# Over-the-Counter Market Liquidity and Securities Lending*

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**Abstract**

This paper studies how over-the-counter market liquidity is affected by securities lending. We combine micro-data on corporate bond market trades with securities lending transactions, in which U.S. life insurance companies are major counterparties. Applying a difference-in-difference empirical strategy, we show that the shutdown of AIG's securities lending programs in 2008 caused a statistically and economically significant reduction in the market liquidity of corporate bonds held by AIG. We also show that an important mechanism behind the decrease in liquidity was a shift towards relatively small trades among a greater number of dealers in the interdealer market.

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# Introduction

The financial crisis of 2007-2008 kindled a wider interest in studies of liquidity in over-the-counter (OTC) markets, in which participants trade without centralized exchanges.[1] In the absence of such exchanges, buyers and sellers in OTC markets must devote time and resources to trade, which impedes their ability to transact efficiently, i.e. market liquidity (Duffie, Gârleanu & Pedersen 2005, Lagos, Rocheteau & Weill 2011). Intermediaries, such as broker-dealers, may emerge to match buyers and sellers and to maintain an inventory of securities (Hugonnier, Lester & Weill 2014, Chang & Zhang 2015, Neklyudov & Sambalaibat 2015, Wang 2016). Nevertheless, costs associated with intermediation, such as inventory holding costs or time to search for and bargain with counterparties, mean that frictions remain an important feature of OTC markets.

Securities lending markets offer intermediaries a way to mitigate the consequences of frictions inherent to OTC markets. As illustrated in Figure 1, an intermediary that receives a buy order from a client will try to find another client with a matching sell order. While searching, the intermediary can fill the buy order using its own inventory, by locating the security in the interdealer market, or by borrowing the security from a securities lender. In exchange for paying a fee and posting collateral, intermediaries borrow securities from other financial institutions with large portfolios of securities, such as insurance companies. When the costs of interdealer trading and inventory are relatively high, securities lending can improve market liquidity by reducing the costs of intermediation.[2] However, identifying and quantifying the importance of securities lending to OTC market liquidity is far from trivial due to the many confounding determinants of market liquidity.[3]

In this paper, our objective is to measure the causal effect of securities lending on

[1] For an overview of OTC markets and some research and policy issues, see Duffie (2012).

[2] In addition to reducing the costs of intermediation directly, the ability to lend securities can improve OTC market liquidity indirectly, for example by helping to avoid delivery fails and by facilitating other market participants' short positions and certain arbitrage strategies. To be sure, the lending market itself may not be frictionless and impediments to the ability to borrow securities will impinge on market liquidity. Such frictions may arise from high lending fees for borrowing certain securities (Duffie 1996, Krishnamurthy 2002, D'Avolio 2002) or from search and bargaining in the securities lending market (Duffie, Gârleanu & Pedersen 2002).

[3] A few papers seek to connect securities lending and market liquidity in non-OTC markets, including Saffi & Sigurdsson (2011), and Kolasinski, Reed & Ringgenberg (2013). Existing empirical studies of corporate bond securities lending describe market details, with a particular focus on borrowing costs, but do not connect bond securities lending transactions with corporate bond market liquidity (Nashikkar & Pedersen 2007, Asquith, Au, Covert & Pathak 2013).

OTC market liquidity. We exploit a shock to corporate bond securities lending during the 2007-2008 financial crisis to identify this causal effect. Figure 2 illustrates the size of the shock that occurred during the financial crisis. The figure shows that, in the period before the financial crisis, around $100 billion of corporate bonds were lent against cash collateral on any given day. The corporate bond securities lending market collapsed by about half towards the end of 2008, largely due to insurance companies, which at that time accounted for more than three-quarters of all loans.[4] While AIG was not solely responsible for the market-wide collapse in late 2008, the narrative of that firm is the canonical example for the shock (Peirce (2014) and McDonald & Paulson (2015)). Amid concerns about the quality of cash collateral reinvestment that were unrelated to liquidity in the market for corporate bonds, securities borrowers demanded the return of their cash and precipitated the collapse in securities lending.

To analyze the interaction between corporate bond market liquidity and securities lending, we construct a new dataset by combining micro-level data on corporate bond transactions with individual corporate bond loans. We obtain a comprehensive overview by matching the over-the-counter Trade Reporting and Compliance Engine (TRACE) records of corporate bond transactions with bond-level securities lending transactions from Markit Securities Finance, which provides the most extensive coverage of the securities lending market. Lastly, we add information on the bond-level holdings and securities lending activity of U.S. insurance companies from their annual statutory filings. Our basic empirical strategy is to study the post-crisis development in the market liquidity of corporate bonds that were held by insurance companies with securities lending programs.

The main empirical challenge is the potentially confounding determinants of market liquidity that also vary as a function of insurers' corporate bond holdings. One specific example of such determinants is set out by Brunnermeier & Pedersen (2009), who describe the interaction between market liquidity and funding liquidity. In our setting, the relationship they describe suggests that funding liquidity shocks could reduce dealers' ability to use cash collateral to borrow a corporate bond held predominantly by insurers, thereby decreasing that corporate bond's market liquidity.

[4] Pursuing a buy and hold strategy, insurance companies are the largest institutional investors in corporate bonds and are natural bond lenders. The income earned from lending securities is one way for institutional investors such as insurance companies to enhance the return on their asset holdings. `http://www.naic.org/capital_markets_archive/140911.htm`

We exploit our institutional setting to address this identification challenge. In particular, we distinguish between AIG and other U.S. life insurers that had securities lending programs. AIG experienced a complete shutdown of the securities lending programs operated by its life subsidiaries, falling from a peak of over $80 billion to nothing in less than one year.[5] By contrast, while other life insurers' securities lending programs shrank somewhat during the crisis, they continued to be active. For example, MetLife remained a significant corporate bond securities lender and has since become the largest lender of corporate bonds.

Our empirical analysis exploits the shutdown of AIG's securities lending programs to implement a difference-in-difference strategy. The dependent variable is an individual bond's market liquidity, measured as the bond's monthly average realized bid-ask spread.[6] The first difference in our strategy is between those bonds in which AIG held a high fraction of the amount outstanding in 2006 and those bonds in which AIG held a low fraction. The second difference is between the period before and the period after the shutdown in AIG's lending programs at the end of 2008. These differences together identify the effect of an exogenous reduction in corporate bond securities lending on market liquidity.[7]

Our identification strategy relies on three key assumptions. First, we assume that AIG did not reinvest their cash collateral mostly in corporate bonds. Second, we assume that the shutdown of AIG's securities lending programs was not due to concerns about corporate bond market liquidity. And, third, we assume that those corporate bonds held and lent by AIG and those bonds held and lent by other insurance companies differ only along observable dimensions, for which we include control variables. Figures 3 and 4 offer some reassurance that the total holdings and lending portfolios of AIG and other insurance companies with securities lending programs are not wildly different, especially with respect to the key outcome variable, market liquidity. Using information from a variety of sources, we provide further support for the validity of all three assumptions.

Our results suggest that securities lending markets have a significant statistical and

[5] Existing studies of corporate bond securities lenders examine transaction level data for lending programs smaller than $15 billion (Nashikkar & Pedersen (2007) and Asquith et al. (2013)).

[6] This well-established measure of market liquidity is the gap between the price that a customer pays to a dealer to purchase a bond and the price a dealer pays to a customer for buying a bond.

[7] Our identification strategy shares features with other studies that exploit differential effects of shocks originating in the crisis. Examples include the Lehman bankruptcy (Aragon & Strahan 2012, Kovner 2012, Chodorow-Reich 2014) and fiscal stimulus programs (Mian & Sufi 2012).

economic effect on corporate bond market liquidity. We find that the shutdown of AIG's securities lending program lowered the market liquidity of those bonds that were held by AIG. Specifically, a one standard deviation increase in the share of a bond that was held by AIG is associated with a reduction in that bond's liquidity of about 4 basis points in the post-crisis period. This point estimate can be compared with typical corporate bond trading costs, which are in the order of 10 basis points for smaller traders, to gauge the economic importance of securities lending to OTC market liquidity.

We further exploit our empirical setting and identification strategy to study how intermediaries responded to the shutdown of AIG's securities lending program. As suggested by Figure 1, in the absence of an available securities lender, intermediaries resort to other markets to meet their clients' orders. Applying our difference-in-difference identification strategy to analyze the post-crisis development of interdealer trading in those bonds in which AIG held a greater share, we find that there was a surge in the number of small trades among a greater number of dealers in the aftermath of the collapse. In addition, intermediation chains became longer for those bonds. All told, the variation in AIG's bond holdings in 2006 accounts for about 2 percent of the variation in interdealer trading in these bonds in the years following the collapse of AIG.

Our paper contributes to several broad research topics in the literature. We provide the first evidence that OTC market liquidity is vulnerable to run risks arising in the securities lending market, particularly in corporate bond securities lending by non-bank financial institutions. The financial crisis of 2007-2008 initiated a surge of interest in the activity of so-called shadow banks and the risks those activities may pose to the broader financial system.[8] While many studies have sought to understand the determinants of market liquidity, few have explored the important contribution of the shadow banking system.[9] Our finding helps to understand the determinants of corporate bond market liquidity and, especially, the connection between market liquidity and the shadow banking system.

In addition, our paper contributes to a growing literature on corporate bond market liquidity during and after the financial crisis. Dick-Nielsen, Feldhütter & Lando (2012)

[8] See Gorton & Metrick (2012) for a survey of the literature.

[9] The effects of corporate bond illiquidity on the level and volatility of investor returns have a wide range of potential real and financial consequences, including consequences for corporate structure (Hoshi, Kashyap & Scharfstein 1991), for portfolio management (Amihud & Mendelson 1988, 2006), and for financial stability (Adrian & Shin 2010).

find evidence of short-run illiquidity, potentially as a consequence of (i) distress at lead underwriters—e.g., Bear-Sterns and Lehman Brothers—, (ii) investor flight towards more highly rated securities, and (iii) information assymetry. Other studies examine long-term corporate bond market liquidity in the aftermath of the financial crisis. As surveyed by Adrian, Fleming, Shachar & Vogt (2017), the literature has found little to no evidence of a long-lasting decline in corporate bond market liquidity.[10] We offer a view that long-term corporate bond market liquidity did decline for those bonds that were both held in large amounts by insurance companies and were made available to market participants through securities lending programs that were shut down.

The remainder of the paper proceeds as follows. In Section 1 we provide an overview of the market for corporate bond securities lending and the experience of insurance companies during the financial crisis. Section 2 describes our data and summary statistics. Sections 3 presents our empirical strategy and main results. Sections 5 investigates the mechanisms driving our results. We conclude in Section 6.

# 1 Institutional background

In this section, we first outline the role of securities lending in OTC corporate bond markets. Then we describe a typical corporate bond securities lending transaction, including the specific part played by insurance companies. Furthermore, we provide an overview of the experience of AIG, which in the pre-crisis period operated the largest corporate bond securities lending program ever maintained by an insurance company.

## 1.1 OTC corporate bond markets and securities lending

The OTC corporate bond market is yuge. In 2015, U.S. corporations issued almost $1,500 billion of debt, compared with only $256 billion in equity.[11] After their initial offering in the primary market, most of this debt is tradable in an OTC secondary market. In 2015, over 25,000 unique corporate bonds were publicly traded, with most of the trading taking place in investment grade bonds (61 percent). Between 2006 and 2016, there were

[10] Exceptions include Bao, O'Hara & Zhou (n.d.) and Choi & Huh (2017), who find some evidence that regulations, in particular the Volcker Rule, may have reduced market liquidity for some corporate bonds.

[11] `www.sifma.org`. The value of new corporate debt excludes the issuance of convertible debt, asset-backed securities, and non-agency mortgage-backed securities.

44,082 daily transactions on average that amounted to almost $30 billion in daily volume traded. About two-thirds of these transactions were between a client and a dealer, and the other third of these transactions were between dealers.[12]

To buy and sell securities in the OTC corporate bond market, participants must search for counterparties (Duffie et al. 2005). The associated costs of search can be reduced by some participants acting as intermediaries—such as broker-dealers—that match buyers with sellers.[13] Intermediaries typically facilitate efficient market functioning either by swiftly finding a matching counterparty for a customer elsewhere in the market, or by trading itself with the customer and maintaining its own inventory of securities. Although intermediaries can help to reduce search costs, they cannot fully eliminate such costs because their inventories are naturally limited by the supply of individual bonds and the associated inventory maintenance costs.

The limitations on intermediaries' ability to make markets create an opportunity for institutional investors, as natural large repositories of securities, to smooth the matching process by lending their securities. Among institutional investors in corporate bonds, insurance companies have the largest holdings, giving them a dominant position as potential bond lenders.[14] When a customer wants to buy a bond that an intermediary does not hold in its inventory, the intermediary may borrow the bond elsewhere and deliver it to the buyer. The intermediary can then wait until it can find another customer willing to sell the same bond, which the intermediary can return to the lender.

In addition to aiding intermediaries in their inventory management, corporate bond securities lending can improve OTC market liquidity by facilitating short positions and certain arbitrage strategies and by avoiding delivery fails.[15] For example, in a capital structure arbitrage trade, a firm's bond is shorted to hedge a long position in the firm equity. Another example is a convertible bond arbitrage trade, in which firm's equity is sold short to hedge a long position in a bond issued by that firm. In this second example, the dealer might also borrow the convertible bond.

[12] `www.finra.org`. All these statistics exclude convertible debt transactions.

[13] A recent literature has studied the reasons for certain institutions to act as intermediaries (Hugonnier et al. 2014, Chang & Zhang 2015, Neklyudov & Sambalaibat 2015) and the equilibrium number of broker-dealers as an outcome of the cost of inventory and the liquidity of the market (Wang 2016)

[14] Flow of Funds Accounts of the United States, Table L213, `https://www.federalreserve.gov/releases/z1/current/accessible/l213.htm`.

[15] For more details, see Duffie (1996), Faulkner (2006), Nashikkar & Pedersen (2007), Faulkner (2008), Musto, Nini & Schwarz (2011), Keane (2013) and Asquith et al. (2013).

## 1.2 Corporate bond securities lending transactions

In a prototypical corporate bond loan, as depicted in Figure 5, full legal and economic ownership of the bond is transfered from the lender (e.g. insurance company) to the borrower. The ownership is essential for borrowers (e.g. dealers) to be able to deliver the bond to other counterparties (customers). To allow the borrower flexibility in the time needed to find another seller of the same bond, the term of the loan is usually open-ended, but either party is able to terminate the deal at any time by returning the security/collateral.[16]

In exchange, the bond borrower gives the bond lender collateral in the form of cash, which the lender may reinvest according to its own strategy and regulatory limitations.[17] Typically, the loan is marked to market daily and is "*overcollateralized*," with borrowers providing, for example, $102 in cash for every $100 in notional value of a security. The percentage of overcollateralization is called the "*margin*," which serves to insure the securities lender against the cost of replacing the lent security if the borrower defaults. Lastly, the bond lender pays a percentage of the reinvestment income to the bond borrower, called the "*rebate rate*." This equilibrium price is negotiated at the outset of the deal and reflects the scarcity of the bond on loan: A hard-to-find "*special*" bond may command a low or negative rebate.

In addition to the ultimate owner and the borrower, a corporate bond securities lending transaction may involve one or two other parties. First, owners of large portfolios like AIG and MetLife often conduct their own lending programs with an affiliated agent lender, while smaller owners typically execute their programs through third party agent lenders, such as custodian banks or asset managers, that act as large warehouses for securities made available for lending.[18] Second, the end users of the borrowed securities may be small and weakly regulated. In such cases, they will often borrow through intermediaries who help to assuage lenders' concerns about counterparty risk. Since these smaller end-users interact repeatedly with the same dealers, corporate bond securities

[16] Even in the unusual cases of term lending, parties often have the ability to break the contract early by paying a nominal penalty. More than 90 percent of the corporate bond loans in our data sample are open-ended.

[17] In principle, the contract may allow a borrower to post non-cash collateral against the bond, but this is uncommon in the U.S. In our data on corporate bond loans, more than 90 percent of transactions are against cash collateral.

[18] Agent lenders that warehouse bonds from many ultimate owners typically use an algorithm to determine which owner will be matched with borrowing requests.

lending may sometimes involve more than one dealer intermediating between the bond lender and the bond borrower.

As discussed in Foley-Fisher, Narajabad & Verani (2016), some insurers aim to supply their securities so as to create and maintain a pool of cash collateral that they use to finance a portfolio of longer-duration, higher-yielding assets. The greater return associated with reinvesting the cash collateral in less liquid and/or longer-term assets is not without cost. In particular, insurers that pursue this strategy create and bear run risk associated with liquidity and maturity transformation. The reinvestment of cash collateral in U.S. mortgage-related securities was one of the root causes for the collapse of AIG in 2008.

## 1.3 AIG's securities lending program during the 2008-09 financial crisis

Although it has been told in greater detail elsewhere, an overview of AIG is helpful to understand the shock to corporate bond securities lending that we will exploit in our empirical exercise.[19] Beginning in the 1980s and through the run-up to the 2007-09 financial crisis, AIG increased profits by diversifying its operations into non-traditional insurance activities that, for the large part, occurred beyond regulatory oversight. Many of these activities created direct and indirect exposures to the U.S. housing market. In addition to exposure through its credit default swap (CDS) portfolio and mortgage insurance business, AIG lent vast quantities of bonds from the general accounts of its life insurance subsidiaries in exchange for cash collateral. The insurer reinvested a large fraction of the incoming cash collateral in non-agency residential mortgage backed securities (RMBS) and other illiquid medium-term securities. At its pre-crisis peak in 2007, AIG's consolidated securities lending business amounted to [[$82 billion]]. When the U.S. housing market collapsed, AIG's massive exposures to the housing-related securities and credit derivatives caused a severe liquidity crisis.

From early 2008, AIG's mortgage insurance business began to experience losses due to poorly performing loans. At about the same time, concerns about the credit quality of securities referenced by CDS that AIG had sold led to a combination of losses and collateral calls that began to drain the company's cash and cash-like assets. As

[19] For more details about AIG, see Peirce (2014) and McDonald & Paulson (2015).

AIG's financial condition deteriorated, securities borrowers reduced the amount of cash collateral they were willing to provide to roll over the securities AIG had lent. Throughout the summer of 2008, many securities borrowers returned the securities and demanded their cash collateral. By September 2008, AIG had exhausted all of the cash and cash-like assets in its securities lending pool and began to make calls on their life insurance companies to avoid selling their reinvestment holdings of RMBS at fire sale prices. The combination of actual losses and lack of cash-like assets undermined the market's confidence in AIG and led to rating downgrades, which prevented the parent company from rolling over the repurchase agreements and commercial paper that many AIG subsidiaries relied on for funding. After several attempts to structure a private-sector rescue for AIG failed, the Federal Reserve Board of Governors, the Federal Reserve Bank of New York, and the U.S. Treasury conducted a number of interventions beginning in September 2008, which ultimately stabilized AIG (GAO 2011). From about 80 billion at the beginning of 2008, AIG securities lending program was almost completely shut down by the beginning of 2009.

# 2 Data

We use several data sources to construct the dataset we use in our analysis. This section lays out how we combine data on corporate bond liquidity, securities lending data, insurers' holdings of corporate bonds, and their lending activity.

We follow the established literature in calculating corporate bond liquidity using data on secondary market over-the-counter trading of corporate bonds from the Trade Reporting and Compliance Engine (TRACE), created by the Financial Regulatory Authority (FINRA). Under regulations introduced in 2002 by FINRA, dealers are required to file detailed reports of their transactions, including trade time, quantity, price, and counterparty.[20] We follow standard procedures for cleaning these data, including deleting all small noise-generating trades below $10,000 and removing duplicate transactions.[21] For our measure of liquidity, we first calculate for each bond on each day the volume-

[20] Our sample, by necessity, begins in 2005 because, although FINRA began collecting data in 2002, the coverage was limited until 2005.

[21] See, for example, Dick-Nielsen (2009) and Bao et al. (n.d.). We use confidential regulatory data with dealer identifiers, which allows us to match trades by buyer, seller, amount, and trade time when removing duplicates.

weighted average buy and sell prices across customer-dealer trades. We then compute bond market liquidity as the *average realized spread*, which is the difference between the average daily price at which a dealer sells a bond to a customer and the average daily price at which a dealer buys the same bond from a customer. With our daily measure of bond liquidity, we compute the average (mean) over days to obtain a monthly unbalanced panel of bond-specific liquidity.

For our analysis of interdealer trading, all data is aggregated from transaction-level data to monthly data. The regulatory version of TRACE allows us to identify dealers and observe the trading behavior of a single dealer in a single bond during a given month. This allows us to calculate the total trading volume of a given dealer in a given bond as well as the number of trades between dealers in a given bond.

We merge the TRACE data with Mergent's Fixed Income Securities Database (FISD) by CUSIP identifier to obtain bond characteristics, including offering amount, offering yield, amount outstanding, credit rating, and a range of indicators on the type of each bond. We exclude from our sample all bonds that are convertible, putable, privately placed, asset-backed, or sold as part of a unit deal. We account for reissuance and early retirement when computing the amount outstanding over time and we define rating changes using the date by the first acting rating agency (Ellul, Jotikasthira & Lundblad 2011). Our final dataset consists of 279,404 bond-month observations covering 17,994 unique bonds between 2006 and 2010. The median initial maturity of the corporate bonds in our sample is 9 years, with an median residual maturity across the entire sample of 5 years.

The major data contribution of our study is to combine the information on corporate bond liquidity with data on corporate bond lending. We match the corporate bond liquidity data from TRACE with loan-level transactions recorded in the Markit Securities Finance (MSF) dataset by CUSIP identifier. These data include both equity and fixed income loans and cover about 85 percent of the global market and more than 90 percent of the U.S. securities lending market. Securities lenders report information about each loan they have outstanding on a given day, including the identity of the security on loan, the value of the loan, duration, lending fee, rebate rate, and the type of collateral posted. In addition, securities lenders report on each day the total value of every security that they have available to lend. We first aggregate these transaction-level data to a daily

frequency by calculating over the daily stock of loans outstanding on each security, the total value on loan, as well as the median value, fee, and rebate rate. Then, using these daily measures across the stock of loans outstanding, we compute monthly median values for each security. After merging the two datasets, we find that MSF reports data on the amount of a corporate bond available for lending for more than 90 percent of all bond-month observations in TRACE. Information on actual loan transactions are available for almost 80 percent of all bond-month observations. We assume that the available and lending amounts are zero for the minority of TRACE bond-month observations that do not match to MSF.

Lastly, we combine our TRACE-MSF merged data with specific information about insurance company security holdings and lending activity from the NAIC Annual Statutory Filings.[22] Within these filings, Schedule D reports all insurers' individual fixed income holdings at year-end, together with cross-sectional information about each security, including the CUSIP identifier, first date of purchase, and whether the bond was on loan as part of the insurer's securities lending program.[23] We calculate aggregate holdings by all life, property and casualty, and health insurers including bonds that are held in their separate accounts, as well as aggregate holdings by all insurance companies that have active corporate bond lending programs. We identify securities lender as those insurance companies that have at least one bond on loan at year-end during the sample period. Unsurprisingly, since insurance companies are one of the largest institutional holders of corporate bonds, we find that about 88 percent of bond-month observations have non-zero holdings by insurance companies, and about 86 percent have non-zero holdings by insurance companies that have active securities lending programs.

We present summary statistics for our final dataset in Table 1. Our main dependent variable on corporate bond market liquidity exhibits substantial variation, both between corporate bonds and within each corporate bond over time (this variation is not shown in the Table). The variables derived from MSF indicate that, on average across the corporate bonds in our sample, securities lenders make roughly one quarter of the amount

[22] Historical NAIC Annual Statutory Filings are contained in the NAIC Financial Data Repository, a centralized warehouse of financial data used primarily by state and federal regulators.

[23] Unfortunately, we do not observe more detailed information on the insurers' securities lending programs at this time. Beginning in 2011, after state regulators adopted regulatory guidelines established by the NAIC, insurance companies started to report information about their lending programs (Foley-Fisher, Narajabad & Verani 2016).

outstanding available to lend. Nevertheless, only about two percent of the amount outstanding is actually on loan at any given time. The median rebate rate is about 1 percent, while the median lending fee is about 0.1 percent. Finally, data on insurance company holdings at year-end reveal that they hold, on average, about 16 percent of the amount outstanding with a distribution that is positively skewed. Insurance companies with active bond lending programs account for the lion's share of the holdings, which is simply a reflection of the tendency of larger insurance companies to lend their bond holdings.

# 3 Identification

Insurance companies are the largest institutional investors in corporate bonds as part of their asset-liability management, and thus naturally occupy a dominant position as large corporate bond lenders. Moreover, insurers select bonds with certain maturities, ratings, and issuers according to their asset-liability management strategy, creating heterogeneity across their bond portfolios. And since many insurance companies make their corporate bond portfolios available to securities borrowers, this heterogeneity has implications for the securities lending market.

Because corporate bond lending reflects both supply and demand factors, estimating the effect of securities lending on bond liquidity requires a shock to bond lending supply that is independent of conditions in the secondary bond market. The main threats to identification are potentially unobserved bond demand factors that are correlated with the amount of a particular bond held by insurers.

One such potentially confounding factor is suggested by Brunnermeier & Pedersen (2009), who describe the relationship between funding liquidity and market liquidity. This relationship might mean that the effect of shocks to funding liquidity on market liquidity may be correlated with insurers' bond holdings. For example, a negative shock to funding liquidity will make it more difficult for intermediaries to borrow any bond. But the harder it is for an intermediary to match buyers and sellers of a particular bond, the stronger will be effect of the greater difficulty to borrow that bond on its market liquidity. By holding and not trading a bond, an insurer reduces the ability of intermediaries to match buyers and sellers of that bond. Thus, the relationship between

insurance companies' bond holdings and market liquidity may be confounded by the relationship between funding liquidity and market liquidity.

Ideally, we would address this identification challenge by comparing the market liquidity of two identical bonds that are held and lent by different insurance companies in the aftermath of an exogenous closure of one insurer's lending program. In what follows, we explain how we can approximate this ideal test by contrasting the experience of bonds predominantly held by AIG with observationally identical bonds predominantly held by other insurance companies.

As discussed in Section 1.3, AIG was the largest lender of corporate bonds prior to the crisis. In 2008, securities borrowers developed concerns about the quality of cash collateral reinvestment portfolios of AIG, which contained a large fraction of higher yielding, illiquid securities related to the U.S. housing market. Following a run by securities borrowers and the massive intervention by the federal government, AIG was forced to shut down its securities lending program by the end of 2008. We tease out the effect of corporate bond lending on corporate bond market liquidity by exploiting the collapse of AIG as the source of exogenous reduction in insurers' bond lending around 2008. What is crucial to our identification is that although AIG was forced to shut down its securities lending program, other insurers holding observationally identical bonds continued to lend them to dealers.

## 3.1 Graphical illustration

We can graphically illustrate our identification strategy with an example. MetLife, the second largest insurance company lending corporate bonds in the pre-crisis period, remained relatively active bond lenders after the collapse of AIG. For example, MetLife securities lending program of around $45 billion at its peak in 2007, and, like AIG, MetLife experienced enormous unrealized losses on its asset portfolio in 2008.[24] As the crisis unfolded, MetLife experienced large withdrawals by investors—including by securities borrowers requesting the return of their cash collateral. MetLife was creative

[24]See GAO report 13-583, "Impacts of and Regulatory Response to the 2007-2009 Financial Crisis." MetLife's losses were second only to those of AIG. The unrealized losses stemmed in part from significant exposures to the U.S. housing market. Both insurance companies funded a material fraction of their assets using short-term non-traditional non-insurance liabilities. This included securities lending cash collateral and other debt-like instruments such as Funding Agreement-Backed Securities with embedded put options (Foley-Fisher, Meisenzahl, Narajabad, Perozek & Verani 2016).

in finding sources of cash and cash-like assets that enabled these withdrawals to be met.[25] Specifically with regards to its securities lending program, MetLife swapped illiquid securities in its securities lending cash reinvestment portfolio for cash and short-term investments in other investment portfolios to avoid selling the illiquid securities in the reinvestment portfolio at fire sale prices.[26] By the beginning of 2009, not only was MetLife's asset portfolio still available to securities borrowers with about [$20 billion]] on loan, but the company had replaced AIG as the largest lender of corporate bonds in the insurance industry.

The contrast between the experience of AIG and that of other insurers, such as MetLife, is the basis for our identification strategy. We exploit cross-sectional differences in the corporate bonds held and lent by AIG and other insurance companies. Holding fixed the total amount of each bond held by all insurance companies, we compare the liquidity of those bonds held in large amounts by AIG with observationally identical bonds held by other insurers that were not forced to close their bond lending programs. Intuitively, the disproportionate shock to AIG's lending program in 2008 will asymmetrically affect the market liquidity of the bonds held by all insurers.

Figure 6 illustrates our identification strategy by focusing on the differences in lending behavior between MetLife and AIG. We calculate and fix the fraction of bonds held by AIG and MetLife at the end of 2006, and we scatter-plot the bonds that they exclusively lent through the crisis, as a function of their holdings. In this example, our new difference-in-difference strategy combines the difference between the bonds held by AIG and those

[25]At the time, MetLife was a Bank Holding Company, which allowed it to borrow from the Federal Reserve Bank of New York Discount Window and from the Federal Reserve Term Auction Facility (See Bloomberg, "The Fed's Secret Liquidity Lifelines," available at `http://www.bloomberg.com/data-visualization/federal-reserve-emergency-lending/#/MetLife_Inc` and Board of Governors, Term Auction Facility, available at `http://www.federalreserve.gov/newsevents/reform_taf.htm`). In addition, MetLife's life insurance subsidiaries ramped up borrowing from the federal government by issuing funding agreement backed commercial paper to the Federal Reserve's Commercial Paper Funding Facility and by increasing funding agreement backed borrowing from the Federal Home Loan Banks (See Board of Governors, Commercial Paper Funding Facility, available at `http://www.federalreserve.gov/newsevents/reform_cpff.htm` and MetLife's Form 10-K for 2007 and 2008.).

[26]From MetLife's 2009Q2 Form 10-Q: "During the three months ended March 31, 2009, a period of market disruption, internal asset transfers were utilized extensively to preserve economic value for MetLife by transferring assets across business segments instead of selling them to external parties at depressed market prices. Securities with an estimated fair value of $3.7 billion were transferred across business segments in the three months ended March 31, 2009 generating $509 million in net investment losses, principally within Individual and Institutional, with the offset in Corporate & Other's net investment gains (losses). Transfers of securities out of the securities lending portfolio to other investment portfolios in exchange for cash and short-term investments represented the majority of the internal asset transfers during this period."

held by MetLife, and exploits AIG's exits from securities lending in 2008.[27] We adapt this approach using the fraction of a bond held and lent by AIG while controlling for the fraction of the bond's total amount held by the insurance industry.

## 3.2 Implementation of the difference-in-difference

Adopting a difference-in-differences approach, we test the hypothesis that corporate bonds held by insurers that were held in larger fraction by AIG became more illiquid after AIG's securities lending program shut-down, and these corporate bonds became relatively less available to securities borrowers. Our main dependent variable is the secondary market liquidity ($\text{Liquidity}_{bt}$) of corporate bond $b$ in month $t$, measured using the average realized spread between the price paid by a dealer to a customer for purchasing bond $b$ and the price at which the dealer sells the same bond to a customer. Our main dependent variable is the fraction of each bond $b$ in our sample held by AIG relative to the total amount held by all insurance companies with bond lending programs at the end of 2006 ($\text{AIGFrac2006}_b$). The first difference is between a bond $b$, of which AIG hold a high fraction of the outstanding par value and a bond in which AIG holds a low fraction. The second difference is between the period before the shutdown in AIG's lending programs and the period after the shutdown, measured using a set of dummy variables ($\text{Year}_y$) for each year $y$.

We implement our difference-in-differences using the following specification:

$$\begin{aligned}\text{Liquidity}_{bt} =& \alpha_b^1 + \alpha_t^2 + \sum_{y=2008}^{2010} \beta_y \text{AIGFrac2006}_b \times \text{Year}_y \\ &+ \zeta \text{InsFrac2006}_b \times \text{Month}_t + \tilde{\mathbf{X}}_{bt}\tilde{\boldsymbol{\gamma}} + \epsilon_{bt}. \end{aligned} \quad (1)$$

where the coefficients $\beta_y$ on the interaction terms allow us to trace the difference-in-difference effect of the reduction in the lending supply of corporate bonds that were mostly held by AIG that occured during the financial crisis. We include both bond fixed effects ($\alpha_b^1$) to control for time-invariant heterogeneity across bonds, and we also include month fixed effects ($\alpha_t^2$) to control for time-varying common shocks to bond market liquidity, including shocks to investors' or dealers' bond demands.

[27] Bond characteristics interacted with time-specific fixed effects absorb the variation in liquidity associated with bond heterogeneity (Friewald, Jankowitsch & Subrahmanyam 2012).

Although insurance companies tend to follow a buy-and-hold portfolio strategy, it is plausible that their buying strategy changed in the post crisis period. For example, some insurance companies may select into more illiquid bonds to earn a higher yield to maintain profitability in a low interest environments. To address this concern, we hold fixed the fraction of insurers' holdings to their level of 2006 by including the fraction of insurers' holdings of the amount outstanding in 2006 ($\text{InsFrac2006}_b$) interacted with time as a control variable. This variable absorbs the potentially confounding effects stemming from unobserved demand factors that are correlated with insurers' bond holdings. To be clear, since we are calculating insurers' holdings at the end of 2006, throughout the analysis we restrict the sample to bonds that were issued in 2006 and before.

Lastly, we include a vector ($\mathbf{X}_{bt}$) of bond-specific control variables interacted with time fixed effects. The interaction between bond characteristics and time is essential to control for, as an example, potential changes in bond demand that occurred during the crisis period (e.g. flight to quality) and the development of the low interest rate environment (e.g. reach for yield). In addition to controlling for unobservable heterogeneity with fixed effects and time-varying bond characteristics, we use two-way clusters by month and bond for our standard errors to alleviate concerns that shocks may be correlated within months or across bonds in all the tests reported in this paper.[28]

# 4 The effect of the collapse of AIG securities lending program on bond liquidity

Table 2 presents the results from estimating equation 1. The dependent variable in columns 1 and 2 is the average realized spread. The test reported in column 1 excludes the interaction between the fraction of insurers' holdings of the amount outstanding in 2006 and time. The test reported in column 2 includes the new control variable that absorbs the potentially confounding effects stemming from unobserved demand factors that are correlated with insurers' bond holdings. The point estimates of the coefficients on the interaction terms are slightly smaller, especially the interaction with 2008, indicating

[28] Across specifications, our standard errors have roughly 55 month clusters and 13,000 bond clusters. The findings reported are not dependent on the clustering assumption. We obtain statistically significant results if we one-way cluster our standard errors by month or bond and if we replace the clustered standard errors with Eicker-White heteroscedasticity robust standard errors. These results are available from the authors on request.

that confounding effects may indeed be present. However, the overall narrative remains essentially the same, with roughly the same magnitude of effect: A one standard deviation increase in the ratio of AIG holdings of a bond to the total amount of the bond held by insurers with bond lending programs (15 percentage points) lowers the liquidity of that bond by about one-tenth of a standard deviation or 4 basis points. Because trading costs are in the order of 10 basis points for smaller traders, this estimate suggests that the collapse of AIG caused the costs of trading bond predominantly held by AIG to increase by at least 40 percent.

We further investigate the collapse of AIG's bond lending program by replacing the dependent variable in equation 1 with a set of variables related to the bond lending and secondary markets. The interaction of our main explanatory variable with the year dummy for 2008 suggests that, after controlling for the overall fraction held by insurers, the availability of bonds held by AIG did not fall significantly (column 3), lending did not fall significantly (column 4), and AIG was not forced to offer cheaper terms for borrowing its bonds (column 5). However, from 2009 onward, even after controlling for the overall fraction held by insurers interacted with time, the availability and lending of bonds held by AIG fell, and the cost of borrowing rose, consistent with a sizeable and significant reduction in the supply of bonds through the insurer's lending program. Finally, column 6 reveals that there was a significantly lower volume of trade in the bonds that AIG held in 2006, after the collapse of AIG's bond lending program.

Although insurance companies' liability-management strategy is generally to buy and hold bonds, a reasonable concern is that insurers may have sold some bonds as part of their overall response to the financial crisis. As we discussed in the institutional background, investors withdrawal from AIG, MetLife, and other companies necessitated the insurers to find sources of cash and cash-like assets. In principle, insurers might have sold bonds to raise cash, and this may have had a direct effect on the market liquidity of these bonds, unrelated to the closure of the insurers' bond lending programs. To test this hypothesis, we restrict our sample only to those bonds that insurers continued to hold at the end of 2010 and repeat the tests of the previous section. Table 3 presents the results. Broadly speaking, they are the same as Table 2, indicating that bond sales are not a substantial confounding factor.

# 5 Mechanism: Rising small trades in the interdealer market

This section studies one possible channel for an increase in illiquidity when securities lending markets shut down – changes in the interdealer market. As explained in Sub-Section 1.1, dealers typically prefer borrowing bonds from institutional investors, such as life insurers, to avoid revealing trading strategies to competing dealers and to maintain costly inventory. Consequently, a decrease in the supply of loanable bonds may force dealers to fulfill client orders by searching for these bonds in the interdealer market. The associated increase in search and bargaining frictions in the interdealer market may, in turn, reflect themselves in bond average realized spread. In what follows, we test this hypothesis, namely that the increase in illiquidity in the aftermath of the AIG collapse is related to an increase in interdealer trading.

To set the stage, Table 4 looks at the correlations between bond liquidity and several characteristics of bond trading in the interdealer market. A less liquid bond is associated with a higher fraction of interdealer trading over total trading (column 1) and is traded by more dealers (column 2). Furthermore, less liquidity is associated with less trades per dealer, both in total number of trades (column 3) as well as in the fraction of all trades in a given bond (column 4). Looking at a given dealer's volume in a bond, less liquidity is associated with a higher fraction of interdealer trading over total trading by this dealer in the bond (column 5).

Using the same difference-in-differences strategy described in Section 3.2, we begin by estimating the response of interdealer trades to the collapse of AIG. That is, we estimate the following equation:

$$\begin{aligned}\text{IntDealerTrade}_{bt} =& \alpha_b^1 + \alpha_t^2 + \sum_{y=2008}^{2010} \beta_y \text{AIGFrac2006}_b \times \text{Year}_y \\ &+ \zeta \text{InsFrac2006}_b \times \text{Month}_t + \mathbf{X}_{bt}\boldsymbol{\gamma} + \epsilon_{bt} \ . \end{aligned} \tag{2}$$

using the same explanatory variables and controls as before and two-way clustered standard errors by bond and month throughout.

Table 5 summarizes the results. The dependent variable ($\text{IntDealerTrade}_{bt}$) is the volume of interdealer trade in bond $b$ in a month $t$ expressed as a fraction of total

volume of trade in bond $b$ in month $t$ and the number of dealers trading $b$ in month $t$ in column 1 and 2, respectively. These coefficient estimates suggest that, following the collapse of AIG, there was a higher volume of interdealer trades among a greater number of dealers. If AIG held half of a given bond issue, on average the volume of interdealer trade increased by 5 percent and the number of dealers by 4 percent after AIG's securities lending collapse.[29] These estimates suggest that the variation in AIG's bond holdings in 2006 accounts for about 2 percent of the variation in interdealer trading in these bonds in the years following AIG's collapse.

Next, we analyze dealer-level trades in those bonds predominately held by AIG. The confidential version of TRACE provides information about the identity of dealers for each bond trade. We use this information to estimate the effect of the collapse of AIG on dealer-level bond trades with the following equation:

$$\begin{aligned}\text{IntDealerTrade}_{bdt} =& \alpha_b^1 + \alpha_d^2 + \alpha_t^3 + \sum_{y=2008}^{2010} \beta_y \text{AIGFrac2006}_b \times \text{Year}_y \\ &+ \zeta \text{InsFrac2006}_b \times \text{Month}_t + \mathbf{X}_{bdt}\boldsymbol{\gamma} + \epsilon_{bdt} \end{aligned} \tag{3}$$

Note that equation implements the same difference-in-differences strategy as before, using bond-dealer-month observations rather than bond-month observations, where $d$ indicates *dealer*. This specification includes dealer fixed effects $\alpha_d^2$ to control for fixed heterogeneity across dealers.

Table 6 summarizes the results. In column 1, the dependent variable is the volume of dealer $d$ trades in bond $b$ in a month $t$ expressed as a fraction of total volume of trade in bond $b$ in month $t$. In column 2, the dependent variable is the volume of interdealer trade in bond $b$ by dealer $d$ in a month $t$ expressed as a fraction of the volume of dealer $d$ trades in bond $b$ in a month $t$. In Columns 3, the dependent variable is the number of trades in bond $b$ by dealer $d$ in a month $t$. In Columns 4, the dependent variable is the number of trades in bond $b$ by dealer $d$ in a month $t$ expressed as the fraction of total number of trades in bond $b$ in month $t$. Taken together, these coefficient estimates suggest that dealers more frequently trade smaller volumes of bonds with others dealers. Regardless

[29] Although the average fraction held by AIG in our sample is 7 percent, this fraction is significantly higher when we exclude bonds that are not held by AIG. If a bond was held by AIG in 2006, AIG held on average one-fifth of the bond issuance, and for 10 percent of its bonds, AIG held over half of the issuance.

whether measured in dollar terms or in the number of trades, if AIG held half of a bond's issuance, on average a dealer's trading in this bond as a fraction of total trading in the same bond decreased between 4 and 8 percent.

# 6 Conclusion

The theoretical literature on over-the-counter markets suggests that natural frictions in those markets prevent fully efficient trading. In this paper, we show that securities lending markets can help intermediaries to mitigate those frictions. We empirically identify and measure the effects of a shock to a securities lending market on market liquidity. During the financial crisis of 2007-2008, AIG's corporate bond securities lending program was shutdown, for reasons unrelated to corporate bond market liquidity, while other life insurance companies' securities lending programs remained active. Differences in these life insurers' corporate bond holdings allows us to tease out the causal effect of corporate bond securities lending on corporate bond market liquidity. We find a statistically and economically significant decrease in the market liquidity of those corporate bonds that AIG held in large quantities relative to other life insurance companies. Our estimate of the effect of securities lending on corporate bond market liquidity is a general equilibrium outcome that accounts for the potential shift by intermediaries towards interdealer markets or inventory. Indeed, we show that the absence of a securities lending market produced a surge in interdealer trading in those corporate bonds that were most affected by the shock to AIG's securities lending program. Our findings highlight the importance of the shadow banking system as a potentially fragile determinant of market efficiency.

## References


Adrian, T., Fleming, M., Shachar, O. & Vogt, E. (2017), 'Market liquidity after the financial crisis', *Annual Review of Financial Economics* **9**(1).

Adrian, T. & Shin, H. S. (2010), 'Liquidity and Leverage', *Journal of Financial Intermediation* **19**(3), 418–437.

Amihud, Y. & Mendelson, H. (1988), 'Liquidity and Asset Prices: Financial Management Implications', *Financial Management* **17**(1), 5–15.

Amihud, Y. & Mendelson, H. (2006), 'Stock and Bond Liquidity and its Effect on Prices and Financial Policies', *Financial Markets and Portfolio Management* **20**(1), 19–32.

Aragon, G. O. & Strahan, P. E. (2012), 'Hedge Funds as Liquidity Providers: Evidence from the Lehman Bankruptcy', *Journal of Financial Economics* **103**(3), 570–587.

Asquith, P., Au, A. S., Covert, T. & Pathak, P. A. (2013), 'The market for borrowing corporate bonds', *Journal of Financial Economics* **107**(1), 155–182.

Bao, J., O'Hara, M. & Zhou, X. A. (n.d.), 'The Volcker Rule and Market-Making in Times of Stress', *Journal of Financial Economics* .

Brunnermeier, M. K. & Pedersen, L. H. (2009), 'Market Liquidity and Funding Liquidity', *Review of Financial Studies* **22**(6), 2201–2238.

Chang, B. & Zhang, S. (2015), 'Endogenous Market Making and Network Formation', *Available at SSRN https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2600242* .

Chodorow-Reich, G. (2014), 'The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008-09 Financial Crisis', *Quarterly Journal of Economics* **129**(1), 1–59.

Choi, J. & Huh, Y. (2017), 'Customer Liquidity Provision: Implications for Corporate Bond Market Transaction Costs', *FEDS WP 2017-116* .

D'Avolio, G. (2002), 'The Market for Borrowing Stock', *Journal of Financial Economics* **66**(2), 271–306.

Dick-Nielsen, J. (2009), 'Liquidity Biases in TRACE', *Journal of Fixed Income* **19**(2).

Dick-Nielsen, J., Feldhütter, P. & Lando, D. (2012), 'Corporate Bond Liquidity Before and After the Onset of the Subprime Crisis', *Journal of Financial Economics* **103**(3), 471–492.

Duffie, D. (1996), 'Special Repo Rates', *The Journal of Finance* **51**(2), 493–526.

Duffie, D. (2012), *Dark markets: Asset pricing and information transmission in over-the-counter markets*, Princeton University Press.

Duffie, D., Gârleanu, N. & Pedersen, L. H. (2002), 'Securities Lending, Shorting, and Pricing', *Journal of Financial Economics* **66**(2), 307–339.

Duffie, D., Gârleanu, N. & Pedersen, L. H. (2005), 'Over-the-Counter Markets', *Econometrica* **73**(6), 1815–1847.

Ellul, A., Jotikasthira, C. & Lundblad, C. T. (2011), 'Regulatory Pressure and Fire Sales in the Corporate Bond Market', *Journal of Financial Economics* **101**(3), 596–620.

Faulkner, M. (2006), *An Introduction to Securities Lending*, London: Spitalfields Advisors.

Faulkner, M. (2008), An Introduction to Securities Lending, *in* M. Faulkner, ed., 'Handbook of Finance, Financial Markets and Instruments', John Wiley & Sons, Inc.

Foley-Fisher, N., Meisenzahl, R. R., Narajabad, B. N., Perozek, M. G. & Verani, S. (2016), Funding Agreement-Backed Securities in the Enhanced Financial Accounts, FEDS Notes 2016-08-05-2, Board of Governors of the Federal Reserve System (U.S.).

Foley-Fisher, N., Narajabad, B. & Verani, S. (2016), 'Securities Lending as Wholesale Funding: Evidence from the U.S. Life Insurance Industry', (22774).

Friewald, N., Jankowitsch, R. & Subrahmanyam, M. G. (2012), 'Illiquidity or Credit Deterioration: A Study of Liquidity in the US Corporate Bond Market during Financial Crises', *Journal of Financial Economics* **105**(1), 18 – 36.

GAO (2011), 'Review of Federal Reserve System Financial Assistance to American International Group, Inc.', *Government Accountability Office Report GAO-11-616* .

Gorton, G. & Metrick, A. (2012), 'Getting Up to Speed on the Financial Crisis: A One-Weekend-Reader's Guide', *Journal of Economic Literature* **50**(1), 128–50.

Hoshi, T., Kashyap, A. & Scharfstein, D. (1991), 'Corporate Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups', *The Quarterly Journal of Economics* **106**(1), 33–60.

Hugonnier, J., Lester, B. & Weill, P.-O. (2014), 'Heterogeneity in Decentralized Asset Markets', *NBER WP 20746* .

Keane, F. M. (2013), 'Securities Loans Collateralized by Cash: Reinvestment Risk, Run Risk, and Incentive Issues', *Current Issues in Economics and Finance* **19**(3).

Kolasinski, A. C., Reed, A. V. & Ringgenberg, M. C. (2013), 'A Multiple Lender Approach to Understanding Supply and Search in the Equity Lending Market', *The Journal of Finance* **68**(2), 559–595.

Kovner, A. (2012), 'Do Underwriters Matter? The Impact of the Near Failure of an Equity Underwriter', *Journal of Financial Intermediation* **21**(3), 507–529.

Krishnamurthy, A. (2002), 'The Bond/Old-Bond Spread', *Journal of Financial Economics* **66**(2), 463–506.

Lagos, R., Rocheteau, G. & Weill, P.-O. (2011), 'Crises and Liquidity in Over-The-Counter Markets', *Journal of Economic Theory* **146**(6), 2169–2205.

McDonald, R. & Paulson, A. (2015), 'AIG in Hindsight', *Journal of Economic Perspectives* **29**(2), 81–105.

Mian, A. & Sufi, A. (2012), 'The Effects of Fiscal Stimulus: Evidence from the 2009 Cash for Clunkers Program', *The Quarterly Journal of Economics* **127**(3), 1107–1142.

Musto, D., Nini, G. & Schwarz, K. (2011), 'Notes on Bonds: Liquidity at All Costs in the Great Recession', *mimeo* .

Nashikkar, A. J. & Pedersen, L. H. (2007), 'Corporate Bond Specialness', *mimeo* .

Neklyudov, A. & Sambalaibat, B. (2015), 'Endogenous Specialization and Dealer Networks', *Available at SSRN* *https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2676116* .

Peirce, H. (2014), 'Securities Lending and the Untold Story in the Collapse of AIG', *George Mason University Mercatus Center Working Paper No. 14-12* .

Saffi, P. & Sigurdsson, K. (2011), 'Price Efficiency and Short Selling', *The Review of Financial Studies* pp. 821–852.

Wang, C. (2016), 'Core-Periphery Trading Networks', *mimeo* .

# 7 Figures

**Figure 1: Corporate bond trading in over-the-counter markets** In this illustration, an intermediary (broker-dealer 1) receives a *buy* order from client 2. The intermediary will try to find a matching *sell* order (client 1). While searching, the intermediary can fill the client buy order either by using its inventory, by locating the securities in the interdealer market (broker-dealer 2), or by borrowing the securities from a securities lender. Thus, the costs associated with securities lending (as well as the costs associated with inventory holding, interdealer trading, and finding the matching client order) have a bearing on overall market liquidity through their effect on the ability of intermediaries to meet client orders.

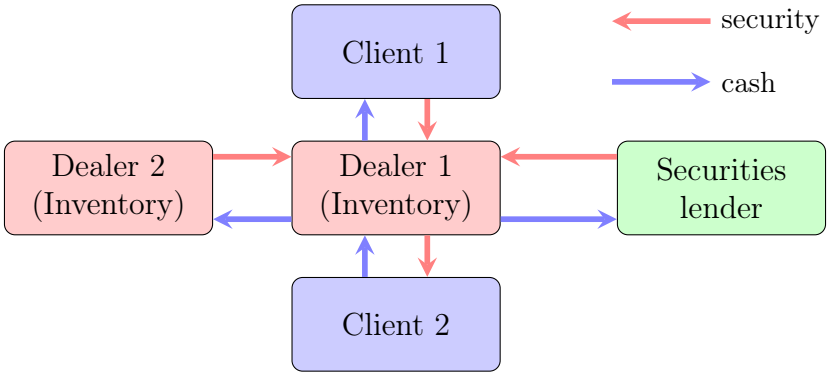

**Figure 2: Corporate bond securities lending against cash collateral in the United States.** These daily data aggregate the fair value of all corporate bonds lent against cash collateral in the United States. The category of other securities lenders includes corporations, endowments, foundations, and government bodies. Source: Markit Securities Finance.

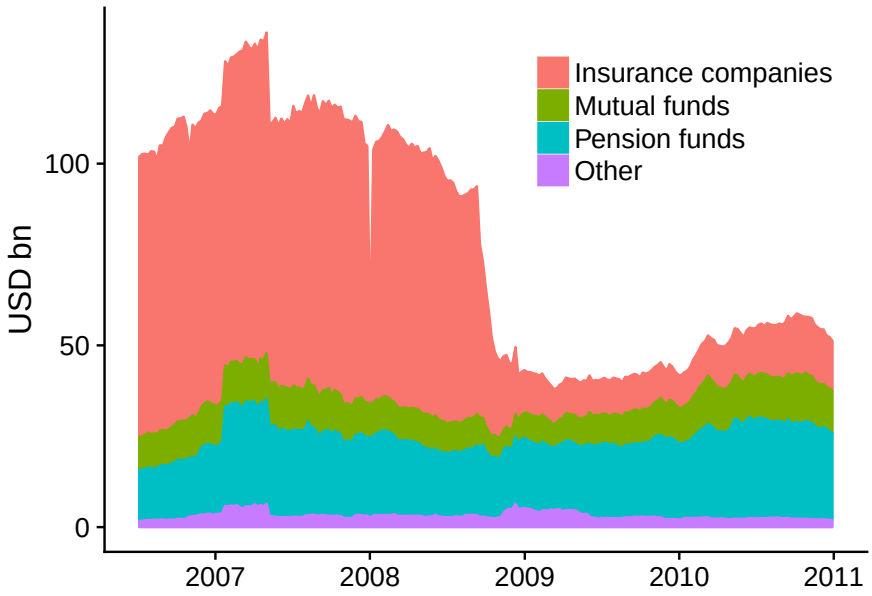

**Figure 3: Comparing total bond holdings AIG and other life insurance companies with securities lending programs** The charts in the left column show the fraction of total bond portfolio par value held at the end of 2006 across (i) broad categories; (ii) NAIC rating classifications; and (iii) residual maturity buckets. The charts in the right column show the same breakdown restricted to the set of bonds that are flagged as being on loan at the end of 2006. Source: Statutory Filings.

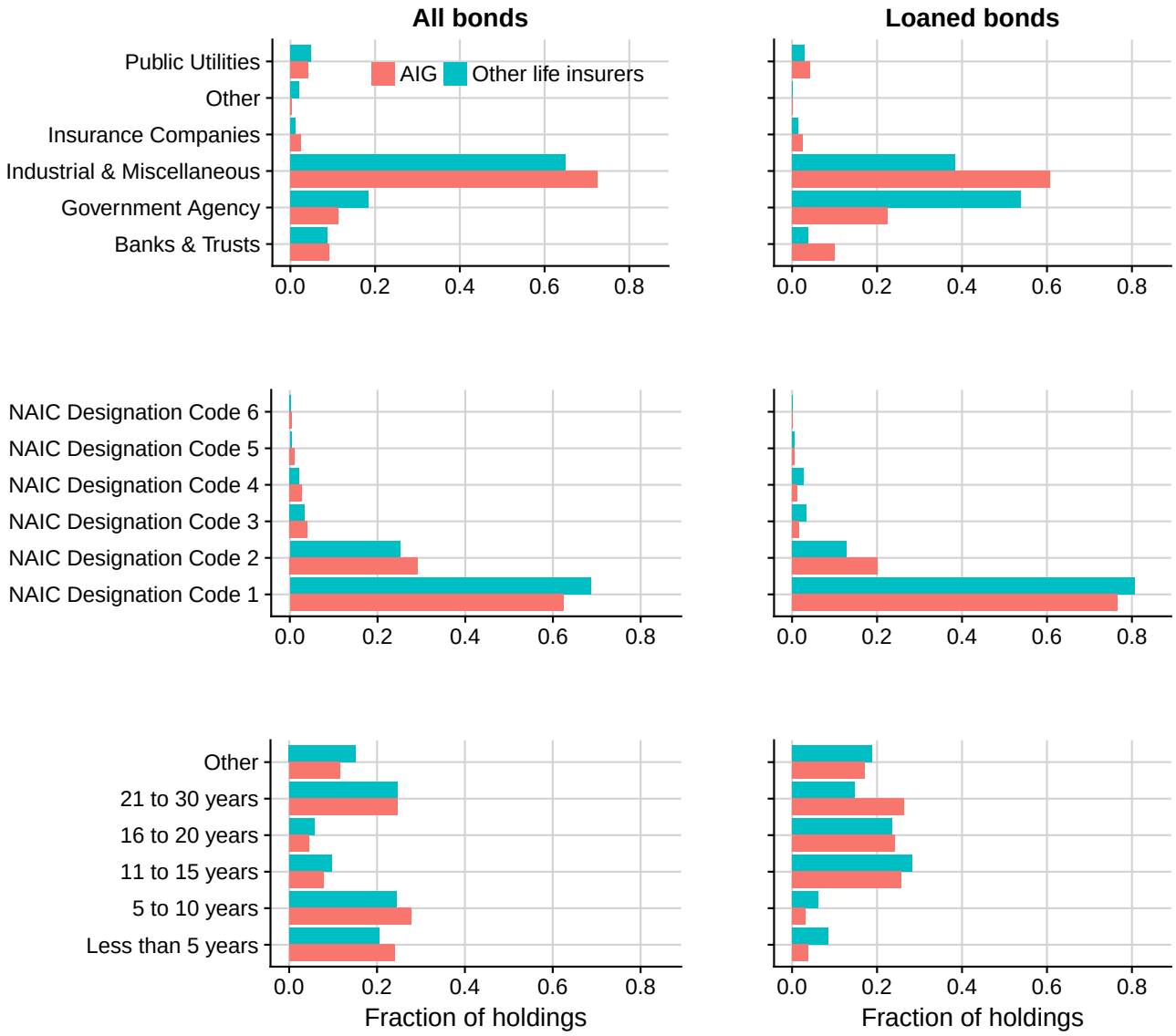

**Figure 4: Comparing corporate bond holdings of AIG and other life insurance companies with securities lending programs** The chart on the left shows the fraction of total bond portfolio par value held at the end of 2006 that was in the first quartile, interquartile, and fourth quartile of the distribution of corporate bond market liquidity. Market liquidity is measured as the realized bid-ask spread on transactions between dealers and clients. The chart on the right shows the same breakdown restricted to the set of bonds that are flagged as being on loan at the end of 2006. Source: TRACE and Statutory Filings.

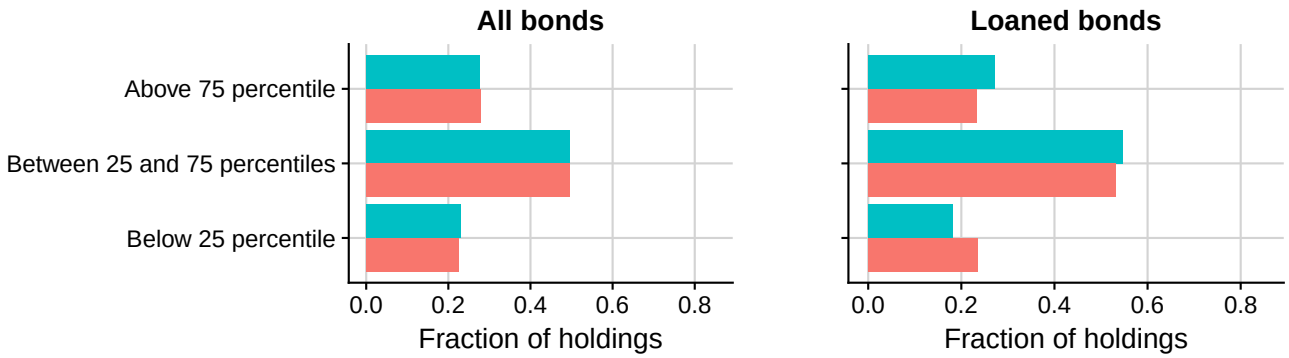


**Figure 5: A simplified securities lending transaction** Securities lenders exchange assets from their portfolios for collateral in the form of either cash or in other securities, from broker-dealers. A portion of the cash reinvestment return is rebated back to the securities borrower.

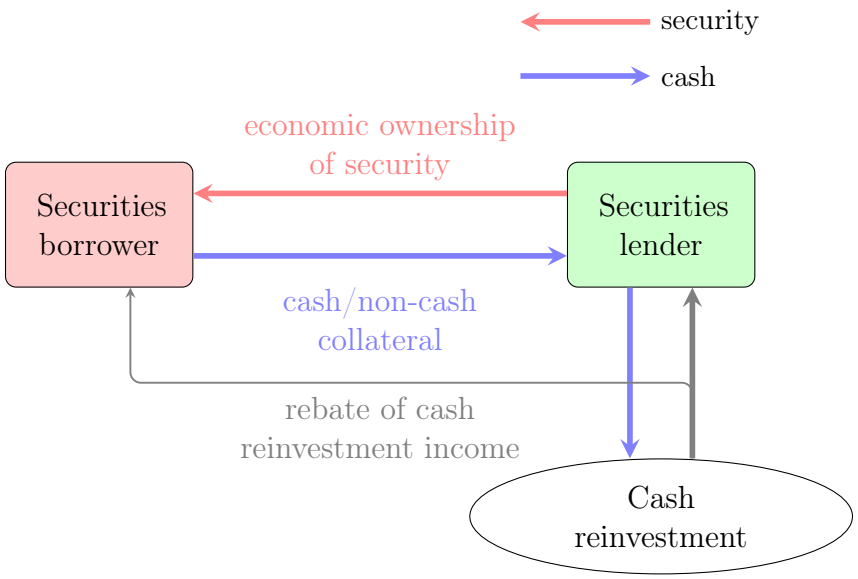

**Figure 6: Corporate bond holdings and lending by MetLife and AIG.** These data provide a graphical representation of our identification strategy. Each dot represents a single bond in the last month of the year. We first calculate, at the end of 2006, the fraction of MetLife and AIG's corporate bond holdings as a share of all holdings by insurance companies with securities lending programs. We restrict our sample to only those bonds in which the combined end-2006 holdings of MetLife and AIG are in the upper quartile of that distribution. Keeping the fraction of holdings fixed at their end-2006 values, we plot for each year from 2007 to 2009, the securities that MetLife is lending and AIG is not lending (blue dots) and the securities that MetLife is not lending and AIG is lending (red dots). The time-series indicates the source of our difference-in-differences empirical strategy. The first difference is that both MetLife and AIG tend to lend bonds in which they individually hold a relatively larger fraction. The second difference is that AIG exits the lending market in 2008, while MetLife remains active. Source: NAIC Statutory Filings and Markit Securities Finance.

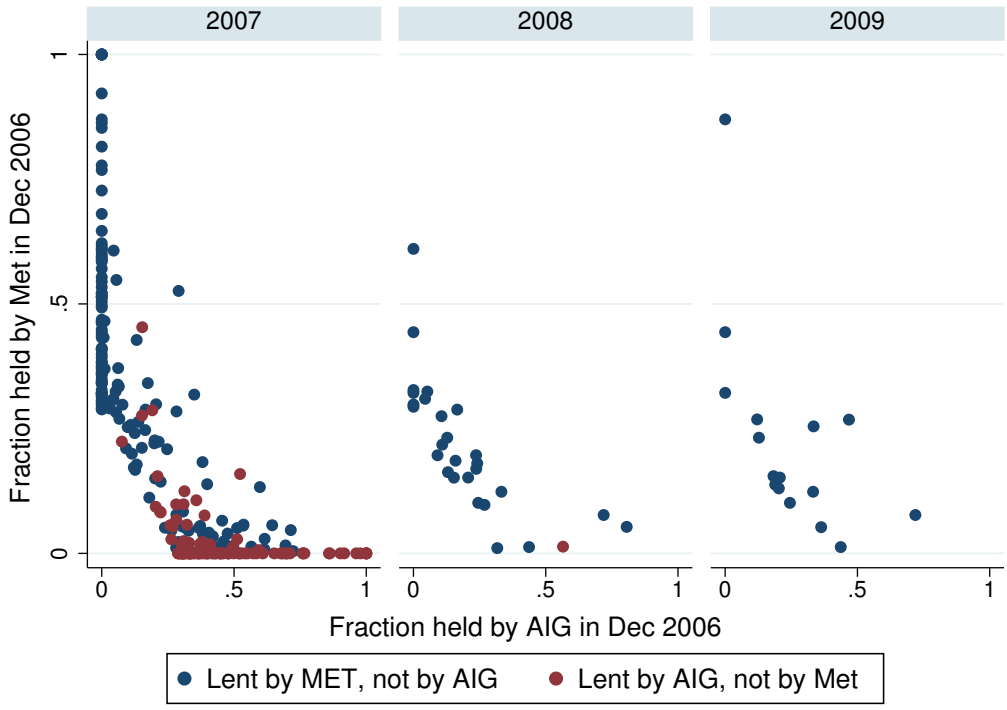

**Table 1: Summary statistics.** Columns 1 through 8 report the number of observations, mean, standard deviation, minimum, maximum, and quartiles of the main variables we calculated from combining corporate bond secondary market transactions reported in TRACE with corporate bond securities lending activity recorded in MSF. Bond market liquidity is the spread between the average price paid by customers to buy a bond from a dealer and the average price paid by dealers to buy the same bond from customers. All variables are winsorized at the 1 percent level to remove outliers. Additional details on the construction of these variables is available in Section 2.

| Variable | Obs | Mean | Std. Dev. | Min | Max | P25 | P50 | P75 |
|---|---|---|---|---|---|---|---|---|
| Liquidity (average realized spread in percentage points) | 279,404 | -0.41 | 0.61 | 0.9 | -2.89 | -0.08 | -0.26 | -0.56 |
| Fraction of bond amount outstanding held by insurers in 2006 | 279,404 | 0.2 | 0.24 | 0 | 0.89 | 0 | 0.09 | 0.35 |
| Fraction of bond amount outstanding held by lending insurers in 2006 | 279,404 | 0.14 | 0.18 | 0 | 0.73 | 0 | 0.06 | 0.24 |
| Fraction of bond held by lending insurers held by AIG in 2006 | 279,404 | 0.07 | 0.15 | 0 | 0.8 | 0 | 0 | 0.08 |
| Fraction of bond that is available to lend | 279,404 | 0.24 | 0.16 | 0 | 0.7 | 0.11 | 0.23 | 0.35 |
| Fraction of bond that is on loan | 279,404 | 0.02 | 0.04 | 0 | 0.21 | 0 | 0.01 | 0.03 |
| Median rebate rate (percentage points) | 223,331 | 2.12 | 2.24 | -15.5 | 18 | 0.12 | 0.95 | 4.9 |
| Ratio of volume traded to total amount outstanding | 279,393 | 0.01 | 0.02 | 0 | 0.11 | 0 | 0.01 | 0.01 |
| Amount issued (USD bn) | 279,404 | 0.65 | 0.61 | 0 | 8 | 0.28 | 0.5 | 0.75 |
| Initial maturity (years) | 278,510 | 7.64 | 8.69 | -7.67 | 99.92 | 2.67 | 5.17 | 8.5 |
| Residual maturity (years) | 278,510 | 7.48 | 7.69 | .08 | 39.58 | 2.67 | 5.17 | 8.5 |
| Number of dealers per bond | 101,382 | 12.11 | 7.39 | 1 | 81 | 7 | 10 | 15 |
| Interdealer volume in bond over total volume in bond | 101,382 | 0.27 | 0.18 | 0 | 1 | 0.13 | 0.25 | 0.39 |
| Volume by dealer in bond over total volume in bond | 1,507,220 | 0.14 | 0.20 | 0 | 1 | 0.01 | 0.05 | 0.17 |
| Interdealer trading in bond by dealer over total trading in bond by dealer | 1,507,220 | 0.484 | 0.397 | 0 | 1 | 0 | 0.5 | 1 |
| Trades in bond by dealer | 1,507,220 | 3.837 | 6.52 | 1 | 5,140 | 2 | 2 | 4 |
| Trades in bond by dealer over total trades in bond | 1,507,220 | 0.12 | 0.14 | 0 | 1 | 0.03 | 0.07 | 0.14 |

**Table 2: The effect of AIG's collapse on corporate bond market liquidity.** This table reports tests of the difference-in-difference strategy described in Section 3. In Columns 1 and 2, the dependent variable is the liquidity of bond $b$ in month $t$, measured using the average realized spread. In Columns 3 and 4, the dependent variables are the fraction of the amount outstanding that is available to lend and the fraction that is actually lent, respectively. The dependent variable in Column 5 is the rebate rate on the cash collateral reinvestment income. And the dependent variable in Column 6 is the ratio of the volume traded to the amount outstanding. The main explanatory variables are the fraction of bond $b$ held in 2006 by AIG ($\text{AIGFrac2006}_b$) interacted with year fixed effects. All tests include month and bond fixed effects, the fraction of bond $b$ held in 2006 by insurers with bond lending programs ($\text{InsFrac2006}_b$) interacted with month fixed effects, and bond characteristics interacted with time fixed effects. The bond characteristics are credit rating, amount outstanding, issue amount, bond type, residual maturity, time since issuance, and a dummy variable for whether the bond is held by any insurer. Standard errors are two-way clustered by bond and month. $t$-statistics are computed using the two-way clustered standard errors are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dependent variable: | Liquidity | Liquidity | Available | Lending | Rebate rate | Volume |
| $\text{AIGFrac2006}_b \times 2008$ | -0.131*** | -0.108*** | -0.00324 | -0.00908 | 0.0585 | 0.000527 |
| | (-4.197) | (-3.423) | (-0.505) | (-1.370) | (1.190) | (0.723) |
| $\text{AIGFrac2006}_b \times 2009$ | -0.227*** | -0.212*** | -0.0672*** | -0.0526*** | -0.230*** | -0.00231*** |
| | (-5.673) | (-5.263) | (-7.323) | (-11.40) | (-3.439) | (-2.812) |
| $\text{AIGFrac2006}_b \times 2010$ | -0.182*** | -0.172*** | -0.0453*** | -0.0530*** | -0.202*** | -0.00183* |
| | (-5.011) | (-4.750) | (-4.120) | (-10.08) | (-3.854) | (-1.965) |
| Observations | 150,452 | 150,452 | 150,452 | 150,452 | 127,364 | 150,450 |
| R-squared | 0.507 | 0.509 | 0.963 | 0.706 | 0.987 | 0.603 |
| Bond & Month FE | Y | Y | Y | Y | Y | Y |
| Bond characteristics × Month | Y | Y | Y | Y | Y | Y |
| $\text{InsFrac2006}_b \times$ Month | N | Y | Y | Y | Y | Y |

**Table 3: The effect of AIG's collapse on corporate bond market liquidity—robustness tests.** This table reports tests of the difference-in-difference strategy described in Section 3.2. The tests are the same as those reported in Table 2 restricting the sample to those bonds that were held by AIG at the end of 2006 and remained in the portfolio of AIG at the end of 2010. In Column 1, the dependent variable is the liquidity of bond $b$ in month $t$, measured using the average realized spread. In Columns 3 and 4, the dependent variables are the fraction of the amount outstanding that is available to lend and the fraction that is actually lent, respectively. The dependent variable in Column 5 is the rebate rate on the cash collateral reinvestment income. And the dependent variable in Column 6 is the ratio of the volume traded to the amount outstanding. The main explanatory variables are the fraction of bond $b$ held in 2006 by AIG ($\text{AIGFrac2006}_b$) interacted with year fixed effects. All tests include month and bond fixed effects, the fraction of bond $b$ held in 2006 by insurers with bond lending programs ($\text{InsFrac2006}_b$) interacted with month fixed effects, and bond characteristics interacted with time fixed effects. The bond characteristics are credit rating, amount outstanding, issue amount, bond type, residual maturity, time since issuance, and a dummy variable for whether the bond is held by any insurer. Standard errors are two-way clustered by bond and month. $t$-statistics are computed using the two-way clustered standard errors are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Dependent variable: | Liquidity | Available | Lending | Rebate rate | Volume |
| $\text{AIGFrac2006}_b \times 2008$ | -0.0407 | -0.0108 | -0.0151* | 0.0947** | -0.000618 |
| | (-0.887) | (-1.236) | (-1.939) | (2.090) | (-0.696) |
| $\text{AIGFrac2006}_b \times 2009$ | -0.137*** | -0.0781*** | -0.0583*** | -0.207** | -0.00210** |
| | (-2.901) | (-6.356) | (-9.901) | (-2.644) | (-2.247) |
| $\text{AIGFrac2006}_b \times 2010$ | -0.0966** | -0.0608*** | -0.0600*** | -0.169*** | -0.00177* |
| | (-2.291) | (-4.214) | (-9.279) | (-3.778) | (-1.717) |
| Observations | 83,929 | 83,929 | 83,929 | 75,662 | 83,929 |
| R-squared | 0.517 | 0.967 | 0.692 | 0.990 | 0.576 |
| Bond & Month FE | Y | Y | Y | Y | Y |
| Bond characteristics × Month | Y | Y | Y | Y | Y |
| $\text{InsFrac2006}_b \times$ Month | Y | Y | Y | Y | Y |

**Table 4: Liquidity and interdealer trading.** This table reports tests on the association between interdealer trading and bond liquidity. In column 1, the dependent variable is the volume of interdealer trade in bond $b$ in a month $t$ expressed as a fraction of total volume of trade in bond $b$ in month $t$. In column 2, the dependent variable is the number of dealers trading in bond $b$ in month $t$. In column 3, the dependent variable is the number of trades done by dealer $d$ in bond $b$ during month $t$. In column 4, the dependent variable is the number of trades done by dealer $d$ in bond $b$ during month $t$ as a fraction of all trades in bond $b$ during month $t$. In column 5, the dependent variable is the volume of interdealer trade in bond $b$ by dealer $d$ in a month $t$ expressed as a fraction of the volume of dealer $d$ trades in bond $b$ in a month $t$. All tests include month and bond fixed effects, and bond characteristics interacted with time fixed effects. The bond characteristics are credit rating, amount outstanding, issue amount, bond type, residual maturity, time since issuance, and a dummy variable for whether the bond is held by any insurer. Dealer-bond specific regressions also include dealer-bond fixed effects as well as dealer-month fixed effects. Standard errors are two-way clustered by bond and month. $t$-statistics are computed using the two-way clustered standard errors are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$

| | (1) $\frac{\text{Interdealer volume}_b}{\text{Volume}_b}$ | (2) # Dealers | (3) # $Trades_{bd}$ | (4) $\frac{\#\text{Trades}_{bd}}{\#\text{Trades}_b}$ | (5) $\frac{\text{Int.deal.vol.}_{bd}}{\text{Volume}_{bd}}$ |
|---|---|---|---|---|---|
| Liquidity | -0.0225*** | -0.152*** | 0.0381** | 0.00223*** | -0.0167*** |
| | (16.75) | (6.10) | (-2.06) | (-6.12) | (17.35) |
| Observations | 158,403 | 158,411 | 2,293,756 | 2,293,756 | 2,29,3756 |
| $R^2$ | 0.742 | 0.939 | 0.520 | 0.738 | 0.811 |
| Bond & Month FE | Y | Y | Y | Y | Y |
| Bond characteristics × Month | Y | Y | Y | Y | Y |
| Dealer × Bond | N | N | Y | Y | Y |
| Dealer × Month | N | N | Y | Y | Y |

**Table 5:** The effect of AIG's collapse on interdealer trading.

This table reports the results from applying the difference-in-difference empirical strategy described in Section 3.2. In column 1, the dependent variable is the volume of interdealer trade in bond $b$ in a month $t$ expressed as a fraction of total volume of trade in bond $b$ in month $t$. In column 2, the dependent variable is the number of dealers trading $b$ in month $t$. The main explanatory variables are the fraction of bond $b$ held in 2006 by AIG ($\text{AIGFrac2006}_b$) interacted with year fixed effects. All tests include month and bond fixed effects, the fraction of bond $b$ held in 2006 by insurers with bond lending programs ($\text{InsFrac2006}_b$) interacted with month fixed effects, and bond characteristics interacted with time fixed effects. The bond characteristics are credit rating, amount outstanding, issue amount, bond type, residual maturity, time since issuance, and a dummy variable for whether the bond is held by any insurer. Standard errors are two-way clustered by bond and month. $t$-statistics computed using the two-way clustered standard errors are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$

| | (1) $\frac{\text{Interdealer volume}_b}{\text{Volume}_b}$ | (2) #dealers trading $b$ |
|---|---|---|
| $\text{AIGFrac2006}_b \times 2008$ | 0.03** | 0.90*** |
| | (2.31) | (2.74) |
| $\text{AIGFrac2006}_b \times 2009$ | 0.04*** | 0.40 |
| | (2.95) | (0.93) |
| $\text{AIGFrac2006}_b \times 2010$ | 0.02* | 0.56 |
| | (1.93) | (1.13) |
| Observations | 120,602 | 120,607 |
| $R^2$ | 0.61 | 0.89 |
| Bond & Month FE | Y | Y |
| Bond characteristics × Month | Y | Y |
| $\text{InsFrac2006}_b \times$ Month | Y | Y |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

**Table 6:** The effect of AIG's collapse on dealer-level trades.

This table reports tests of the difference-in-difference strategy described in Section 3.2. In column 1, the dependent variable is the volume of dealer $d$ trades in bond $b$ in a month $t$ expressed as a fraction of total volume of trade in bond $b$ in month $t$. In column 2, the dependent variable is the volume of interdealer trade in bond $b$ by dealer $d$ in a month $t$ expressed as a fraction of the volume of dealer $d$ trades in bond $b$ in a month $t$. In columns 3, the dependent variable is the number of trades in bond $b$ by dealer $d$ in a month $t$. In Columns 4, the dependent variable is the number of trades in bond $b$ by dealer $d$ in a month $t$ expressed as a fraction of total number of trades in bond $b$ in month $t$. The main explanatory variables are the fraction of bond $b$ held in 2006 by AIG ($\text{AIGFrac2006}_b$) interacted with year fixed effects. All tests include month, dealer and bond fixed effects, the fraction of bond $b$ held in 2006 by insurers with bond lending programs ($\text{InsFrac2006}_b$) interacted with month fixed effects, and bond characteristics interacted with time fixed effects. The bond characteristics are credit rating, amount outstanding, issue amount, bond type, residual maturity, time since issuance, and a dummy variable for whether the bond is held by any insurer. Standard errors are two-way clustered by bond and month. $t$-statistics are computed using the two-way clustered standard errors are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$

| | (1) $\frac{\text{Volume}_{bd}}{\text{Volume}_b}$ | (2) $\frac{\text{Int.deal.vol.}_{bd}}{\text{Volume}_{bd}}$ | (3) $\#\text{Trades}_{bd}$ | (4) $\frac{\#\text{Trades}_{bd}}{\#\text{Trades}_b}$ |
|---|---|---|---|---|
| $\text{AIGFrac2006}_b \times 2008$ | -0.01** | 0.01 | -0.20 | -0.01** |
| | (-2.08) | (1.43) | (-0.45) | (-2.40) |
| $\text{AIGFrac2006}_b \times 2009$ | -0.01* | 0.03** | -0.46 | -0.01* |
| | (-1.91) | (2.44) | (-1.01) | (-1.96) |
| $\text{AIGFrac2006}_b \times 2010$ | -0.02*** | 0.03*** | -0.18 | -0.02*** |
| | (-2.69) | (2.76) | (-0.46) | (-3.24) |
| Observations | 997,625 | 997,630 | 997,630 | 997,630 |
| $R^2$ | 0.63 | 0.81 | 0.61 | 0.73 |
| Dealer × Bond | Y | Y | Y | Y |
| Dealer × Month | Y | Y | Y | Y |
| Bond char. × Month FE | Y | Y | Y | Y |
| $\text{InsFrac2006}_b \times$ Month FE | Y | Y | Y | Y |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$