LogVol = \log(1 + Vol)$ where *Vol* is the bond's average daily trading volume, expressed in thousands of trades. This variable measures the overall trade in the market. *HoldersExposure* and *InvRating* are defined as above, μ_j is an issuer-fixed effect for issuer j, and x is a set of standard control variables, including the average weekly log-trading volume as of June 2007, as well as issuance year fixed effects.

The results are reported in Table 7. The first row coefficient, *HoldersExposure*, is positive and significant, implying that the higher the bondholders' exposure to securitized bonds, the higher the trading volumes of corporate bond *i*. The second row coefficient, *InvRating*, is negative and significant, implying that unconditionally lower-rated bonds are traded less and are thus more illiquid. More importantly, the third coefficient, the interaction between the first two, is positive and significant. This implies that, even though lower-rated bonds traded less in the initial months of the crisis in general, among those held by investors with exposure to securitized bonds, higher exposure and lower bond rating were directly related to more trades. This is consistent with Hypothesis 3b.

This provides the final link between securitized bond holdings, investor sales, and corporate bond yields. It shows that the corporate bonds that experience increases

[33] In unreported analysis, we also re-estimate the model using proxies for funds' liquidity needs measured as of December 2006 instead of July 2007 and find that the results are qualitatively unchanged.

[34] There may be concerns that the term spread differences between the exposed bond and the matched bond may drive some of these results. In the results reported here, the exposed bonds have, on average, slightly longer duration (about 8.75 years) than the matched bonds (8.13 years) by the same issuers. To address these concerns, we repeated the exercise with a restricted sample where the matched bonds had longer duration than the exposed bonds, and the results were qualitatively unchanged.

[35] As before, the results are robust to measuring proxies for funds' liquidity needs as of December 2006 (unreported).

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Table 8
Relation between mutual funds' and insurance companies' trades.

Panel A reports the estimates of a model:

$$MF\_Netbuy_{it} = \alpha + \beta_1 INS\_Netbuy_{it} \times (1 - Crisis_t)\beta_2 INS\_Netbuy_{it} \times Crisis_t + \gamma' x_{it-1} + \varepsilon_{it}, \quad (8)$$

where each observation is a corporate bond i in quarter t. The dependent variable *MF_Netbuy* is the net purchases of the bond by all mutual funds in column 1. In columns 2 and 3 they are the net purchases by high-liquidity-needs, exposed mutual funds (i.e., funds that have high liquidity needs with exposure to securitized bonds above the median). We use two proxies for high liquidity needs: High turnover (column 2) and High flow volatility (column 3). In columns 4 and 5 they are the net purchases by all funds except the high-liquidity-needs, exposed funds. *MF_Netbuy* is calculated as the net purchases of bond i by the funds divided by the total institutional holdings of the bond (holdings of mutual funds plus holdings of insurance companies) as of the previous quarter. *INS_Netbuy* is the net purchases of the bond by insurance companies, again divided by the total institutional holdings of the bond. *Crisis* is an indicator equal to one for dates between 2007Q3 and 2008Q1. x is a vector of standard bond characteristics (see Appendix A for variable definitions). The last row of the table reports the F-test statistic for H_0: $\beta_1 = \beta_2$. The sample is for the period 1998Q1–2008Q1.

Panel B reports the estimates of a model:

$$MF\_Netbuy_i = \alpha + \beta\, INS\_Netbuy_i + \gamma' x_i + \varepsilon_i,$$

where *MF_Netbuy* is the net purchases of bond i by funds that experience below-median flows over the last six months of 2007 (*LowFlow* funds) in column 1 and *HighFlow* funds in column 2. *INS_Netbuy* is defined as above, and x is a set of standard bond characteristics (see Appendix A for variable definitions), including offering year effects. The standard errors are italicized and appear below coefficients. In both panels, the symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Correlations of mutual fund and insurance company trades, before and after the onset of the crisis

	All funds	High turnover	High flow volatility	Non-high turnover	Non-high volatility
	(1)	(2)	(3)	(4)	(5)
INS_Netbuy × (1 − Crisis)	0.0892***	0.0010***	0.0016***	0.0862***	0.0835***
	11.18	*5.05*	*5.03*	*10.75*	*10.56*
INS_Netbuy × Crisis	0.2075***	0.0041***	0.0068***	0.1789***	0.1735***
	8.86	*5.03*	*5.29*	*7.69*	*7.81*
[Control variables suppressed]					
Bond and quarter fixed effects	Y	Y	Y	Y	Y
Standard error cluster	Bond	Bond	Bond	Bond	Bond
No. obs.	68,233	67,744	67,718	67,077	67,069
R^2	0.06	0.05	0.05	0.06	0.06
F-stat for H_0: $\beta_1 = \beta_2$	23.00***	15.51***	14.01***	14.69***	14.39***

Panel B: Trade correlations and flows after the onset of the crisis

	LowFlow funds	HighFlow funds
	(1)	(2)
INS_Netbuy	0.0008***	0.0017***
	2.76	*2.67*
[Control variables suppressed]		
Offering year fixed effect	Y	Y
Standard error	White	White
No. obs.	9,598	9,539
R^2	0.02	0.02
F-stat for H_0: $\beta_{LowFlow} = \beta_{HighFlow}$	5.75 (0.0165)	

in yields due to high exposure of their holders to securitized bonds are also the ones that display spikes in trading volumes and increases in representations of mutual fund trades among overall trades during the initial months of the crisis. Combined, these results suggest that funds significantly increased their price pressure on corporate bonds during the crisis and that this impact was positively related to their exposure to securitized bonds.

6.3. Are insurance companies strategic liquidity providers?

In the previous sections, we found that insurance companies traded relatively little and in fact, were small net purchasers of both corporate bonds and securitized bonds at the onset of the crisis. Magnitudes of their trades are small compared to those of mutual funds, which suggests they did not fully offset the mutual funds' liquidity demand. Moreover, unlike mutual fund holders whose exposure to securitized bonds affected increases in bond yield spreads, insurance companies' exposure to securitized bonds had no significant impact on the yields of the corporate bonds they held. Similarly, their exposure did not impact how much mutual fund holders contributed to the selling pressure on a given bond. At the same time, we find, in Table 7, that the effect of insurance companies' exposure on the overall trades of a bond was significantly positive in the period including the last quarter of 2007.

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Table 9
The structural break in institutional trades and the correlation of the yield spread to trades.

In columns 1-2, the table reports the estimates of a model:

$$Netbuy_{it} = \beta_1(1-Crisis_{it}) + \beta_2\, Crisis_{it} + \varepsilon_{it},$$

where *Netbuy* is either *INS_Netbuy* (column 1) or *MF_Netbuy* (column 2). *INS_Netbuy* is the aggregate net purchases of bond *i* by all insurance companies, divided by the prior-quarter total holdings of insurance companies plus mutual funds. *MF_Netbuy* is analogously defined. *Crisis* is an indicator variable equal to one for dates between 2007Q3 and 2008Q1. The last row reports the *F*-test statistic for H_0: $\beta_1=\beta_2$.

In column 3, the table reports the estimates of a model:

$$\Delta YS_{it} = \alpha + \beta_1\, INST\_Netbuy_{it}(1-Crisis_t) + \beta_2\, INST\_Netbuy_{it} \times Crisis_t + \gamma' x_{it} + \varepsilon_{it},$$

where *INST_Netbuy* is the sum of *INS_Netbuy and MF_Netbuy*, *Crisis* is as defined above, and *x* is a set of standard bond characteristics (see Appendix A for variable definitions), including bond and quarter fixed effects. The last row reports the *F*-test statistic for H_0: $\beta_1=\beta_2$.

In columns 4–5, the table reports the estimates of a model:

$$\Delta YS_{it} = \alpha + \beta_1\, INS\_Netbuy_{it}(1-Crisis_t) + \beta_2\, INS\_Netbuy_{it} \times Crisis_t + \beta_3\, MF_{it}(1-Crisis_t) + \beta_4\, MF_{it} \times Crisis_t + \gamma' x_{it} + \varepsilon_{it},$$

where *Crisis* and *INS_Netbuy* are defined as above, and *MF* is either *MF_Netbuy* (column 4), defined as above, or *LowFlow_Netbuy* (column 5), defined as the net purchases of bond *i* by mutual funds that experience below-median flows in the quarter, divided by the prior-quarter total holdings of insurance companies plus mutual funds. *x* is a set of standard bond characteristics (see Appendix A for variable definitions), including individual bond and quarter fixed effects. The last row reports the *F*-test statistic for H_0: $\beta_3=\beta_4$. The standard errors are italicized and appear below coefficients. The sample is for the period 1998Q1–2008Q1. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable	INS_Netbuy	MF_Netbuy	ΔYS	ΔYS	ΔYS
	(1)	(2)	(3)	(4)	(5)
1 − Crisis	−0.0302***	−0.0233***			
	−109.75	*−66.95*			
Crisis	−0.0266***	−0.0436***			
	−54.88	*−53.83*			
INST_Netbuy(1 − Crisis)			0.1099		
			0.80		
INST_Netbuy × Crisis			−2.3966***		
			−9.86		
INS_Netbuy(1 − Crisis)				−0.1709	−0.1258
				−1.39	*−1.01*
INS_Netbuy × Crisis				−0.6031*	−0.6001*
				−1.83	*−1.78*
MF_Netbuy(1 − Crisis)				0.6210***	
				3.51	
MF_Netbuy × Crisis				−3.4781***	
				−12.11	
LowFlow_Netbuy(1 − Crisis)					−0.3964
					−1.01
LowFlow_Netbuy × Crisis					−5.1208***
					−5.73
[Control variables suppressed]					
Bond and quarter fixed effects	N	N	Y	Y	Y
Standard error cluster	Bond	Bond	Bond	Bond	Bond
No. obs.	63,330	63,757	63,520	63,137	62,231
R^2	0.23	0.19	0.11	0.16	0.15
F-stat (*p*-value)	6.19 (0.01)	719.11 (0.00)	84.19 (0.00)	153.36 (0.00)	22.48 (0.00)

In this section we provide additional analysis on whether insurance companies acted as strategic liquidity providers to offset the sales of corporate bonds by mutual funds.[36] Our analysis consists of comparisons of insurance companies' behavior in pre-crisis and crisis periods—such as a correlation of their trades with mutual funds' and price impact of their trades and mutual funds' trades on bond yield spreads.

First, we examine the extent to which mutual funds' net trades of individual corporate bonds are (positively or negatively) correlated with insurance companies' net trades of the same bonds. The model we estimate and report in Table 8, Panel A is as follows:

$$MF\_Netbuy_{it} = \alpha + \beta_1\, INS\_Netbuy_{it}(1-Crisis_t) + \beta_2\, INS\_Netbuy_{it} \times Crisis_t + \gamma' x_{it-1} + \varepsilon_{it}, \quad (8)$$

where MF_Netbuy_{it} and INS_Netbuy_{it} are mutual funds' and insurance companies' net purchases of corporate bond *i* at *t*, respectively. Column 1 in Panel A reports the

[36] We acknowledge that our analysis is limited by the fact that we do not observe holdings by other classes of investors, such as hedge funds, banks, governments, and foreign investors. Clearly, it is important to understand who besides insurance companies acted as liquidity providers in various asset class markets during this time of the crisis. For example, He, Khang, and Krishnamurthy (2010) argue that banks were liquidity providers in the securitized bond market.

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results for all the mutual funds, while columns 2–3 and 4–5 report the results for funds with and without high liquidity needs, respectively.[37] Positive and significant coefficients for β_1 and β_2 imply that insurance companies' trades and mutual funds' trades are positively correlated both in the pre-crisis and crisis periods. The large *F*-stat values for H_0: $\beta_1=\beta_2$ show that the positive correlation between the trades became significantly stronger, not weaker, during the crisis months.

In Panel B, we compare for a cross-section sample of corporate bonds the correlation of mutual funds' trades with insurance companies' trades in the crisis periods for low-flow funds and high-flow funds, respectively. While they are both positively correlated, trades of low-flow funds are significantly less correlated with the insurance companies' trades, suggesting that their trades offset each other to a greater degree than trades of high-flow funds and those of insurance companies.

Next, we break down the institutional trades into mutual fund trades and insurance company trades to see if there was a structural break in the relation between the trades and the bond yields at the onset of the crisis. The results are reported in Table 9. This analysis provides several interesting findings. First, we show in column 2 that mutual funds are larger net sellers of corporate bonds in the crisis period than in the pre-crisis period. In contrast, insurance companies' net sales are significantly smaller as a percentage of their total holdings during the crisis period than in the pre-crisis period (column 1). This suggests that, at least to a degree, insurance companies' trades mitigate the overall fluctuations in trades caused by mutual funds. In column 3, we show that the relation between the institutional investors' (i.e., mutual funds and insurance companies combined) net trades and bond yield spread changes was positive in the pre-crisis periods, whereas it turns negative, i.e., net sales are associated with yield increases, in the crisis periods. In column 4, we break down the institutional investors' net trades into mutual funds' and insurance companies' trades, and show that this structural break in the relation between trades and yield changes is driven by mutual funds rather than insurance companies. Further, in column 5, we examine the net purchases by funds that experience more negative flows (below median). We find that their trades are significantly correlated with bond yield spread changes with a negative sign in the crisis periods, and that the coefficient is significantly larger than for mutual funds overall (p-value$=0.0131$).

Our interpretation of the results is as follows: Mutual funds were strategic liquidity providers for the corporate bonds they held during the pre-crisis period, buying when yield for the bond was going up (when price was low). As the crisis hit, mutual funds became liquidity demanders, effectively selling when the price was low; this is especially true for funds with negative flows. In contrast, insurance companies never acted strategically. We think that this is perhaps because their flows are steady and they do not have much room to act strategically. Also, their capital regulation might have curtailed their economic incentives to hold (especially) lower-rated corporate bonds.

Overall, these findings suggest that insurance companies did not act as strategic liquidity providers at the onset of the crisis and that at best, there is only weak evidence that their trades partially offset the net sales of corporate bonds by mutual funds.

7. Conclusion

Using a novel data set of institutional investors' corporate and securitized bond holdings, we study a transmission mechanism that explains the contagion of the crisis from the securitized bond market to the corporate bond market. Prior to the onset of the crisis, institutional investors were active participants in the securitized bond market, especially in the top-rating category—by 2007, they held nearly $2 trillion worth of securitized bonds, approximately 80% of which were AAA-rated. In the pre-crisis period, these securitized bonds were designed to be safe, liquid, and information-insensitive (in the sense of Dang, Gorton, and Holmström, 2010), relative to corporate bonds with higher idiosyncratic risk and, therefore, a need for more intensive credit research. Thus, funds with high liquidity needs – such as funds with high turnover and high flow volatility – rationally held large amounts of securitized bonds prior to the crisis.

When the negative shock from delinquent subprime mortgages caused the entire securitized bond asset class to turn "toxic" and illiquid in August 2007, many institutional investors had to liquidate portions of their portfolios because they faced liquidity needs. Mutual funds did not rush to sell the now illiquid securitized bonds en masse, but, instead, sharply reduced their holdings of corporate bonds. The insurance companies, in contrast, sold neither class of assets (except those with a below-threshold level of risk-based capital, which reduced holdings of securitized bonds). In addition, funds with negative contemporaneous flows, high turnover, or high flow volatility liquidated greater portions of their corporate bond holdings than other funds, behavior suggesting that their portfolio decisions were dominated by liquidity needs. Interestingly, the average mutual fund tended to sell more junk bonds than investment-grade bonds.

We further show that yield spreads and bond sales increased more for corporate bonds held immediately before the crisis by mutual funds with heavy exposure to securitized bonds, compared to *same-issuer* bonds that were held by unexposed mutual funds. This within-issuer variation in yield spread changes gives us direct evidence that the transmission mechanism that we identify indeed contributed to the sharp increase in credit spreads that corporate bonds and especially junk bonds experienced in the first months of the crisis. Together, our findings show that mutual funds with high liquidity needs that were left with exposure to the now illiquid securitized bonds played a significant role in spreading the crisis from the securitized bond market to the seemingly unrelated corporate bond market.

[37] As before, the results are robust to measuring proxies for funds' liquidity needs as of December 2006 (unreported).

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Appendix A

A.1. Mutual fund characteristics

H: The percentage of corporate bonds (respectively, securitized bonds) in the mutual fund's portfolio, in excess of the average percentage holdings of corporate bonds (respectively, securitized bonds) among the funds in the same sector as the fund. We define sectors based on the maturity and rating of the securities held in the funds' portfolios by crossing three maturity terciles and three rating terciles, obtaining nine sectors.

ΔB, ΔC: ΔB is the net change in holdings of corporate bonds as fraction of the portfolio between June 2007 and December 2007, in excess of the fund sector average. ΔC is defined analogously for investment-grade and sub-investment-grade corporate bonds, respectively.

Flow volatility: Standard deviation of the mutual fund's monthly flows, computed over a rolling window of 12 months.

Turnover ratio: Turnover ratio of the mutual fund's portfolio, defined as the minimum *Turnover ratio*: Turnoff aggregated sales or aggregated purchases of securities, divided by the average 12-month total net assets (TNA) of the fund.

Log(Family size): Natural logarithm of the total net assets under management of the fund's mutual fund family, expressed in hundred millions of dollars.

Affiliated with commercial bank: Indicator variable equal to one if the mutual fund belongs to a fund family that is affiliated with a commercial bank (following Massa and Rehman, 2008).

Past flow: Investment flow into the mutual fund over the previous year (moving average).

Fund return: Quarterly return of the mutual fund.

Family equity holdings: Equity holdings by the fund's fund family as a fraction of total holdings.

Mgmt fee: Management fees of the mutual fund, as a fraction of its average net assets, obtained from the CRSP Survivor-Bias-Free Mutual Fund Database.

Expense ratio: Fund's expense ratio in the most recent fiscal year, defined as the total investment that the shareholders pay for the fund's operating expenses (including 12b1 fees).

Actual 12b1: Ratio of total assets of the fund attributed to marketing and distribution costs, as reported in the Annual Report Statement of Operations.

Average maturity of the holdings: Natural logarithm of the average maturity of the fixed-income holdings of the mutual fund, expressed in quarters.

No equity (N/Y): Indicator variable equal to one if the fund does not hold any equity, zero otherwise.

Fund's equity holdings return: Quarterly return on the equity holdings of the mutual fund.

A.2. Bond characteristics

LogSale(July–December 2007): Natural logarithm of the net sales (in $K) of the bond by institutional investors over the period from July to December 2007.

ΔYS(July–October 2007/July–December 2007): Change in the bond's yield spread (defined as the spread between the bond's yield and the yield of a government bond of comparable maturity) over the periods July to October 2007 or July to December 2007.

ΔTr(July–October 2007/July–December 2007): Net sales of the bond by mutual funds as a fraction of the bond's total trading volume, over the specified periods (July–October 2007/July-Dec 2007).

LogVol(July–October 2007/July–December 2007): The natural logarithm of the bond's average daily trading volume (expressed in number of trades), over the periods July–October 2007 or July–December 2007.

Holders' exposure: A weighted-average exposure measure of all mutual fund investors who held a given corporate bond before the crisis, as defined in the text.

Insurance holders' exposure: A weighted-average exposure measure of all insurance company investors who held a given corporate bond before the crisis, analogously defined to *Holders' exposure*.

No rating(Y/N): Indicator variable equal to one if the bond does not have a rating, zero otherwise.

InvRating: An inverse measure of the quality of the bond's rating, as defined in the text.

Bond face value: Natural logarithm of the total amount outstanding of the bond at the issuance date, expressed in thousands of dollars.

Bond face value (orthogonalized): Bond face value orthogonalized with respect to the rating by regressing *Bond face value* on *InvRating* and *No rating (Y/N). Bond face value [orthogonalized]* is equal to the residuals from this regression.

Covenants (Y/N): Indicator variable equal to one if there are covenants attached to the bond, and zero otherwise. Data on covenants are obtained from the Mergent Fixed Income Database.

CovIndex: Billet, King, and Mauer (2007) index of covenant protection ranging from zero (no covenant protection) to one (complete covenant protection).

Log(Months to maturity): Natural logarithm of the bond's time to maturity, expressed in months.

Amihud: Amihud's (2002) illiquidity proxy, as defined in the text.

InvTrades: The natural logarithm of the inverse of the number of trades on the bond, as retrieved from FINRA's TRACE Corporate Bond Data.

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