Drawing the Line between Bond Dealer and Bandit

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Abstract

We use TRACE transactions data to assess trading activity and measure dealer markups on riskless principal trades in structured products. Median markups on such transactions with market values in the $5-$10 million range for MBS and ABS are just 0.03%, comparable to the 0.02% observed for Corporate bonds. Corresponding median markups are 0.10% for Agency CMO and 0.20% for Non-Agency CMO. Skewed markup distributions exist in all products, suggesting that customers are short-changed in a significant number of trades by opportunistic ("bandit") dealers. The top quartile of both Agency and Non-Agency CMO riskless principal trades cross at markups above 1.0%, more than *quadruple* their median values. The top eighth of these paired trades cross at markups above 2.0%, more than *nine times* their median values.

The incidence of dealer banditry increased during the COVID-19 pandemic crisis week beginning March 23, 2020. One bandit dealer made $54.5 million in excessive markups by buying 238 Non-Agency CMO worth $1.732 billion from a single seller, while simultaneously splitting sales of these same positions among five counterparty accounts during a 12-minute "fire sale" on March 25, 2020. Benchmarks suggest this dealer also facilitated at least a 20% suppression of the fair value of these trades, benefiting the buying group while disadvantaging the seller by an extra $346 million. One of the buyers realized a $139.4 million capital gain (39% return on investment) after unwinding 35 days later in highly unusual "after hours" trades that also netted the dealer an extra $22.9 million in markup profits.

In sharp contrast to its near immediate dissemination of prices from Corporate bond, MBS, and ABS transactions, FINRA waits more than 18 months after the trade date to release data for CMO trades with transaction quantities equal to or greater than $1 million. We show that the March 2017 TRACE dissemination rollout for CMO trades with transaction quantities less than $1 million reduced both the level and variability of markups in that segment. However, the post-2017 incidence of banditry appears to have increased for large Non-Agency CMO trades. The March 25, 2020, "crime scene" makes the costs of continuing to withhold reliable and timely information from customers all too real. We recommend that FINRA commence near real-time dissemination of TRACE transactions reports on all riskless principal trades in all structured products, including not only CMO but also Commercial Mortgage-Backed Securities (CMBS), Collateralized Loan Obligations (CLO), and Collateralized Debt Obligations (CDO).

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1. Introduction

We analyze Trade Reporting and Compliance Engine (TRACE) transactions data from the Financial Industry Regulatory Authority (FINRA) to assess trading activity and measure over-the-counter broker-dealer (hereafter, "dealer") pricing performance as matchmakers for customers desiring to buy or sell positions in structured products. Acting as a matchmaker transacting against a customer order, a dealer buys (sells) a security from (to) that customer and simultaneously offsets the position with a companion trade in the same security with a second counterparty. In such "riskless principal trade" intermediation, the dealer avoids holding inventory while profiting through the "markup" – the difference between the dealer's purchase and sale prices.

Markups on riskless principal trades do not measure what economists might regard as the dealer's bid-ask spread. As in Glosten and Harris (1988), a dealer offering immediate liquidity sets bid and ask prices to reflect the adverse selection and inventory risks that unmatched customer flow trading entails. Markups resulting from customer trades with pre-arranged position exits should be (much) smaller than quoted bid-ask spreads in illiquid and opaque markets like those for structured products.

As in a commission-based brokered market such as that for residential housing, it is natural to measure markups as a percentage of the dollar value of the transaction. In equilibrium, markups should be set to fairly compensate dealers for search (e.g., to pay a sales force) and any related opportunity costs. While riskless principal trades in all products embody a common profile, the relative scarcity of investors in more esoteric products like Non-Agency Collateralized Mortgage Obligations as well as point-of-sale customer education costs may justify differences in markups across products. Trade size may also matter for percentage markups if dealers face fixed costs (e.g., a salesperson's time to educate a customer). FINRA requires that members trading as principals with their customers must transact at prices which are "fair." However, FINRA offers only general guidelines on markups instead of specific schedules.

We examine TRACE data on all specified-pool Agency Mortgage-Backed Securities (MBS), Asset-Backed Securities (ABS), Agency Collateralized Mortgage Obligations (CMO), and Non-Agency CMO transactions taking place between May 16, 2011 (the initiation of TRACE coverage of structured products) and December 31, 2022. The overall trading volume percentages attributable to riskless principal trades differ sharply across products. Even under our broadest definition, such paired trades account for only 14.8% of overall volume in specified-pool Mortgage-Backed Securities, implying that dealers readily take MBS inventory from customers without the need for prearranged position exits. Corresponding paired trades account for 33.3% of Non-Agency CMO volume. The percentages of volume attributable to paired trades are 24.0% for ABS and 22.7% Agency CMO.

We assess dealer performance regarding pricing fairness on riskless principal trades in structured products by analyzing the distribution of markups. The median markups on such paired-trade MBS and ABS transactions with market values in the $5-$10 million range are just 0.03%, comparable to the 0.02% observed for Corporate bonds. Corresponding median markups in the less liquid Agency CMO and Non-Agency CMO are higher at 0.10% and 0.20%, respectively. Such outcomes support the view that securities dealers perform extremely well on Corporate, MBS, and ABS trades. The higher median markups on Agency and Non-Agency CMO trades are most likely justified because of added sales costs related to illiquidity and product complexity.

We find highly skewed markup distributions in all four types of structured products. The bottom quartile of MBS, ABS, and Agency CMO pairs cross at markups no greater than 0.03%.

The corresponding bottom quartile for Non-Agency CMO cross at markups no greater than 0.12%. Yet, the top quartile of both Agency CMO and Non-Agency CMO pairs cross at markups at above 1.0%, more than *quadruple* their median values. The top eighth of both Agency CMO and Non-Agency CMO pairs cross at markups above 2.0%, more than *nine times* their median values. Judging from the medians and bottom quarters of the markup distributions, most customers on both sides of riskless principal trades receive very attractive pricing. But the upper ends of the distributions suggest that customers are short-changed in a significant number of trades by opportunistic ("bandit") dealers, especially in Agency CMO and Non-Agency CMO.

We investigate differences in post-trade price transparency via TRACE transaction reporting as a possible reason for the differences in markup distribution across product types. In a non-transparent over-the-counter (OTC) market, customers have no defense against bandit dealers using their informational advantage to reap excessive markups. In contrast, post-trade dissemination of bond trade reports collected by TRACE gives customers the means to audit dealer performance by comparing the prices of their own transactions to the prices of comparable trades done by other market users. For Corporate bond trades, FINRA disseminates TRACE transaction reports almost immediately after trade execution. Bessembinder, Maxwell, and Venkataraman (2006), Edwards, Harris, and Piwowar (2007), Goldstein, Hotchkiss, and Sirri (2007), and Bessembinder and Maxwell (2008) show that the rollout of TRACE price dissemination beginning in 2002 decreased corporate bond transaction costs.

FINRA began disseminating TRACE transactions reports for (i) Agency Mortgage-Backed Securities (MBS) on July 22, 2013; (ii) Asset-Backed Securities (ABS) on June 1, 2015; and (iii) Collateralized Mortgage Obligations (CMO) on March 20, 2017. But dissemination for CMO trades is still limited to just those transactions with trade quantities (measured as original face value) lower than $1 million. Such small-sized trades account for just 1.2% of the total dollar value of CMO riskless principal pairs trading over the period from March 20, 2017 to the end of our sample. FINRA does not release reports for any CMO trades with original face values exceeding $1 million.

Consistent with the previous literature, the MBS, ABS, and Corporate bond transactions that we examine here have not only lower, but much less variable, markups than those for CMO. The differences in markup variability between the transparent and non-transparent segments of the bond markets are stark. Furthermore, a careful analysis of non-retail CMO trades with original face values less than $1 million shows that their TRACE reporting rollout in March 2017 appears to have reduced both the level and variability of markups in that tiny market segment. In contrast, incidences of dealer banditry appear to have increased for large Non-Agency CMO trades after March 20, 2017.

We also examine dealer performance during the stressed conditions surrounding the onset of the COVID-19 pandemic. We present a model analyzing how an unscrupulous dealer constrained by a binding regulatory cap on markups, but in touch with a vulnerable fire-sale seller, could be incentivized to collude with a "vulture" buyer. The aim of the collusion would be to bargain unfairly against the seller to depress the prices paid. Even if the dealer's markup is set no higher than the regulatory cap, the dealer could be enticed by concurrent side payments or future considerations (e.g., promised future high-markup business) from the buyer to bargain unfairly and depress the prices paid to the seller. In such a case, the seller's losses would not only include dealer's markup, but also an illegal suppression of prices.

We filter all riskless principal trades in Non-Agency CMO, the less liquid of the two non-transparent security types, over the five-month period from January through May 2020 to identify closely-clustered-in-time trades potentially representing forced selling of entire portfolios of positions by vulnerable customers. We focus on clusters that are at least $100 million in dealer purchase cost and encompass at least 30 different securities. We identify seven such clusters and analyze each in terms of both dealer markups and pricing bias.

One particular cluster of riskless principal trades stands out. On March 25, 2020, one dealer made $54.5 million in riskless profits by buying 238 Non-Agency CMO worth $1.732 billion from a single seller, while simultaneously splitting sales of these same positions among five counterparty accounts to generate proceeds of $1.787 billion. The value-weighted average markup on this portfolio crossing trade was 3.15% (about *fifteen times* the full-sample median level of 0.20% for average-sized Non-Agency CMO trades).

We interpret these March 25, 2020 trades as an egregious example of a dealer who conspired with a group of five vulture buyers to profit from a vulnerable seller. We provide benchmarks that suggest this dealer also orchestrated a price suppression of at least 20% of the fair value of this trade, benefiting the buying group while disadvantaging the seller by more than $346 million. Summing together both the price suppression and the markup effects, at least $400 million of the seller's interests vaporized in this dealer-facilitated transaction.

Thirty-five days later, on April 29, 2020, exactly one-fifth of this same set of 238 Non-Agency CMO was "unwound" with a dealer who crossed its buy trades with matched sales to a new customer. The investor received $496.8 million from the dealer upon sale of its positions, generating $139.4 million in capital gains relative to its initial investment of $357.4 million (i.e., one-fifth of $1.787 billion). The $139.4 million capital gain corresponds to a 39.0% return on invested capital in 35 days for the unwinding investor. The dealer set the value-weighted markup on this exit trade at 4.62% to generate another $22.9 million in riskless principal trading profits.

The $22.9 million excess markup from this trade along with a one-fifth share ($10.9 million) of the $54.5 million in markups from the initial March 25, 2020, trade gave a total allocated profit to the dealer of $33.8 million on this one vulture customer's trades.

We interpret this one-fifth portion of the joint dealer-vulture buyer enterprise initiated on March 25 as generating $173.2 million in profits (i.e., $33.8 million for the dealer plus $139.4 for the investor). We interpret the dealer's 4.62% markup on the April 29 unwind trade as being set to capture about 20% of the $173.2 million gains to the joint enterprise (i.e., $33.8/$173.2 = 19.5%). Twenty percent is the standard "performance-based incentive fee" in the hedge fund industry. Here, we would interpret the dealer facilitating the initial March 25, 2020, transaction as the "performer." On both March 25 and April 29, the dealing firm's compliance department failed to stop the trades from being settled as priced.

Timely TRACE dissemination has helped create a level playing field for Corporate bond, MBS, and ABS market participants. Because FINRA currently continues to withhold timely transactions data from most CMO investors, customers have no defense against bandit dealers using their informational advantage to reap excessive markups on riskless principal trades. Our analysis of the March 25, 2020, "crime scene" makes the costs of withholding this information from unarmed customers all too real. Ensuring equal access to reliable and timely pricing information will increase the integrity of the CMO market. The policy recommendation from our findings is straightforward: after requiring dealers to flag riskless principal trades, FINRA should begin near real-time dissemination of TRACE transaction reports in all structured products, including extensions to disseminate reports on riskless principal trades in Commercial Mortgage Backed Securities (CMBS), Collateralized Loan Obligations (CLO), and Collateralized Debt Obligations (CDO).

2. Market background

An OTC securities market dealer buys and sells securities both for its own account and on behalf of its customers. A dealer standing ready to transact with its customers offers trade execution immediacy, fulfilling the customer's demand for liquidity by transacting in a security without having first arranged an offset with a second counterparty. The customer buys at the dealer's quoted ask price or sells at the dealer's (lower) quoted bid price. The spread between the bid and the ask affords the dealer the opportunity to profit from liquidity provision over time by servicing offsetting customer flows from buyers and sellers. Here, the dealer acts as principal by using its own inventory as the servicing buffer and bears inventory risks.

2.1 Crossed-pair transactions

Often, a would-be customer buyer judging the dealer's ask price to be too high or a would-be seller judging the dealer's bid price to be too low, gives the dealer a "not-held" order to buy or sell a specific security at a specific price for given period of time. This type of order allows the dealer to use discretion over the timing and execution of the trade, reducing market impact and permitting possible price improvement. Instead of being an inventory risk-exposed principal, the dealer merely acts as a matchmaker. With a not-held order from one customer, the dealer (via electronic messaging conduits or a sales force) uses the allotted time to search for a second counterparty with whom to execute an offsetting trade at a markup or markdown to the first customer's order price. As a matchmaker transacting against a customer order, a dealer buys (sells) a security from (to) that customer and offsets the position with a companion trade in the same security entered with a second counterparty. The counterparty to this crossing transaction could be a second customer or another dealer. Not-held orders do not guarantee execution at the customer's order price. The customer risks that market conditions could worsen over the time frame that an unexecuted not-held order remains in place. For a dealer, not-held customer orders are valuable as the dealer avoids holding inventory while retaining profit potential via a markup.

FINRA sets regulations regarding fair dealing. FINRA Rule 2121, "Fair Prices and Commissions," requires that member dealers trading for their own account with their customers must buy or sell at a price which is fair. FINRA's "Debt Mark-Up Interpretation" states that, presumptively, the prevailing market price of a debt security is the dealer's contemporaneous cost or proceeds. Thus, for the riskless principal trades we study here, the price set by the initiating customer on the dealer's not-held order to sell a bond becomes the reference price on the dealer's offsetting sell trade to a buying counterparty. The price charged to this buying counterparty should equal the original customer's sell order price plus a "fair" markup. Alternatively, the price set by the initiating customer on the dealer's not-held order to buy a bond would be the reference price on a dealer's offsetting buy trade with the selling counterparty. The price paid to the selling counterparty should equal the buying customer's order price less the fair markdown. In either case, if the dealer finds a counterparty that is another customer, we term the riskless principal trade to be a "single-dealer customer-crossed" pair.

Riskless principal trades can also occur when the dealer executes a not-held order from a customer while offsetting the acquired position by trading with a second dealer in the interdealer market. The dealer should execute the customer's trade at the fair markup or markdown relative to the offsetting interdealer market transaction price. The price charged to a buying customer should equal the price paid by the dealer in the interdealer market plus the fair markup. Alternatively, the price paid to a selling customer would be the price received by the dealer in the interdealer market less the fair markdown. When a dealer uses a second dealer as the counterparty to fill a customer order, we term the riskless principal trade as an "interdealer-customer" crossed pair.

2.2 Dealer pricing of crossed-pair transactions

Customers transacting in opaque markets characterized by poor pre-trade and post-trade transparency cannot adequately audit dealer performance on specific trades. Consider, for example, Non-Agency CMO, the privately sponsored structured products based upon pools of residential mortgage collateral. The markets for such securities are illiquid and opaque. There are no price screens offering a real-time view into live quotes for the thousands of existing securities. Thus, buyers and sellers of such securities only learn the prices that bond dealers pay and receive through private disclosures from dealers. Moreover, in sharp contrast to its nearly immediate dissemination of prices from corporate bond transactions, FINRA waits more than 18 months after the trade date to release reports for CMO transactions with trade quantities greater than $1 million. After the 18-month period, the data becomes available for purchase from FINRA in quarterly releases. The absence of timely trade report dissemination in CMO means that customers have no practical way to audit dealer performance. Thus, dealers in CMO have much wider scope to profit from unfair handling of not-held customer orders than in otherwise similar Corporate bond, MBS, and ABS transactions.

For example, in the search for and negotiations with either a second customer or another dealer, the dealer with the not-held customer order may find room to improve upon the order's price terms in the process of crossing the trade. Suppose that the dealer has a customer order to sell at 90.00 and that the fair markdown on such a trade is 0.20%. If the dealer finds a buyer at 90.18, the dealer can execute a sale at 90.18 while simultaneously filling the customer order to sell the security at 90 to earn a fair profit of 0.20% (= [90.18 – 90.00]/90.00). However, suppose that the dealer finds a bid of 92.00 in the interdealer market. A dealer who respects the 0.20% level for a fair customer markdown should execute the same paired sell and buy trades but improve the customer's sell price to 91.816 (0.20%= [92 – 91.816]/91.816). If, instead, the dealer buys from the customer at the original 90.00 order level, while selling on the interdealer market at 92.00, the dealer earns 2.22% (= [92 – 90]/90). Of course, should the dealer buy from the customer at the original 90.00 order level, while selling on the interdealer market at an unexpectedly high 94.00, the dealer would earn 4.44% (= [94 – 90]/90).

By definition, when the dealer applies an unfair markup/markdown, the dealer engages in rent-seeking behavior that ignores the opportunity to improve the customer's price outcome. Had FINRA immediately disseminated the transaction reports for dealer's riskless principal trades, the customer would have seen the unfair pricing and could have disciplined the dealer by withholding future business.

Excessive markups (now using "markup" to refer to both markups and markdowns) are not random outcomes. Randomness does enter the crossing process, but only through the outcomes of the search itself. The dealer with a not-held order from the initiating customer either finds a counterparty willing to offset that order at terms allowing for a fair markup or does not. If such a counterparty is found, the price in the transaction tied to the initiating customer's order is either the order's fixed price or an improved price delivered by the dealer. As in the examples above, by transacting at the order price, the dealer finding a counterparty willing to buy or sell at price terms permitting an improved price at a fair markup makes a specific choice to short-change the initiating customer.

Of course, other outcomes are possible if the dealer's search fails. Suppose that the dealer can only find a counterparty at terms that permit a less-than-fair markup. The dealer can report that failure to the customer and let the customer decide the next step. Else the dealer can decide to fill the customer order at the order price and accept a less-than-fair markup outcome. One can easily imagine that, late in the trading day, a dealer prints a riskless principal trade at cost (i.e., a zero markup) as a service to a good customer, especially if the dealer had provided the customer initial guidance in setting the order price.

In sum, dealers choose the markups they apply to transactions tied to customer orders. In markets with good post-trade transparency, customers can audit dealer performance. Such markets allow customers to withhold future business from dealers found to charge excessive markups as the assumed available transactions data would make it easy to estimate industry-standard ("fair") markups. Consequently, variation of actual outcomes around fair levels should be relatively small.

Because CMO markets do not exhibit timely post-trade transparency, customers lack the information they need to discipline dealers. This lack of discipline incentivizes some dealers to act as bandits, which will produce a pronounced skew in the distribution of markups. Fortunately, FINRA's 18-month-delayed historical transactions database can be used to estimate fair markups and measure the extent of dealer banditry in different segments of the structured product markets.

2.3 Related literature and regulatory background

Previous academic studies of transaction costs in over-the-counter Corporate and Municipal bond markets typically parse transactions data to treat close-in-time "matched pair" roundtrip trades as a separate category. Zitzewitz (2010*),* Harris and Mehta (2020), Ederington, Guan, and Yadav (2020), and Choi, Huh, and Shin (2024) interpret these transactions as representing riskless principal trades. For Corporate bonds trades reported to TRACE from July

8, 2002 through March 31, 2011, Goldstein and Hotchkiss (2020) find mean price point differences between dealer sell and buy prices to be 0.10 for such paired roundtrips, less than half the 0.23 found for other same-day roundtrips, and about one-third the 0.29 found for multi-day roundtrips. For data from 2006 to 2016, Choi, Huh, and Shin (2024) also find the mean percentage price spread for riskless principal trades executed as single-dealer, customer-crossed pairs to be smaller than those for trades requiring dealers to take on inventory. Harris and Mehta (2020) find corresponding mean quarterly price point differences of institutional-sized riskless principal trades to fluctuate between 0.20 and 0.30 over the five years ending June 30, 2019.

These Corporate bond market papers emphasize measuring mean markup levels. Griffin, Hirschey, and Kruger (2023) study customer purchases in the mainly retail-sized Municipal bond market and, armed with codes tracking individual dealers, find that Municipal bond trade markups exhibit considerable variation. Municipal bond trade markups vary widely across trades, even for same-size trades of the same bond on the same day from the same dealer. Bessembinder, Spatt, and Venkataraman (2020) focus on the question of why transaction costs in bond markets are high. The equally compelling question posed by Griffin, Hirschey, and Kruger (2023) asks why bond markups are so variable.

A member dealer violates FINRA Rule 2121 by entering into any transaction with a customer in any security at any price not reasonably related to the current market price of the security. Some wiggle room exists via an exemption for a qualified institutional buyer ("QIB") as defined in Rule 144A under the Securities Act of 1933 that is purchasing or selling a non-investment grade debt security. However, in a June 12, 2018, filing, the SEC has confirmed that undisclosed excessive markups on transactions violate federal anti-fraud securities laws (see In the Matter of Merrill Lynch, Pierce, Fenner & Smith Incorporated, File No. 3-18538): "When a broker-dealer, without disclosure, charges a customer a mark-up that results in a price that is not reasonably related to the prevailing market price, the broker-dealer commits fraud." The specific case involved Merrill personnel who purchased and sold Non-Agency CMO and made false or misleading statements, directly and indirectly, to Merrill customers and/or charged Merrill customers undisclosed excessive markups. While this enforcement action focused on excessive markups, violations of Rule 2121 can also relate to dealer use of unreasonable reference prices.

3. Riskless principal trading activity in structured products

We examine TRACE Enhanced Historical Data for the period beginning May 16, 2011 and ending December 31, 2022. These structured product transactions data include transaction-level information not disseminated to market participants or the public in real time, such as date and time of execution, transaction price, transaction quantity, buy/sell indicator, and anonymized counterparty type (dealer or customer). FINRA tags each CUSIP with one of three labels: MBS, ABS, and CMO. We use data on each security's issuer from LSEG (formerly Refinitiv) Eikon to distinguish Agency CMO from Non-Agency CMO. These transactions data have not previously been studied by academic researchers.

TRACE reports the original face value of the security as the trade quantity. For securitized products, principal repayments on the security's underlying pool of loans shrink the outstanding principal value. The security's "prepayment factor" represents the outstanding percentage of its original face value. The corresponding current face value for any TRACE trade entry can be calculated by multiplying the reported original face value by the security's prepayment factor appropriate for the trade's settlement date. TRACE also provides prepayment factors in each of its trade reports. The TRACE prepayment factor data attached to individual trade reports are 99.7% complete for MBS. However, the prepayment factor data in the TRACE

Enhanced Historical Data are substantially incomplete for both CMO (only 84% complete) and ABS (only 68% complete). We obtained historical factors from LSEG Eikon, which successfully covers 99% of the TRACE CMO trades and 92% of ABS trades. Cross-checks showed consistency of the reported Eikon factors with the available data from TRACE. Some errors in the factors no doubt still remain. Because we found it difficult to assess possible errors in "accrual tranches" of CMO that can generate factors that are much greater than 1.0, we drop the 0.25% of all trades with factors greater than 1.0. For riskless principal trades, we delete all markup observations with negative percentage markups and also those for which the buy or sell price is below one basis point. To mitigate the impacts of other possible price and quantity errors in the TRACE trade reports themselves, we follow Green, Hollifield, and Schürhoff (2007) by winsorizing the current face value and implied percentage price markup data across the full sample at the 0.5% and 99.5% levels.

3.1 Overall structured product trading activity

Table 1 summarizes trading beginning May 16, 2011 and ending December 31, 2022. For subsamples broken down by calendar year, we present (i) the number of issues traded, (ii) the total trading volume measured by current face value, (iii) trading volume per issue, (iv) the total number of trades, (v) the number of trades per issue, (vi) the average trade size, and (vii) the median trade size.

<Insert Table 1 here>

The specified-pool MBS is the largest product sector measured by average number of issues (over 130,000) and average yearly total volume (about $3.1 trillion). While the median trade sizes in all years but 2020 are well below the $100,000 mark traditionally used to distinguish retail from institutional trades, the specified-pool transactions data vastly understate the true size distribution of overall MBS transacting, which also includes the highly-liquid "To-Be-Announced" (TBA) contracts. Corresponding TBA contracting is not available for the other product categories. Even so, the average size of specified-pool MBS trades is about $3.7 million, a decidedly non-retail amount.

The Asset-Backed Security (ABS) trades reported on TRACE show the importance of "per issue" adjustments since their relatively small number of issues – averaging about 4,200 – masks the actual level of liquidity of their roughly $300 billion average yearly total trading volume. While only about one-tenth the size of specified-pool MBS, ABS trading volume per issue (about $76 million) is more than three times larger than that of specified-pool MBS (about $23 million). Not only is average trade size for ABS larger than that for specified-pool MBS, but the median trade size for ABS averaged over $800,000 per calendar year during our sample period. In sum, these TRACE transactions data support the conclusion that ABS trade within an active, institution-oriented market.

The number of Agency CMO issues (over 30,000) and average yearly total volume (just under $900 billion) imply a relatively small average per issue trading volume (about $29 million) despite a large number of trades (averaging over 300,000). At just under $3 million, the average trade size is lower than either MBS or ABS. The calendar year average for Agency CMO median trade size is just over $29,000.

Finally, Non-Agency CMO have only about half the number of issues (just over 17,000) and 40% of the average yearly total volume (about $375 billion) of its Agency CMO counterpart. The number of Non-Agency CMO trades per issue (8.8) is close to that for Agency CMO (10.2). The average Non-Agency CMO trade size ($2.5 million) is about four-fifths that of Agency CMO, while the median trade size (about $38,000) is nearly a third larger.

3.2 Single-dealer customer crossed pairs

A single-dealer customer-crossed pair is created when a dealer acts as a matchmaker transacting against a not-held customer order. The dealer buys (sells) a security from (to) that customer and offsets the position with a companion trade in the same security entered with a second customer. On the one hand, the first customer's incentive to give the dealer an order might be the desire for a more favorable price versus the dealer's terms for immediate execution. On the other hand, the dealer's initial reticence to show favorable prices may reflect a desire to avoid the price change risks of holding inventory. In either case, the propensity to transact via order-driven customer-crossed pairs rather than outright trades may yield more insight into the relative liquidity of the products under study.

We examined all single-dealer customer-crossed pairs defined as quantity-matched customer buys and sells that are completed within 15 minutes absent intervening interdealer trades.[1] We interpret these as resulting from a single dealer (1) taking an order from customer A to sell a security at a fixed price and (2) finding a customer B willing to buy the same quantity of the same security at A's order price plus a markup. The dealer buys the security from A and sells it to B. The dealer profits from the markup applied to its purchase price. Appendix A discusses this and subsequent crossed-pair matching algorithms.

Table 2 reports trading activity for such customer-crossed pairs by presenting (i) the number of issues traded, (ii) the total pairs current face value volume (including both sides of the dealer's trades) as a percentage of total volume, (iii) pairs volume (including just the dealer's buy trades) per issue, (iv) the total number of pairs, (v) the number of pairs per issue, (vi) the average pair size (including just the dealer's buy trades), and (vii) the median pair size (including just the

[1] We follow Choi, Huh, and Shin (2024) in using a 15-minute interval. Our main results would follow through if we instead chose the entire trading day.

dealer's buy trades). For all four products, the transaction profiles of customer-crossed pairs trades are dramatically different from those for overall trading activity reported in Table 1.

<Insert Table 2 here>

First, customer-crossed pairs involve large trades. The average pair sizes range from $5.0 million (Non-Agency CMO) to $8.2 million (MBS). These average pair sizes are more than twice those reported for overall activity in MBS, Agency CMO, and Non-Agency CMO. The average pair size for ABS is about 50% higher than the already large average ABS trade size reported in Table 1. Median pair trade sizes for all four classes of securities are comfortably above the $100,000 retail-trade cutoff, while those for ABS and Non-Agency CMO are higher than the $1 million institutional "round-lot" amount.

The percentages of overall trading volume attributable to customer-crossed pairs differ markedly across products. Such pairs account for only 7.4% of overall volume in MBS. Apparently, dealers are quite confident in either quickly turning over MBS inventory or else placing effective hedges without much trouble. In contrast, dealers show much more inventory risk avoidance in Non-Agency CMO by prearranging customer counterparties that pair off 28.1% of their trades. The crossed-pair volume percentage for ABS rose sharply over the period from mid-teens early on to breach 30% by 2020. Crossed-pair volume percentage for Agency CMO (12.7%) lies between those of MBS and Non-Agency CMO and shows no special time pattern.

3.3 Interdealer-customer crossed pairs

For interdealer-customer crossed pairs, Table 3 presents results for (i) the number of issues traded, (ii) the total pairs volume as a percentage of total volume (again measured by current face value), (iii) pairs volume per issue, (iv) the total number of pairs, (v) the number of pairs per issue, (vi) the average pair size, and (vii) the median pair size.

<Insert Table 3 here>

The transaction profiles of interdealer-customer crossed pairs show some key differences versus customer-crossed pairs trades. While MBS and Agency CMO, the total volumes transacted via interdealer-customer and customer-crossed pairs are roughly the same, interdealer-customer crossed pairs for both ABS (about one-fourth that of single-dealer customer-crossed pairs) and Non-Agency CMO (about one-sixth) are substantially smaller. Relative to the $2.5 - $3.8 million range for single-dealer customer-crossed pairs, the average pair sizes of interdealer-customer crosses are much lower—about $800,000 for MBS, $1.3 million for ABS, $900,000 for Agency CMO, and $425,000 for Non-Agency CMO. Median trade sizes show even more pronounced differences, ranging between $5,000 and $13,000 for MBS, Agency CMO, and Non-Agency CMO, substantially below the $100,000 retail-trade cutoff. The median interdealer-customer crossed pair size for ABS is just below $100,000.

3.3 One-to-many and many-to-many crossed pairs

The crossed-pair matching algorithms for Tables 2 and 3 require trade size equality for each side of the trade. A more general definition would permit “one-to-many” and “many-to-many” matching of customer trades. Such an expanded matching concept would handle the case where large customer positions are crossed against smaller pieces from multiple customer counterparties. Table 4 presents combined results for the “one-to-many” and “many-to-many” crossed-pair categories. Such trades account for only a tiny proportion of overall trading volume, especially for Agency-sponsored securities. The largest such volume share occurred for Non-Agency CMO during 2020 (3.9%), about two-and-a-half times its full sample average of 1.6%.

<Insert Table 4 here>

3.4 Crossed-pair trading volume as a percentage of all trading volume

Aggregated single-dealer customer-crossed pair, interdealer-customer crossed pair, and the remaining combined one-to-many and many-to-many crossed pair data still show that overall trading volume percentages attributable to such riskless principal transactions differ markedly across products. Paired trades account for only 14.8% of overall volume in MBS, 24% in ABS, and 22.7% in Agency CMO. In contrast, paired trades account for 33.3% of Non-Agency CMO volume. Again, by pairing off one-third of their volume, dealers show themselves to be much more sensitive to inventory risk in Non-Agency CMO than in the other product categories.

4. Markups on structured product riskless principal trades

Table 5 presents a regression analysis of markups on single-dealer customer-crossed pair trades. We use markup data for all four products over the full May 16, 2011 to December 31, 2022 sample, but include intercept shift effects for a "Pre-Pandemic Crisis" period defined as January 2020 to February 2020 and a "Post-Pandemic Crisis" period defined as May 2020 to December 2022. We also include intercept shift effects for each day during an intervening "Pandemic Crisis" period beginning March 2, 2020, and ending April 30, 2020. The regression uses MBS as the baseline product and adds product indicators for ABS, Agency CMO, and Non-Agency CMO. The regression uses trades with current face values above $1 million (an institutional round-lot) as the baseline size group and adds trade size indicators for observations with current face values below the usual retail trade cutoff level of $100,000 and those between $100,000 and $1 million (small institutional trades). The regression also includes the intermediary capital ratio, defined as the ratio of total market equity to total market assets (book debt plus market equity) of primary dealer holding companies, as well as interaction terms for this variable with the product indicators. He, Kelly, and Manelo (2017) argue that innovations to the intermediary capital ratio capture shocks affecting the soundness of the financial intermediary sector, such as shocks to agency/contracting frictions.[2]

The regression results show important product-related differences in markups versus MBS. The estimated ABS markup shift is +9 basis points above the 24-basis point intercept estimated for MBS. The estimated Agency CMO markup intercept shift is +36 basis points versus MBS. The estimated Non-Agency CMO markup intercept shift is +114 basis points versus MBS. All three intercept shift effects are statistically significant at standard levels (see the reported p-values). As suggested by previous literature emphasizing a bond dealer's fixed costs of trading, we also find quantitatively important and statistically significant inverse trade size effects on markups. The estimated markup intercept shift on retail trades is +59 basis points higher versus round-lot trades. The estimated markup intercept shift on small institutional-sized trades is +9 basis points versus round-lot trades.

Markups are inversely related to the intermediary capital ratio variable. The slope effect for the baseline MBS trades is highly statistically significant (p-value < .0001). Product indicator interaction terms show that the impacts for ABS and, especially, Non-Agency CMO are even more important. The impact of intermediation stress was quantitatively significant for Non-Agency CMO markups given the measured fall in the intermediary capital ratio variable between February 28, 2020 (6.1%) to its crisis period low on April 3, 2020 (4.0%). The estimates in Table 5 imply that the increases in markups from this extra intermediation stress ranged from 5 basis points for MBS to 23 basis points for Non-Agency CMO. Note that these estimates show that intermediation stress increases the average dealer markup even for these riskless principal trades

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[2] We thank Zhiguo He for providing updated daily data on https://zhiguohe.net/data-and-empirical-patterns/intermediary-capital-ratio-and-risk-factor/.

(in which dealer balance sheet usage does *not* come into play).

<Insert Table 5 here>

Appendix B presents a stylized model extending the bargaining model of Green, Hollifield, and Schürhoff (2007) to a three-party framework where the dealer bargains with both a selling customer and a buying customer. The key idea is that the outcome of the seller–dealer bargaining depends upon the dealer's expected profit from a related sale to the buyer. The price outcomes for both trades determine an equilibrium markup and reflect both customers' reservation prices as well as the dealer's relative bargaining powers. While the model is mute regarding the determination of relative bargaining powers, it seems natural to imagine that a dealer's relative bargaining power may increase during times of market stress and lead to an increase in the equilibrium compensation for trade execution, i.e., an increased markup. Within this view, an inverse relation between markups and the intermediary capital ratio reflects increased value placed by customers on ensuring trade execution.

Markups in both the January-February 2020 period as well as the May-December 2020 period averaged 7 basis points lower than the baseline period. The daily intercept shifts for March 2020 and April 2020 are presented in Figure 1. The plotted coefficients track how the average markup independently varied throughout the most severe stage of the COVID-19 pandemic-related financial market crisis. These estimated shifts show positive and statistically significant (p-values < .0001) impacts for all but one day throughout a crucial 6-day period from March 19, 2020 to March 25, 2020. The largest daily intercept shift (+40 basis points) was associated with dealer trades occurring on Sunday, March 21. The average daily intercept shift for this extremely stressed period is +21 basis points.

On the whole, the measured average markup movements attributable to a falling intermediate capital ratio and the daily intercept shifts during this period appear to be meaningful but manageable for customers. Specifically, average MBS markups shifted by +26 basis points (i.e., about +5 due to an observed decrease in the intermediary capital ratio and +21 in an extra average residual daily effect). It seems sensible to conclude that competition among dealers kept the average markup on this group of riskless-principal, non-balance-sheet-consuming trades reasonably in check even amidst severe market stress. The only outlier among the estimated daily intercept shifts is the +200-basis point shift for April 29, 2020. There is no obvious way to tie this April 29 result to any specific crisis-related effect.

Table 5's regression results yield important insights into systematic impacts on average markups on structured products over our full sample period as well as throughout the COVID-19 market crisis. We now turn to a main concern of Griffin, Hirschey, and Kruger (2023): markup variability. We also draw attention to differences between mean and median markups and the incidence of high-markup trades within each product.

4.1 Analysis of univariate markup distributions

Table 6 summarizes the univariate distributions of markups on single-dealer, customer-crossed pair trades over the full 2011-2022 sample period for the four structured product types as well as for all Corporate bonds. The mean markups for the four structured product types range from 0.15% for ABS to 0.91% for Non-Agency CMO. The mean markups for the two high liquidity products – MBS (0.34%) and ABS (0.15%) – are comparable to that for Corporate bonds (0.31%). The mean markups for the two low liquidity products – Agency CMO (0.75%) and Non-Agency CMO (0.91%) – are much higher. The standard deviations of the markups show a similar pattern. The standard deviation of the markups on Non-Agency CMO is nearly triple that for ABS and two-and-a-half times that for Corporates.

<Insert Table 6 here>

We use median markups to estimate the industry-standard markups. For each product, the median markup is substantially lower than its corresponding mean. The median markups for MBS and ABS are just 0.06% and 0.03%, respectively, and compare favorably to that for Corporate bonds (0.08%). The bottom quartile of trades in these three high-liquidity categories have markups of 0.01% or less. The median markups for Agency CMO and Non-Agency CMO are just 0.22% and 0.29%, respectively. The bottom quartile of Agency CMO pairs cross at markups no greater than 0.03%. The bottom quartile of Non-Agency CMO pairs cross at markups of no greater than 0.12%. Such outcomes support the view that securities dealers perform well for their customers even in the not-fully-transparent markets for CMO.

However, as shown in Figure 2, the right-hand-sides of these markup distributions suggest a very different story for both Agency CMO and Non-Agency CMO. The top quartile of both Agency CMO and Non-Agency CMO pairs cross at markups greater than 1.0%. Such markups are about *quadruple* their median values. The top eighth of both Agency CMO and Non-Agency CMO pairs cross at markups greater than 2.0%. These markups are about *nine times* their median values. Higher-than-1% markups for MBS, ABS, and Corporate trades are much less frequent, but such outcomes do occur.

<Insert Figure 2 here>

4.2 Trade-size impacts on median single-dealer, customer-crossed pair markups

Aa previously argued and documented, markups on smaller trades must exceed those on large trades to pay for the fixed costs of generating any transaction. Table 7 presents median markups computed across alternative trade size buckets for corporate bonds as well as the four structured products over the full sample period. The computed medians display the expected inverse pattern between the magnitude of the markup and trade size. Recall from Table 2 that average crossed-pair trade sizes range between $5.0 million (Non-Agency CMO) and $8.2 million (MBS). The $5 million - $10 million size bucket in Table 6 shows the median markups for such trades: 0.01% for Corporates, 0.03% for MBS and ABS, 0.10% for Agency CMO, and 0.20% for Non-Agency CMO.[3] These estimates, plotted in Figure 3, show a distinct "kink" in the median markup-to-trade size relation for retail-sized trades (i.e., trades sizes below $100,000).

<Insert Table 7 here>

<Insert Figure 3 here>

Figure 4 plots the corresponding standard deviations of markups across alternative trade size buckets for all five categories. Markup variation is higher among smaller trades in all five categories. Agency CMO exhibit high variability for all but the largest trades. Retail-sized Non-Agency CMO trades show the highest standard deviations of markups across all alternative trade size buckets. Non-Agency CMO exhibit high markup variability even for trades sized above $25 million. There is a distinct kink in the inverse standard deviation-versus-trade-size relation for MBS, ABS and Agency CMO at the $100,000 retail size cut-off. Taken together, Table 7 and Figure 3 suggest that trade size is an important determinant of markup distributions and that

[3] One previous SEC investigation provides some insight on perceptions of fair markups via an example negotiated by a customer for a specific Non-Agency CMO transaction (In the Matter of Merrill Lynch, Pierce, Fenner & Smith Incorporated, File No. 3-18538). The SEC describes a dealer-customer negotiation in which the customer agrees to set the markup for a purchase of $30,000,000 in original face value of a specific bond (no factor is provided). The communicated dealer purchase price and actual sale price agreed to by the customer reveal that the buyer believed that a 0.234375 markup (= 41.875 - 41.640625) was "fair" for this purchase. The corresponding percentage markup was 0.563% (=.234375/41.640625). This customer's willingness to knowingly pay this markup indicates the customer believed that 0.563% was "appropriate" for this Non-Agency CMO trade. Actually, our historical markup data in Table 6 for Non-Agency CMO (not available to this customer) shows that a spread closer to 0.20% would have been more in line with industry standards. Furthermore, as this SEC investigation reveals, Merrill Lynch lied about its actual acquisition price (41.00, not 41.640625). Thus, Merrill Lynch's true percentage markup was 2.0% (= .875/41.00), not the 0.563% perceived by the customer. Note that because FINRA did not disseminate a transaction report for this Non-Agency CMO trade on a timely basis, this customer was left in the dark both about the industry standard markup (0.20%) and the actual order-of-magnitude higher markup Merrill Lynch applied (2.0%).

outcomes for retail-size trades differ meaningfully from those for institutional-size trades.

<Insert Figure 4 here>

4.3 Markup impacts of TRACE report dissemination

Table 8 reports regression analyses of markup distributions of all riskless principal structured product trades with current face values of at least $100,000 (i.e., non-retail). The left-hand side reports a regression of percentage markups (the outcome variable) on product indicator variables for ABS, Agency CMO, and Non-Agency CMO, a size indicator for trades with current face values between $100,000 and $1 million, and a transparency indicator for trades subject to contemporaneous TRACE trade report dissemination. The intercept measures the average markup for MBS trades with current face values greater than $1 million (i.e., round-lot). Compared to round-lot MBS and ABS, markups for round-lot Agency and Non-Agency CMO are on average 0.35% and 0.70% higher, respectively. The estimated markup on trades with current face values between $100,000 and $1 million ("odd lot") trades averages about nine basis points higher. The impact of transparency on markups is small and not significantly different from zero.

The left-hand side of Table 8 reports results of a logistic regression designed to assess the incidence of markups greater than 2%. The regression's outcome variable is an indicator variable equal to one if a trade's markup is greater than 2% and zero otherwise. The 2% level is about 10 times the sample median markup on round-lot Non-Agency CMO trades. We interpret markups greater than 2% on non-retail riskless principal trades as reflecting dealer banditry. This logistic regression uses the same independent variables as previously used for the markup regression. Results show statistically significant positive effects on the incidence of banditry for all three product indicator variables (relative to the MBS baseline). The indicator variable for small-sized institutional trades also shows a statistically significant positive effect on the incidence of banditry. Importantly, the impact of transparency on the incidence of banditry is negative and highly significantly different (p-value < .0001).

<Insert Table 8 here>

FINRA began disseminating CMO TRACE reports for trades of less than $1 million in original face value on March 20, 2017. This shift generates a natural experiment for analyzing the effect of increased dissemination on the distribution of markups in both small (less than $1 million in original face value) and larger trades ($1 million or greater in original face value). Using the initiation of size-based asymmetrical dissemination regime for CMO, we estimate Differences-in-Differences regressions on the sample of non-retail CMO trades focused on trades around the $1 million threshold within a Regression Discontinuity design. This design is based upon our expectation that trades of similar size on either side of the $1 million threshold are comparable except for dissemination status. Again, we analyze two outcome variables: percentage markup and the incidence of banditry (i.e., probability of percentage markup greater than or equal to 2%).

Table 9 reports results for four specifications of this analysis with varying definitions of what trades constitute the sample “around $1 million.” A given bandwidth parameter defines the regression sample as $1 million/B to $1 million*B. The first sample includes 28,188 trades with original face values ranging from $500,000 to $2 million (bandwidth parameter B = 2). The second sample includes 42,534 trades with original face values ranging from $333,000 to $3.0 million (bandwidth parameter B = 3). The third sample includes 63,095 trades with original face values ranging from $200,000 to $5.0 million (bandwidth parameter B = 5). For completeness, we also report the results for the entire sample of 145,120 non-retail CMO trades.

Panel A reports results for the percentage markup outcome variable using indicator variables for original face trade size below $1 million, the post-dissemination calendar period, and the key interaction parameter identifying disseminated trades (post March 17, 2020 trades with original face values below $1 million). The regression also includes an indicator variable for the Non-Agency CMO product type and the natural logs of each trade's current and original face values as additional controls. Estimates for the key interaction parameter identifying disseminated trades show that TRACE dissemination of CMO was associated with a 5-basis point decrease in average markups across the three bandwidth samples. The estimated drops in markups are statistically significant at the 10 percent level in all three cases.

Panel B reports corresponding results for the incidence of markup outcomes greater than or equal to 2% ("dealer banditry"). Estimates for the key interaction parameter identifying disseminated trades show that TRACE dissemination of CMO was associated with a decrease in the incidence of dealer banditry across the three bandwidth samples. The estimated drops in markups are statistically significant at the five percent level in three of the four cases. Point estimates indicate a reduction in the incidence of banditry through transparency for trades with less than $1 million in current face compared to larger trades by between 18% (= 1 - exp(-.197)) and 47% (= 1 – exp(-.633)). Interestingly, the incidence of banditry appears to have *increased* after March 17, 2020, within the sample for original face values ranging from $200,000 to $5.0 million and also within the full sample.

Altogether, the results from Tables 8 and 9 support the view that expanding TRACE dissemination for riskless principal CMO trades beyond trades with original face values above $1 million would lead to both lower average markups and a decrease in the incidence of dealer banditry in this currently opaque market sector.

<Insert Table 9 here>

5. Dealer performance in "fire sales"

Table 7's evidence for the medians and bottom quarters of the structured product crossed-pairs markup distributions indicates that dealers apply fair markups on most trades. But the high and variable markups in the upper end of the skewed markup distributions from Table 6 suggest the existence of bandit dealers who violate markup norms.

The performance of structured product dealers upon the onset of the COVID-19 pandemic crisis is of special interest. Beginning in mid-March 2020, the stress on financial markets became so great that the Federal Reserve extended credit under the "unusual and exigent circumstances" provision contained in Section 13(3) of the Federal Reserve Act.[4] He, Nagel, and Song (2022) show that even the Treasury debt market experienced severe stress and illiquidity. More specific to structured product markets, Frame, McCarthy, and Steiner (2021) report that, amid the declining liquidity in agency MBS markets and a widening MBS–Treasury yield spread during this crisis period, many Mortgage Real Estate Investment Trusts (MREIT) faced increased margin calls on their repurchase agreement-based financings. These institutions raised cash by selling assets—including MBS, Agency CMO, and Non-Agency CMO—into an already liquidity-challenged market, creating a feedback loop that forced additional deleveraging amid deteriorating market conditions.[5] In such an environment, some institutional sellers may have had no choice but to hold "fire sales" of their securities portfolios, transactions not driven by fundamentals, but by urgent needs to raise cash. The signatures of a fire sale would be large

[4] See O'Hara and Zhou (2020) for a full review of the March 2020 crisis in fixed income markets.
[5] MREIT balance sheets collectively contracted by $158 billion during the first quarter, or 23 percent from year-end 2019 (see Frame, McCarthy, and Steiner, 2021).

quantities of securities sold within a short interval of time by institutions like mutual funds, hedge funds, and/or MREIT at prices reflecting steep discounts to estimated fair values.

Within all dealing firms, market-making capacity for structured products during March 2020 was constrained by competing internal claims on balance sheet space. Moreover, dealers owned by bank holding companies were limited by Volker-rule restrictions on at-risk principal trading even when presented with opportunities to buy securities at fire-sale prices. In such a chaotic environment, dealers naturally shifted the mode of market-making activities away from providing immediate liquidity for vulnerable sellers toward finding suitable buying counterparties with whom to execute order-driven, riskless-principal trades.

In the context of the model in Appendix B, a fire sale describes a situation where the pressured seller has both a low reservation price and low bargaining power. The model shows how an unscrupulous dealer, in touch with a vulnerable fire-sale seller but constrained by a binding regulatory cap on markups, could be incentivized to collude with a vulture buyer. The aim of the collusion would be to bargain unfairly against the seller to depress the prices paid to the seller. Even if the dealer's markup is set no higher than the cap, the dealer could be enticed by concurrent side payments or future considerations (e.g., promised future high-markup business) from the advantaged buyer. In such a case, the seller's losses would not only include dealer's markup, but also an illegal suppression of prices.

We look for possible fire sales by filtering all crossed-pair trades in Non-Agency CMO (the least liquid structured products) to identify closely-clustered-in-time trades that are open to interpretations as portfolio liquidations intermediated by a single dealer between January 2, 2020, and May 31, 2020. In particular, we construct clusters based upon grouping Non-Agency CMO riskless principal trades executed within fifteen minutes of each other. We allow the dealer to split one side of the transaction into multiple pieces allocated among a set of customer accounts. Whether these multiple pieces are of equal or different sizes, the economics remains the same. Dealers doing this type of quantity intermediation bear no valuation risk and should honor the fair markup rules applicable to simple one-to-one crossed pairs.

We focus on clusters that are at least $100 million in dealer purchase cost and encompass at least 30 different securities. These minimum cluster cost and breadth filters identify seven potential fire sales during our five-month period. We compute two metrics of dealer performance for each cluster: (1) the weighted-average dealer markup and (2) the deviation of the dealer's average buy price relative to a benchmark derived from Bloomberg's evaluated pricing marks for the same securities ("BVAL"). The weighted-average markup is simply the dealer's total riskless principal trading profits on the cluster scaled as a percentage of the dealer's cost in purchasing from the seller. The cluster's average price deviation is derived from the difference in trade prices and Bloomberg's evaluated pricing marks for the cluster's securities after adjusting for any difference between trade prices and BVAL marks for a "control sample" of all other Non-Agency CMO securities not included in any cluster (i.e., a "difference-in-differences" procedure). In particular, for any cluster trade date, we first compute the average difference between the dealer's buy prices and Bloomberg BVAL prices for the cluster's securities for that same day. We next compute the average difference between trade prices and Bloomberg BVAL prices for the control sample of securities for the same date. The derived excess cluster price deviation variable is the difference between cluster's price deviation from BVAL and that day's average discrepancy for the control sample.

Table 10 describes each of the seven clusters by giving its trade date, the number of individual securities contained, the number of the dealer's individual buy and sell trades, the sum of the dollar invoices on the dealer's buy trades, the dealer's total profits (total proceeds from the dealer's sell trades minus the costs of the dealer's buy trades), the weighted-average markup, the cluster's percentage price deviation versus BVAL, the corresponding control sample's percentage price deviation versus BVAL, and the excess cluster price deviation.

As might be anticipated, none of the identified clusters traded prior to mid-March. Five of the clusters traded during the turbulent period between March 19 and April 7. The other two clusters traded after the financial markets had calmed, one on April 29 and another on May 15.

When ranked by dealer cost, the cluster traded on March 25 cluster stands out: 1,408 trades in 243 Non-Agency CMO purchased by a dealer for $1.7 billion and marked-up 3.10% to generate $52.9 million in riskless dealer profits. This cluster is 6.2 times the median size ($275 million) and generated 51.3 times the median profit ($1.03 million) of the other six clusters. This March 25 cluster's 3.10% markup is 8.4 times the median markup (0.37%) for the other six clusters. The only other cluster generating outsized profits was the $494 million cluster traded on April 29 that generated $22.7 million in dealer profits via a 4.61% markup. A third cluster traded on May 15 had a relatively high markup (2.56%) and resulted in dealer profits of $2.8 million. In contrast, four of the clusters show markups no higher than 0.42%, again suggesting that responsible dealers entrusted with trading large Non-Agency CMO positions transacted at reasonably fair markups even during a stressed environment.

Table 10 also analyzes dealer performance regarding prices paid to the potentially distressed sellers of each cluster. Again, the cluster traded on March 25 cluster stands out. This cluster traded an average *discount* to BVAL of 16.4%, while the control security sample traded at a 9.8% *premium* to BVAL. The excess difference between the two implies that the dealer crossing the March 25 cluster paid the seller prices that averaged 26.2% *below* values implied by other non-cluster bonds traded that same day. A t-test rejects that this difference is nonzero at a high level of statistical significance (p-value < .01). Our excess pricing measure for the $131 million cluster of 73 securities traded on March 27 also implies that its dealer priced the cluster at a 15.4% discount to values implied by other non-cluster bonds traded that same day. This difference is statistically significant at the 5% level. None of the other clusters show double-digit or statistically significant pricing deviations.

In sum, Table 10's results for the March 25 cluster stand out in terms of total size ($1.7 billion), breadth (243 distinct securities), dealer profit ($52.2 million), percentage markup (3.1%), and pricing bias (-26.2%). This cluster's characteristics raise suspicion that it represents a fire sale by a vulnerable seller at artificially depressed security prices and an inflated markup. The second largest cluster, traded on April 29, had an even higher markup (4.61%) but traded at a slight premium (actually favoring the seller). The other unusual transaction, the $131.5 million cluster traded on March 27, was sold at a 15.4% discount but was crossed by the dealer at a reasonable 0.31% markup.

<Insert Table 10 here>

6. Crime Scene Investigation

Table 10's results invite a more detailed analysis of the $1.7 billion cluster of March 25, 2020.

6.1 The $1.732 billion portfolio transaction on March 25, 2020: orderly liquidation or hijacking?

A trade-by-trade examination of the time pattern of trade executions within the filter-identified cluster leads us to drop 14 of the original pairs and add nine other crossed pairs.[6] Thus, we classify 1,433 trades in 238 different Non-Agency CMO on March 25, 2020, as single-dealer customer-crossed pair trades that reflect a "one-to-five" crossing mechanism.[7] As it happens, this cluster is the sole example of a one-to-many intermediation among the seven clusters examined in Table 10. For the other six, the intermediating dealer was able to cross all securities in each cluster with a single counterparty.

Our version of TRACE data does not include dealer-identifying codes. We believe these trades to have been crossed by one dealer as all trades within the 238 pairs were time-stamped within twelve minutes of each other and there are no intervening interdealer market trades. The dealer purchased positions in each of 238 securities from one selling customer beginning at 2:07:09. The dealer then sold evenly split portions of these positions to five different customer accounts ending at 2:19:09. To provide some possible context for the trades, we might presume the seller to have been the initiating party, perhaps under pressure to deleverage from repo mark-to-market losses or to raise cash to fund investor redemptions. We might also presume the five buyers to be well-capitalized opportunists ready to pounce on market dislocations.

What are the fair outcomes in this situation? First, the overwhelmed seller liquidates the 238-security, $1.7 billion portfolio for cash. Second, the dealer provides an intermediation service and, bearing no price risk, should follow the rules prohibiting excessive markups. For 238 institutional-sized customer-crossed pairs, the results in Table 7 suggest that the dealer should have charged the normal 0.20% markup placed on institutional-sized trades, or about $3.4

[6] The 14 pairs that we drop are single-dealer customer-crossed pairs that consist of just two trades and that clearly follow a different time pattern. The nine additional pairs were not identified by our automated cluster detection due to reporting inaccuracies (mainly duplicate trade entries).

[7] Actually, 236 of the security cases had a "one-to-five" split (i.e., six trades). One security case was split one-to-four (i.e., 5 trades). For one security case, there are two "one-to-five" splits (i.e., twelve trades). In total, these cases sum up to 6 x 236 + 5 + 12 = 1,433 individual trades.

million on the $1.7 billion portfolio.

Instead, this dealer violated the rules prohibiting excessive markups. The contemporaneous costs to this dealer for the purchases of 238 bonds summed to a total of $1,732,120,647. The 1,194 paired-off bond sales generated proceeds of $1,786,695,854. Thus, the markups applied by this bandit generated an aggregated profit of $54,575,207 in 12 minutes of riskless principal trading. The effective volume-weighted markup percentage on these trades was 3.15%. The unweighted mean markup was 3.01%. Both values are more than *fifteen times larger* than the normal 0.20% markup. Apparently, the dealing firm's compliance department ignored the excessive markups and permitted the trades to be settled as priced.

Figure 5 plots the distribution of percentage markups against the dollar costs of the March 25, 2020, buy trades from the selling customer. The red dashed line indicates the 0.20% benchmark. Only one (at 0.47%) of the 238 markups is close to 0.20%. Twenty trades have markups equal to 0% (see the discussion of Figure 5 below). The remaining 217 of the bandit dealer's buy trades from the vulnerable selling customer show excessive markups. Of these 217 trades, 211 have markups above 2.25%. The highest percentage markup is 4.88%.

<Insert Figure 5 here>

6.2 The $1.732 billion portfolio transaction on March 25, 2020: pricing anomalies

Figure 6 plots the dealer's markups for these 238 crossed pairs in price points (not percentage values) against the dealer's buy price. In all but two cases, Figure 6 reveals that the dealer set price-point markups via a non-standard formula: for Price > 45, Markup = 2; for 20 < Price <= 45, Markup = 1; for Price <= 20, Markup = 0. There is some method to this price point markup madness. This formula for *price point* markups ensures that *percentage* markups fall below the old, and now discredited, NASD 5% markup ceiling. For example, for Price = 46, the

2-point markup implies a 4.35% markup. For Price = 41, the 2-point markup implies a 4.88% markup. Under this regulatory optics logic, a 1-point markup could not be applied to any dollar price of 20 or lower as it would generate a 5% or higher markup. For such cases, the dealer set a zero markup.

<Insert Figure 6 here>

This markup-fixing scheme generates quite non-standard outcomes. For example, one $67,272,675 original face trade for CUSIP 144539AC7 at the dealer-buy price of 42 is worth $27,581,797, but has the cluster's largest percentage markup: 4.88%. Yet, while another $225,487,860 original face trade for CUSIP 3622EUAA4 at a dealer-buy price of 11 is worth only $2,341,523 in market value, it carries the cluster's smallest markup: 0.00%. There are numerous similar examples. Obviously, the dealer is inverting the industry standard of charging high percentage markups on only the smallest dollar value trades. In these unusual trades, the dealer charged its highest spread (4.88%) on one of its largest individual trades.

6.3 Shifts in pair trading patterns of March 25, 2020 Non-Agency CMO group

The unusual ("suspect") March 25, 2020, cluster contains trades in 238 different Non-Agency CMO. During the first quarter of 2020, another 7,342 Non-Agency CMO issues also traded. Table 11 presents results of a before (fourth quarter of 2019) and after (second quarter of 2020) comparison of pair trades in these two Non-Agency CMO groups. Just 22 (9.2%) of the 238 suspect group's securities traded as pairs during the fourth quarter of 2019. This percentage is below the 18.5% traded within the control group of 7,342 other Non-Agency CMO. However, in the second quarter of 2020, the percentage of suspect securities traded in pairs jumped to 100%, while the pair-trade percentage for the control group (22.8%) barely moved. This hyperactivity of pair trading within the suspect securities group deserves further analysis.

<Insert Table 11 here>

6.4 A partial (20%) unwind of the March 25, 2020, clustered pair trade on April 29, 2020?

For present purposes, define the New York City working day to end at 7:00 PM Eastern Time (i.e., end of "regular hours"). Of the 301,252 Non-Agency CMO trades reported in TRACE for our sample period, 99.5% occur before 7:00 PM. We define the 0.5% of trades that occur after 7:00 PM Eastern Time as "after hours" trades.

A second highly suspicious bloc of trades was executed on April 29, 2020 in exactly the same 238 securities that were traded on March 25, 2020. Again, it seems likely that these 238 pairs were crossed by one dealer as all of these highly unusual "after-hours" trades were time-stamped between 7:20:41 PM and 7:27:14 PM. These April 29, 2020 trades likely reflect an unwind of a one-fifth share of a $1.732 billion position that was acquired by a set of five customers just after 2:00 PM on March 25, 2020 (i.e., one of the five vulture customers unwound their full position). The contemporaneous costs to the dealer for the 238 bond purchases summed to a total of $496,763,254. The linked 238 bond sales generated proceeds of $519,675,477. Thus, the markups applied by the dealer generated an aggregated profit of $22,912,223 over a 6.5-minute time span. The effective volume-weighted dealer markup percentage on these riskless crossed pairs was 4.61%. The unweighted mean markup on these pairs was 4.36%.

Figure 7 plots the markups on these 238 crossed-pairs against each pair's market value. The vast majority of the pairs have markups greater than 4.25%, well above the typical markups for crossed trades in the full 2011-2022 sample presented in Tables 4 and 5. These outlier markups can now be seen to have driven the estimated +200-basis point shift "outlier" in Figure 1 for April 29, 2020.

<Insert Figure 7 here>

Of course, it is possible that pandemic-related stresses beginning in mid-March 2020 led to a temporary general increase in intermediation costs during April 2020. Table 12 compares the distribution of percentage markups on the unusual after-hours crossed pairs on April 29, 2020, with the other pairs traded during regular hours on April 29 as well as all regular-hours pairs for the entire week beginning April 27. Of the 226 regular-hours pairs traded for the full week, 82 (36%) were crossed at markups between 0-24 basis points and a total of 159 (70%) were crossed at markups below 100 basis points. Just nine (4.0%) of the week's regular-hours 226 pairs had markups exceeding 400 basis points. The regular-hours pairs crossed on Wednesday, April 29, show similar patterns. The median ("typical") markup was 50 basis points, about double that of the full 2011-2022 sample. However, just two (4.3%) of the 46 regular-hours pairs had markups exceeding 400 basis points.

<Insert Table 12 here>

In sharp contrast, a dense cluster of high-markup trades is observed for the same unusual after-hours transactions identified on Wednesday, April 29. Indeed, 220 (92.4%) of the 238 pairs crossed in the after-hours period on Wednesday, April 29, had markups exceeding 400 basis points. These calculations show that the dealer who crossed the 238 after-hours pairs marked up the typical pair more than *eight times* the median 50-basis point markup for pairs crossed earlier that same day. Again, the dealing firm's compliance department ignored the excessive markups on these highly unusual "after hours" trades and permitted the transactions to be settled as priced.

In spite of these excess markups, the exiting vulture investor reaped significant profits from this investment. Approximating this investor's return by applying the appreciation in recorded transactions prices over the 35-day interval to the initial positions implies a profit of $139.4 million, representing a 39% return on initially invested capital.[8]

6.5 Price suppression on March 25, 2020

A member dealer violates FINRA Rule 2121 by entering into any transaction with a customer in any security at any price not reasonably related to the current market price of the security. If the dealer were acting as an honest broker, the transaction prices on the set of 238 single-dealer customer-crossed pairs traded after 2:00 PM on March 25, 2020, should reflect prevailing interdealer market prices. Alternatively, it is possible that, in violation of FINRA rules, the dealer acted to suppress prices paid to the seller either by misleading this customer about current market conditions and/or by leaking confidential information about the selling customer's vulnerability to the five buyers.

Table 10's evidence indicated that the vulnerable seller on March 25 cluster sold to its dealer at prices averaging 26.2% below trade prices in a control group of securities purchased by dealers that same day. Table 13 provides additional evidence regarding the possibility that the dealer and the consortium of buying counterparties conspired in an illegal enterprise to acquire the 238 Non-Agency CMO positions at unfair terms from the dealer's vulnerable selling customer. Table 13 presents prices for the five securities among the set of 238 securities having individual TRACE reports for additional non-clustered transactions on March 25, 2020. Compare the pricing details of the suspect transactions, reported on the left-hand-side of the table, with the five "benchmark" transactions on the table's right-hand-side. In each case, the sale price of the suspect crossed-pair transaction is lower than that of its benchmark transaction

[8] This approximation ignores both the positive effects coupon interest and principal repayments and the negative effects of any credit losses.

price. The average discount is 23.59% (quite close to the estimated 26.2% discount from Table 9). The median discount is 20%.

We calculate the impact on the seller's proceeds for these five positions if the new benchmark prices were substituted for the (suppressed) actual prices paid by the dealer. The total value loss to the seller of this suppression of five security prices is a proceeds shortfall of $14.6 million. This shortfall represents 36.2% of the counterfactual proceeds calculated on the basis of benchmark prices, much larger than the calculated mean and median price discounts because the largest discount is applicable to the largest individual position and the smallest discount is applicable to the smallest individual position. If the median 20% suppression were applied uniformly across the entire $1.732 billion portfolio, the total loss for the vulnerable seller due to price suppression versus counterfactual proceeds of $2.078 billion would have been $346 million.

<Insert Table 13 here>

A final benchmarking approach analyzes the 39.0% "bounceback" return on the 238-security portfolio between March 25, 2020, and April 29, 2020 (i.e., the return to the vulture investor's initial capital upon an April 29, 2020, unwinding date). Table 14 reports results from a comparison of this 39% capital gain return to observed total returns on the two mutual funds entering March 2020 that both reported assets of more than $100 million and reported Non-Agency CMO holdings (Morningstar data and category definitions) greater than 50% of assets. The two funds are the Rational Special Situations Income Fund (RFXIX) and the Angel Oak Multi-Strategy Income Fund (ANGIX). The average total return on the two funds for this period was 6.57%. We impute returns on the Non-Agency CMO portion of each fund's holdings from the fund's realized net asset value return for two different assumptions for returns on their other holdings: 3.20% (the periodic return on the US Aggregate Investment Grade Index) and 1.44% (the periodic return on the iShares MBS ETF). The implied average returns on the Non-Agency CMO holdings of the funds are 8.55% and 9.57%, respectively. Under these benchmarks, the vulture investor's "bounceback" return of 39% generates unexplained components of 30.45% and 29.43%, respectively, even larger than the 20% median estimate taken from the five same bond/same day TRACE data (Table 13) and the 26.2% estimate based on trades from the control securities (Table 10).

<Insert Table 14 here>

6.6 A joint bandit-vulture enterprise?

We interpret this evidence to show that the bandit dealer not only charged excessive markups, but also orchestrated a price suppression of at least 20% of the initial $1.732 billion transaction with the vulnerable seller. Clearly, the price suppression hurt the seller's interests to the great advantage of the vulture buyers. But the excessive markups both on the initial buy trades and, especially, on the one-fifth unwind of the positions on April 29, 2020 hurt the exiting vulture investor.

The relationship between the bandit and the exiting vulture investor might be best interpreted as a joint enterprise. The vulture investor gained $139.4 million in 35 days. The dealer profited from this investor via excess markups twice: first, by $10.9 million (calculated as one-fifth of the $54.5 million total) of markups on the initial March 25, 2020 trades, and second, by $22.9 million on markups associated with the vulture's exit trades. Thus, the joint enterprise initiated on March 25 generated $173.2 million in profits (i.e., $10.9 + $139.4 + $22.9). We interpret the dealer's 4.62% markup on the April 29 unwind trade as being set to bring the dealer's total markups on the roundtrip trade to $33.8 million (i.e., $10.9 + $22.9). In this fashion, the bandit captured about 20% of the $173.2 million gains to the joint enterprise (i.e., $33.8/$173.2 = 19.5%). Twenty percent is the standard "performance-based incentive fee" in the hedge fund industry. Here, we view the dealer facilitating the initial March 25, 2020, transaction as the "performer."

7. Conclusions

When acting as a mere matchmaker transacting against a customer order, a bond dealer searches for a companion trade in the same security with a second counterparty to provide an immediate position exit. Such riskless principal trades take place in all OTC debt markets. Dealers find pair trades attractive because, as opposed to true immediate liquidity provision, they generate no new inventories. Riskless principal trades account for about one-third of the trading volume in Non-Agency CMO, the most illiquid of the four structured product types we examine.

Dealers profit from the markups they apply to customer orders when the offsetting exit trade is arranged. FINRA rules require dealers to transact with customers at a price that reflects the prevailing market price of the security and a fair markup. Using the full sample of available TRACE data, we estimate median ("typical") markups on average-sized riskless principal trades for MBS and ABS to be just 0.03%, comparable to the 0.02% observed for Corporate bonds. Corresponding median markups Agency CMO (0.10%) and Non-Agency CMO (0.20%) are higher.

The markup distributions in all four products are highly skewed. The top quartile of both Agency CMO and Non-Agency CMO pairs cross at markups more than *quadruple* their median values. The top eighth of both Agency CMO and Non-Agency CMO pairs cross at markups more than *nine times* their median values. Judging from the medians and bottom quarters of the markup distributions, most customers on both sides of pairs trades receive very attractive pricing even in these non-transparent markets. Yet, the upper end of the distributions suggests that customers are routinely short-changed by bandit dealers.

Of special interest is how dealers perform in large transactions involving multiple securities (“clusters”) under stressed conditions, like those observed during the chaotic COVID-19 pandemic week beginning March 23, 2020. Twenty-five of the 125 largest clusters of Non-Agency CMO we identified during this stressed period were marked-up more than *double* the median markup during the same week and *ten times* the full-sample median markup on institutional-sized trades. In one particular cluster traded on March 25, 2020, one dealer made $54.5 million in riskless profits by buying 238 Non-Agency CMO worth $1.732 billion from a single seller, while simultaneously splitting sales of these same positions among five counterparty accounts at markups about *fifteen times* the relevant full-sample median level of 0.20%.

A comparison of the pricing details of the suspect 238 transactions with benchmark transactions on a subset of the same securities on the same day suggests that the bandit dealer also orchestrated a price suppression of about 20%. Such suppression benefited the buying group and, under this possibly conservative 20% estimate, disadvantaged the seller by another $346 million. One of the buyers realized a $139.4 million capital gain (a 39% return) after unwinding 35 days later on April 29, 2020, in highly unusual “after hours” trades that netted the dealer an extra $22.9 million in markup profits. The dealing firm’s compliance department failed to stop the suspect trades on both days from being settled as priced.

Previous academic studies and our estimates here show that timely TRACE dissemination has helped create a level playing field for Corporate bond, MBS, and ABS market participants. FINRA currently withholds timely transactions data from CMO investors for trades greater than $1 million in original face value. Customers have no defense against bandit dealers who use their informational advantage to reap excessive markups on riskless principal trades. Our analysis of the March 25, 2020, "crime scene" makes the costs of withholding this information from vulnerable customers all too real.

The usual industry arguments against timely dissemination of transactions reports involve business risks from possible reverse engineering of both dealer inventories and dealer trading strategies. TRACE transactions reports on riskless principal trades carry no information about dealer inventories. The only dealer trading strategy that would be exposed by timely dissemination is dealer banditry. Thus, the policy recommendations from our findings are straightforward. First, FINRA should require dealers to flag riskless principal trades in TRACE reporting. Second, FINRA should begin near real-time dissemination of TRACE transaction reports on all riskless principal trades in all structured products, including extensions beyond CMO to Commercial Mortgage-Backed Securities (CMBS), Collateralized Loan Obligations (CLO), and Collateralized Debt Obligations (CDO). Moving these markets into the light will enable all customers to both expose the bandits and reward their more responsible competitors.

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Table 1. Summary Statistics for Trading in Corporates, ABS, MBS, Agency CMO, and Non-Agency CMO by Product and Calendar Year

Sample: May 16, 2011–December 31, 2022.

Year	Number of Traded Issues (in 1,000)	Total Volume Traded (Current Face, in $billion)	Total Volume per Issue (in $1,000)	Number of Trades (in 1,000)	Number of Trades per Issue	Average Trade Size (in $1,000)	Median Trade Size (in $1,000)
Panel A: Mortgage-Backed Securities-Specified Pools							
2011	103.02	1,652.6	16,041	510.7	4.96	3,236.0	91.2
2012	145.77	2,896.0	19,867	836.1	5.74	3,463.6	93.4
2013	150.02	2,623.1	17,485	923.3	6.15	2,840.9	43.4
2014	147.33	1,992.8	13,526	851.6	5.78	2,340.0	51.7
2015	132.49	2,470.1	18,643	750.9	5.67	3,289.5	64.7
2016	146.93	3,026.5	20,599	783.5	5.33	3,862.8	71.8
2017	125.39	2,842.2	22,667	809.5	6.46	3,510.9	29.8
2018	128.91	2,636.6	20,452	813.7	6.31	3,240.2	18.6
2019	120.58	3,503.9	29,058	770.8	6.39	4,545.8	35.5
2020	130.53	5,109.8	39,145	825.2	6.32	6,192.3	145.3
2021	133.65	4,914.0	36,768	920.4	6.89	5,339.0	70.3
2022	127.24	3,473.9	27,302	1,312.8	10.32	2,646.2	4.1
Averages	**132.66**	**3,095.1**	**23,463**	**842.4**	**6.36**	**3,708.9**	**60.0**
Panel B: Asset-Backed Securities							
2011	2.30	187.7	81,447	34.5	14.99	5,432.0	1,094.9
2012	2.99	336.4	112,599	64.3	21.50	5,236.2	1,069.3
2013	3.24	323.9	100,092	75.9	23.46	4,267.0	870.3
2014	3.74	395.1	105,739	87.8	23.48	4,503.1	905.5
2015	4.22	372.2	88,289	88.6	21.01	4,201.8	998.0
2016	4.45	342.5	76,931	86.4	19.40	3,966.0	952.8
2017	4.75	406.9	85,600	97.4	20.49	4,177.7	750.0
2018	4.91	355.7	72,499	102.5	20.90	3,468.8	700.0
2019	4.85	258.7	53,298	95.6	19.69	2,706.4	623.0
2020	5.00	269.7	53,949	87.6	17.51	3,080.9	820.0
2021	5.14	199.1	38,758	75.5	14.69	2,637.6	626.0
2022	5.06	201.2	39,793	90.8	17.95	2,217.1	298.2
Averages	**4.22**	**304.1**	**75,749**	**82.2**	**19.59**	**3,824.5**	**809.0**
Panel C: Agency Collateralized Mortgage Obligations							
2011	24.81	658.1	26,525	308.7	12.44	2,131.8	22.6
2012	33.41	1,086.1	32,513	481.8	14.42	2,254.1	25.0
2013	31.16	910.3	29,216	413.8	13.28	2,199.5	22.8
2014	30.28	838.1	27,679	336.2	11.10	2,493.0	24.5
2015	30.12	715.6	23,758	318.8	10.59	2,244.3	23.0
2016	29.78	800.6	26,884	293.9	9.87	2,723.6	25.0
2017	30.36	787.2	25,928	300.1	9.89	2,622.9	23.0
2018	30.39	787.4	25,913	282.2	9.29	2,789.9	21.7
2019	33.68	944.6	28,045	307.9	9.14	3,068.2	27.0
2020	35.20	1,207.6	34,304	269.9	7.67	4,473.7	45.0
2021	32.22	1,106.9	34,352	241.4	7.49	4,585.8	50.0
2022	27.04	822.4	30,419	196.3	7.26	4,189.7	40.0
Averages	**30.70**	**888.7**	**28,795**	**312.6**	**10.20**	**2,981.4**	**29.1**
Panel D: Non-Agency Collateralized Mortgage Obligations							
2011	15.90	324.4	20,403	149.5	9.41	2,169.1	30.0
2012	21.38	649.7	30,386	247.2	11.56	2,628.7	41.2
2013	20.30	539.2	26,558	228.3	11.24	2,362.4	32.0
2014	20.38	521.3	25,587	209.1	10.26	2,493.2	33.5
2015	19.25	452.6	23,519	176.6	9.18	2,562.8	31.7
2016	17.89	363.6	20,329	152.5	8.53	2,383.5	34.4
2017	17.55	341.4	19,456	142.7	8.13	2,392.5	27.0
2018	15.13	270.3	17,864	121.0	7.99	2,234.6	24.6
2019	13.76	251.0	18,243	109.3	7.95	2,295.7	27.2
2020	15.00	340.3	22,682	113.3	7.55	3,002.9	84.1
2021	15.21	267.7	17,602	104.2	6.85	2,569.0	40.7
2022	12.67	212.7	16,790	83.7	6.61	2,540.3	45.8
Averages	**17.03**	**377.9**	**21,618**	**153.1**	**8.77**	**2,469.6**	**37.7**

Table 2. Summary Statistics for Single-Dealer, Customer-Crossed Pairs in Corporates, ABS, MBS, Agency CMO, and Non-Agency CMO by Product and Calendar Year

In a customer-crossed pair, a dealer buys (sells) a security from (to) a customer and offsets the position with a companion trade in the same security done with a second customer. Sample: May 16, 2011–December 31, 2022.

Year	Number of Traded Issues (in 1,000)	Pairs Volume Traded (Current Face)	Percentage of Total Volume (in %)	Pair Volume per Issue (in $1,000)	Number of Traded Pairs (in 1,000)	Number of Pair Trades per Issue	Average Pair Size (in $1,000)	Median Pair Size (in $1,000)
Panel A: Mortgage-Backed Securities-Specified Pools								
2011	7.89	43.10	5.22	5,461	10.67	1.35	4,039.2	84.8
2012	13.68	79.31	5.48	5,798	19.42	1.42	4,084.4	95.2
2013	13.69	80.82	6.16	5,905	24.08	1.76	3,356.2	38.3
2014	12.55	60.63	6.08	4,832	18.15	1.45	3,341.4	89.1
2015	11.31	90.98	7.37	8,043	16.26	1.44	5,594.2	226.0
2016	10.26	97.84	6.47	9,541	13.28	1.29	7,368.6	322.8
2017	8.28	85.61	6.02	10,337	10.50	1.27	8,150.9	771.5
2018	7.58	97.09	7.36	12,815	9.81	1.30	9,893.7	1,324.3
2019	8.13	141.27	8.06	17,373	10.57	1.30	13,360.5	1,737.8
2020	11.99	275.03	10.76	22,948	16.42	1.37	16,746.7	2,357.7
2021	12.43	236.93	9.64	19,055	20.89	1.68	11,344.5	1,847.5
2022	10.42	173.61	10.00	16,655	15.47	1.48	11,225.8	1,770.2
Averages	**10.68**	**121.85**	**7.39**	**11,563**	**15.46**	**1.43**	**8,208.8**	**888.8**
Panel B: Asset-Backed Securities								
2011	0.86	17.25	18.39	19,971	1.84	2.13	9,372.5	1,800.0
2012	1.25	15.66	9.31	12,490	2.84	2.26	5,518.9	1,038.8
2013	1.37	17.42	10.76	12,697	3.34	2.43	5,215.6	1,162.8
2014	1.65	27.89	14.12	16,863	4.17	2.52	6,696.6	1,589.3
2015	1.95	31.78	17.08	16,266	6.17	3.16	5,148.1	1,599.6
2016	2.13	24.74	14.45	11,638	5.36	2.52	4,612.8	1,500.0
2017	2.03	28.49	14.00	14,005	4.83	2.37	5,899.1	1,845.5
2018	2.04	27.27	15.33	13,349	5.10	2.50	5,349.4	1,706.9
2019	2.23	27.43	21.20	12,298	5.74	2.57	4,778.0	1,542.0
2020	2.80	44.52	33.01	15,904	8.13	2.90	5,478.9	2,000.0
2021	2.42	24.28	24.39	10,046	5.09	2.10	4,773.0	1,769.0
2022	2.59	31.31	31.12	12,084	6.25	2.41	5,013.5	1,797.0
Averages	**1.94**	**26.50**	**18.60**	**13,968**	**4.90**	**2.49**	**5,654.7**	**1,612.6**
Panel C: Agency Collateralized Mortgage Obligations								
2011	4.93	33.91	10.30	6,879	8.32	1.69	4,076.7	16.6
2012	6.81	49.65	9.14	7,291	12.55	1.84	3,956.3	21.5
2013	5.89	52.75	11.59	8,955	11.13	1.89	4,740.5	25.8
2014	5.85	49.33	11.77	8,428	9.65	1.65	5,111.4	44.2
2015	5.42	52.44	14.66	9,668	7.92	1.46	6,617.8	113.3
2016	5.57	54.68	13.66	9,820	8.19	1.47	6,677.7	111.6
2017	5.23	44.71	11.36	8,552	7.19	1.38	6,219.1	101.6
2018	5.22	51.20	13.00	9,805	7.24	1.39	7,073.0	145.5
2019	6.34	70.97	15.03	11,188	8.85	1.40	8,017.0	299.7
2020	6.70	107.27	17.77	16,008	8.93	1.33	12,007.9	1,606.1
2021	4.73	64.22	11.60	13,580	6.31	1.33	10,179.4	819.0
2022	3.65	53.33	12.97	14,631	4.82	1.32	11,071.3	1,000.0
Averages	**5.53**	**57.04**	**12.74**	**10,400**	**8.42**	**1.51**	**7,145.7**	**358.8**
Panel D: Non-Agency Collateralized Mortgage Obligations								
2011	5.89	45.65	28.15	7,747	10.11	1.72	4,517.1	596.2
2012	9.67	88.82	27.34	9,188	17.74	1.84	5,006.3	995.3
2013	8.98	78.87	29.25	8,783	14.58	1.62	5,410.6	1,433.7
2014	8.58	67.18	25.77	7,829	13.78	1.61	4,877.0	980.4
2015	8.54	70.84	31.30	8,299	12.79	1.50	5,537.7	1,348.4
2016	8.11	66.45	36.55	8,192	11.87	1.46	5,600.2	1,330.7
2017	7.30	53.37	31.27	7,317	10.12	1.39	5,276.8	849.1
2018	5.27	33.67	24.91	6,388	7.19	1.36	4,681.6	913.3
2019	4.86	30.58	24.37	6,290	6.67	1.37	4,586.3	680.1
2020	6.29	52.63	30.93	8,370	9.36	1.49	5,624.8	1,783.6
2021	5.10	24.77	18.50	4,854	6.66	1.31	3,719.1	896.7
2022	3.98	30.21	28.41	7,598	5.48	1.38	5,508.5	1,333.5
Averages	**6.88**	**53.59**	**28.06**	**7,571**	**10.53**	**1.50**	**5,028.8**	**1,095.1**

Table 3. Summary Statistics for Interdealer-Customer Crossed Pairs in Corporates, ABS, MBS, Agency CMO, and Non-Agency CMO by Product and Calendar Year

In an interdealer-crossed pair, a dealer buys (sells) a security from (to) a customer and offsets the position with a companion trade in the same security done with a second dealer. Sample: May 16, 2011–December 31, 2022.

Year	Number of Traded Issues (in 1,000)	Pairs Volume Traded (Current Face, in $billion)	Percentage of Total Volume (in %)	Pair Volume per Issue (in $1,000)	Number of Traded Pairs (in 1,000)	Number of Pair Trades per Issue	Average Pair Size (in $1,000)	Median Pair Size (in $1,000)
Panel A: Mortgage-Backed Securities-Specified Pools								
2011	20.20	63.91	0.08	3,163	78.32	3.88	816.0	9.8
2012	35.22	111.89	0.08	3,177	153.24	4.35	730.2	9.6
2013	31.45	97.47	0.07	3,099	168.51	5.36	578.4	5.8
2014	27.39	73.38	0.07	2,680	134.33	4.91	546.3	4.9
2015	28.30	72.35	0.06	2,557	117.05	4.14	618.1	4.8
2016	27.41	88.41	0.06	3,226	118.93	4.34	743.4	4.5
2017	28.48	87.67	0.06	3,078	139.96	4.91	626.4	3.7
2018	26.98	79.34	0.06	2,941	145.45	5.39	545.5	3.2
2019	28.20	126.90	0.07	4,501	139.53	4.95	909.4	3.3
2020	25.92	177.33	0.07	6,843	141.66	5.47	1,251.9	4.0
2021	27.27	194.08	0.08	7,117	169.06	6.20	1,148.0	3.0
2022	27.84	196.32	0.11	7,052	177.83	6.39	1,104.0	2.6
Averages	**27.89**	**114.09**	**0.07**	**4,120**	**140.32**	**5.02**	**801.5**	**4.9**
Panel B: Asset-Backed Securities								
2011	0.83	6.97	0.07	8,424	2.41	2.90	2,900.1	450.0
2012	1.26	10.53	0.06	8,334	4.46	3.53	2,362.7	404.1
2013	1.29	7.27	0.04	5,629	5.21	4.03	1,396.3	100.0
2014	1.33	9.23	0.05	6,933	6.04	4.54	1,527.5	19.0
2015	1.38	8.66	0.05	6,277	5.91	4.29	1,464.6	50.0
2016	1.45	8.21	0.05	5,652	5.76	3.96	1,426.2	65.0
2017	1.49	7.17	0.04	4,808	7.27	4.87	986.7	10.0
2018	1.66	6.44	0.04	3,879	7.25	4.37	888.7	23.0
2019	1.21	4.58	0.04	3,773	5.28	4.35	867.0	8.0
2020	1.29	3.59	0.03	2,780	5.09	3.93	706.7	15.0
2021	0.98	3.84	0.04	3,936	4.81	4.93	798.6	9.0
2022	1.20	3.23	0.03	2,695	5.90	4.92	547.6	7.0
Averages	**1.28**	**6.64**	**0.04**	**5,260**	**5.45**	**4.22**	**1,322.7**	**96.7**
Panel C: Agency Collateralized Mortgage Obligations								
2011	9.79	34.58	0.11	3,532	47.07	4.81	734.7	16.6
2012	13.60	54.97	0.10	4,042	77.78	5.72	706.8	19.1
2013	11.55	39.21	0.09	3,396	61.12	5.29	641.6	15.0
2014	11.40	33.66	0.08	2,952	47.75	4.19	705.0	14.6
2015	11.03	33.32	0.09	3,020	45.90	4.16	725.9	13.0
2016	10.97	42.03	0.11	3,831	41.74	3.80	1,006.9	14.2
2017	11.47	40.89	0.10	3,566	47.15	4.11	867.4	10.0
2018	11.23	39.38	0.10	3,508	47.05	4.19	837.1	8.7
2019	12.44	48.61	0.10	3,907	55.53	4.46	875.4	9.0
2020	12.17	53.42	0.09	4,391	48.74	4.01	1,096.1	11.8
2021	10.56	54.81	0.10	5,192	43.20	4.09	1,268.6	13.0
2022	8.90	40.35	0.10	4,532	31.87	3.58	1,266.2	11.0
Averages	**11.26**	**42.94**	**0.10**	**3,822**	**49.57**	**4.37**	**894.3**	**13.0**
Panel D: Non-Agency Collateralized Mortgage Obligations								
2011	4.15	8.85	0.05	2,130	14.40	3.47	614.1	19.4
2012	6.49	14.27	0.04	2,197	26.37	4.06	541.1	19.4
2013	6.00	11.57	0.04	1,929	25.65	4.28	451.0	15.7
2014	5.88	11.05	0.04	1,880	21.01	3.57	526.0	15.0
2015	5.21	8.75	0.04	1,679	18.83	3.61	464.8	10.4
2016	5.04	10.32	0.06	2,047	15.82	3.14	652.5	10.4
2017	4.77	7.00	0.04	1,467	17.75	3.72	394.1	7.8
2018	4.11	4.28	0.03	1,042	14.36	3.50	297.9	6.8
2019	3.72	3.02	0.02	813	12.21	3.28	247.7	5.6
2020	3.63	4.28	0.03	1,179	11.76	3.24	363.9	5.9
2021	3.64	3.06	0.02	843	11.72	3.22	261.6	4.9
2022	3.03	2.26	0.02	745	8.27	2.73	273.1	4.5
Averages	**4.64**	**7.39**	**0.04**	**1,496**	**16.51**	**3.49**	**424.0**	**10.5**

Table 4. Analysis of Trading Activity: "One-to-Many" and "Many-to-Many" Crossed Pairs by Product and Calendar Year

These single-dealer, customer-crossed pairs are those cases where customer positions are crossed by aggregating pieces from multiple customer counterparties. Sample: May 16, 2011–December 31, 2022.

Year	Number of Traded Issues (in 1,000)	Pairs Volume Traded (Current Face, in $billion)	Percentage of Total Volume (in %)	Pair Volume per Issue (in $1,000)	Number of Traded Pairs (in 1,000)	Number of Pair Trades per Issue	Average Pair Size (in $1,000)	Median Pair Size (in $1,000)
Panel A: Mortgage-Backed Securities-Specified Pools								
2011	0.12	0.37	0.04	3,093	0.13	1.08	2,851.7	129.6
2012	0.24	0.39	0.03	1,619	0.26	1.07	1,513.1	161.4
2013	0.22	0.93	0.07	4,255	0.24	1.08	3,948.4	159.1
2014	0.16	0.55	0.06	3,535	0.18	1.11	3,171.1	1,110.0
2015	0.08	0.96	0.08	11,699	0.09	1.13	10,314.9	1,399.5
2016	0.10	1.63	0.11	16,421	0.11	1.06	15,482.7	871.8
2017	0.07	0.41	0.03	6,115	0.07	1.06	5,770.6	453.6
2018	0.06	1.48	0.11	26,965	0.06	1.05	25,570.0	4,834.0
2019	0.09	1.85	0.11	19,690	0.09	1.00	19,689.9	687.0
2020	0.14	4.52	0.18	32,975	0.15	1.09	30,319.5	4,000.0
2021	0.24	4.47	0.18	18,614	0.27	1.11	16,731.6	2,250.0
2022	0.10	1.69	0.10	17,256	0.11	1.07	16,105.6	1,730.9
Averages	**0.13**	**1.60**	**0.09**	**13,520**	**0.15**	**1.08**	**12,622.4**	**1,482.3**
Panel B: Asset-Backed Securities								
2011	0.03	0.79	0.84	28,310	0.03	1.04	27,333.9	10,000.0
2012	0.04	0.96	0.57	24,097	0.04	1.00	24,096.5	7,467.1
2013	0.05	1.20	0.74	23,452	0.06	1.08	21,746.2	3,585.3
2014	0.05	0.93	0.47	20,577	0.06	1.36	15,179.7	5,000.0
2015	0.06	1.83	0.99	32,174	0.08	1.39	23,213.9	3,750.0
2016	0.07	2.19	1.28	29,964	0.09	1.26	23,776.0	13,065.3
2017	0.07	1.88	0.92	28,019	0.07	1.04	26,818.5	10,200.0
2018	0.08	2.18	1.22	27,910	0.08	1.08	25,916.8	8,900.0
2019	0.05	0.98	0.76	19,618	0.05	1.06	18,507.1	7,190.0
2020	0.12	2.34	1.73	19,789	0.14	1.14	17,297.0	8,685.0
2021	0.07	1.05	1.06	15,514	0.08	1.24	12,559.1	6,325.0
2022	0.09	1.36	1.35	15,073	0.10	1.09	13,842.1	8,566.5
Averages	**0.06**	**1.47**	**0.99**	**23,708**	**0.07**	**1.15**	**20,857.2**	**7,727.8**
Panel C: Agency Collateralized Mortgage Obligations								
2011	0.35	0.64	0.20	1,821	0.39	1.11	1,640.1	44.7
2012	0.51	1.24	0.23	2,409	0.64	1.25	1,928.7	58.9
2013	0.40	0.89	0.20	2,247	0.49	1.23	1,823.2	65.2
2014	0.28	1.26	0.30	4,466	0.32	1.15	3,887.3	85.4
2015	0.30	1.63	0.46	5,487	0.33	1.10	4,999.2	114.9
2016	0.34	1.71	0.43	5,007	0.39	1.16	4,333.2	96.2
2017	0.33	1.33	0.34	4,035	0.38	1.14	3,539.6	116.2
2018	0.27	1.47	0.37	5,371	0.31	1.12	4,792.0	56.2
2019	0.35	2.80	0.59	7,999	0.39	1.12	7,124.1	72.0
2020	0.27	2.70	0.45	9,849	0.31	1.12	8,761.9	100.1
2021	0.12	1.19	0.22	9,708	0.13	1.06	9,185.0	207.7
2022	0.09	1.27	0.31	14,116	0.09	1.00	14,115.6	110.1
Averages	**0.30**	**1.51**	**0.34**	**6,043**	**0.35**	**1.13**	**5,510.8**	**94.0**
Panel D: Non-Agency Collateralized Mortgage Obligations								
2011	0.32	2.08	1.29	6,473	0.61	1.89	3,433.5	29.0
2012	0.53	3.46	1.07	6,500	0.74	1.38	4,713.5	70.5
2013	0.40	2.85	1.06	7,156	0.44	1.10	6,517.2	297.0
2014	0.38	2.41	0.93	6,334	0.40	1.06	5,988.3	232.3
2015	0.28	2.64	1.17	9,317	0.30	1.07	8,730.6	370.1
2016	0.38	3.82	2.10	10,055	0.39	1.04	9,698.0	1,158.8
2017	0.31	3.63	2.13	11,594	0.32	1.03	11,269.6	781.4
2018	0.22	1.73	1.28	7,816	0.23	1.05	7,445.1	97.4
2019	0.20	1.21	0.96	6,032	0.21	1.05	5,744.9	115.8
2020	0.43	6.64	3.90	15,593	0.45	1.04	14,927.4	9,948.3
2021	0.14	0.87	0.65	6,072	0.15	1.03	5,907.1	245.3
2022	0.11	0.99	0.93	8,995	0.11	1.00	8,995.5	5,788.3
Averages	**0.31**	**2.69**	**1.45**	**8,495**	**0.36**	**1.14**	**7,780.9**	**1,594.5**

Table 5. Regression Analysis of Markups on Single-Dealer, Customer-Crossed Pairs of ABS, MBS, Agency CMO, and Non-Agency CMO

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price) in a quantity-matched, riskless principal trade crossed by a single dealer. Full Sample: May 16, 2011–December 31, 2022. The "Pre-Pandemic Crisis" period is defined as January 2020 – February 2020. The "Post-Pandemic Crisis" period is defined as May 2020 – December 2022. Intermediate Capital Ratio is as the ratio of total market equity to total market assets (book debt plus market equity) of primary dealer holding companies. We cluster standard errors by month.

	Coefficient (%)	T-stat	P-value
Intercept	0.243	7.1	0.000
Product indicator: ABS	0.093	2.0	0.050
Product indicator: CMO agency	0.364	7.9	0.000
Product indicator: CMO non-agency	1.141	25.2	0.000
Trade Size indicator: Current Face < 100,000	0.593	33.1	0.000
Trade Size indicator: $100,000 < Current Face < $1 million	0.089	13.7	0.000
Jan 2020 - Feb 2020 "Pre-Pandemic Crisis" period	-0.072	-7.0	0.000
May 2020 - Dec 2022 "Post-Pandemic Crisis" period	-0.073	-5.6	0.000
Intermediary Capital Ratio	-2.368	-3.9	0.000
Intermediary Capital Ratio*Product Indicator: ABS	-1.806	-2.4	0.019
Intermediary Capital Ratio*Product Indicator: Agency CMO	-0.402	-0.5	0.606
Intermediary Capital Ratio*Product Indicator: Non-Agency CMO	-8.771	-10.9	0.000
Daily Intercept Indicator Estimates March 2020 - April 2020	See Figure 1.		
Adjusted R-Square	.151		
Observations	454,144		

Table 6. Comparison of Markup Distributions on Single-Dealer, Customer-Crossed Pairs of Corporates, ABS, MBS, Agency CMO, and Non-Agency CMO

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price) in a quantity-matched, riskless principal trade crossed by a single dealer. Full Sample: May 16, 2011–December 31, 2022.

				Percentiles										
Product	Number Obs.	Mean	Std. Dev.	5	12.5	25	37.5	50	62.5	75	87.5	95	97.5	99
Corporates	36,745,645	0.31%	0.54%	0.00%	0.00%	0.00%	0.00%	0.08%	0.11%	0.31%	0.98%	1.62%	2.00%	2.35%
ABS	58,130	0.15%	0.48%	0.00%	0.00%	0.00%	0.01%	0.03%	0.06%	0.12%	0.26%	0.68%	1.14%	2.17%
MBS	170,808	0.34%	0.74%	0.00%	0.00%	0.01%	0.03%	0.06%	0.12%	0.32%	0.85%	1.59%	2.28%	3.39%
Agency CMO	100,124	0.75%	1.13%	0.00%	0.00%	0.03%	0.10%	0.22%	0.50%	1.01%	2.04%	3.00%	3.79%	5.15%
Non-Agency CMO	125,082	0.91%	1.34%	0.00%	0.03%	0.12%	0.18%	0.29%	0.55%	1.15%	2.44%	3.63%	4.79%	7.27%

Table 7. Median Markups by Trade Size Bucket on Single-Dealer, Customer-Crossed Pairs of Corporates, ABS, MBS, Agency CMO, and Non-Agency CMO

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price) in a quantity-matched, riskless principal trade crossed by a single dealer. Full Sample: May 16, 2011–December 31, 2022.

Trade Size Bucket	Corporates	ABS	MBS	Agency CMO	Non-Agency CMO
Below $100,000	0.094%	0.063%	0.230%	0.653%	1.010%
$100,000-$500,000	0.044%	0.030%	0.085%	0.147%	0.299%
$500,000-$1 million	0.025%	0.016%	0.057%	0.155%	0.274%
$1-$5 million	0.018%	0.030%	0.029%	0.128%	0.246%
$5-$10 million	0.006%	0.031%	0.027%	0.101%	0.200%
$10-$25 million	0.001%	0.020%	0.022%	0.047%	0.174%
Above $25 million	0.000%	0.014%	0.015%	0.023%	0.147%

Table 8. Markup Distributions and TRACE Dissemination

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price) in a quantity-matched, riskless principal trade crossed by a single dealer. The left-hand side reports results of an OLS regression; the right-hand side shows log-odds for a logistic regression modeling the probability that the markup is at least 2%. All regressions include monthly fixed effects. The base group is defined as MBS trades with current face values greater than $1 million. We exclude retail trades from the sample (i.e., trades where current face value is less than $100,000). Transparency equals 1 if trade reports are disseminated for a particular trade and zero otherwise. Dissemination began for MBS starting on July 22, 2013, for ABS starting on June 1, 2015; and for CMO with an original face value above $1 million starting on March 20, 2017. We cluster standard errors by month.

	Outcome Variable: Percentage Markup			Outcome Variable: Probability of Percentage Markup ≥ 2%		
	Coefficient (%)	T-stat	P-value	Coefficient	χ^2	P-value
Intercept	0.101	6.0	.000	-5.218	984.2	.000
Product ABS	0.006	0.9	.397	0.938	24.0	.000
Product Agency CMO	0.254	17.1	.000	2.214	153.3	.000
Product Non-Agency CMO	0.604	30.6	.000	3.152	343.2	.000
Between $100,000 and $1 Million	0.087	13.9	.000	0.334	123.6	.000
Transparent	-0.001	-0.1	.937	-0.918	83.9	.000
Month Fixed Effects	Yes			Yes		
Observations	302,051			302,051		

Table 9. Results from Differences-in-Differences Regression of CMO Markups before vs. after Small-Trade TRACE Dissemination

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price) in a quantity-matched, riskless principal trade crossed by a single dealer. We exclude retail trades from the sample (i.e., trades where current face value is less than $100,000). Panel A reports results of an OLS regression; Panel B shows log-odds for a logistic regression modeling the probability that the markup is at least 2%. All regressions include monthly fixed effects. The base group is defined as CMO trades with original face values greater than $1 million. Post 2017 is 1 starting on March 20, 2017. Models with a "B" parameter include all trades with original face values between $1,000,000/B and $1,000,000*B (e.g., when B = 2, the sample includes trades with original face values between $500,000 and $2,000,000). We cluster standard errors by month.

Panel A. Outcome Variable: Percentage Markup

	B = 2			B=3			B=5			All Trades		
	Coefficient (%)	T-stat	P-value	Coefficient (%)	T-stat	P-value	Coefficient (%)	T-stat	P-value	Coefficient (%)	T-stat	P-value
Post 2017*Original Face<$1 million	-0.054	-1.9	0.063	-0.048	-1.7	0.092	-0.061	-2.2	0.030	-0.189	-7.4	0.000
Post 2017	-0.347	-31.4	0.000	-0.137	-13.4	0.000	0.017	1.9	0.054	0.083	17.1	0.000
Original Face<$1 million	0.008	0.3	0.731	0.004	0.2	0.868	-0.013	-0.7	0.513	0.074	3.5	0.001
Product Non-Agency CMO	0.395	15.2	0.000	0.393	15.3	0.000	0.384	15.5	0.000	0.320	15.6	0.000
Ln(original face)	0.106	3.4	0.001	0.095	4.8	0.000	0.067	5.3	0.000	0.066	7.0	0.000
Ln(current face)	-0.069	-4.9	0.000	-0.073	-5.3	0.000	-0.075	-6.6	0.000	-0.072	-10.4	0.000
Intercept	0.104	0.2	0.808	0.080	0.3	0.744	0.411	2.9	0.004	0.432	4.9	0.000
Observations	28,188			42,534			63,095			145,120		

Panel B. Outcome Variable: Probability of Percentage Markup ≥ 2%

	B = 2			B=3			B=5			All Trades		
	Coefficient	χ^2	P-value	Coefficient	χ^2	P-value	Coefficient	χ^2	P-value	Coefficient (%)	χ^2	P-value
Post 2017*Original Face<$1 million	-0.197	2.2	0.138	-0.245	4.2	0.039	-0.285	6.0	0.015	-0.633	33.7	0.000
Post 2017	-1.264	981.7	0.000	-0.238	53.3	0.000	0.200	53.2	0.000	0.511	1479.4	0.000
Original Face<$1 million	0.065	0.7	0.419	0.032	0.2	0.641	-0.030	0.3	0.587	0.232	17.2	0.000
Product Non-Agency CMO	1.477	231.5	0.000	1.395	255.4	0.000	1.262	257.4	0.000	0.903	193.5	0.000
Ln(original face)	0.325	10.5	0.001	0.233	15.7	0.000	0.140	14.3	0.000	0.162	44.0	0.000
Ln(current face)	-0.171	17.1	0.000	-0.182	22.5	0.000	-0.193	41.4	0.000	-0.180	111.4	0.000
Intercept	-4.662	11.9	0.001	-4.451	37.3	0.000	-3.102	50.3	0.000	-3.385	179.1	0.000
Observations	28,188			42,534			63,095			145,120		

Table 10. Details on Clusters of Non-Agency CMO trades worth at least $100 million that traded during the January – May 2020 period

CUSIPs in Cluster denotes the number of individual securities contained in the cluster, Trades in Cluster denotes the number of the dealer's individual buy and sell trades contained in the cluster, Dealer Cost denotes the sum of the dollar invoices on the dealer's buy trades in the cluster, and Dealer Profit is the difference between the sum of the dollar proceeds from the dealer's sell trades and Dealer Cost. A cluster's Weighted-Average Markup is Dealer Profit expressed as a percentage of Dealer Cost. Cluster Trade Price Diff to BVAL denotes the average percentage difference of the dealer's buy prices relative to that date's Bloomberg BVAL marks. Control Trade Price Diff denotes the average percentage difference of the prices at which dealers bought other Non-Agency CMOs on the same day relative to that date's Bloomberg BVAL marks. Excess Cluster Price Difference (Cluster-Control) denotes the difference between the Cluster Trade Price Diff to BVAL and the Control Trade Price Diff. The values in bold are statistically significant from zero at 5% level.

Trade Date	Execution Time	CUSIPs in Cluster	Trades in Cluster	Dealer Cost	Dealer Profit	Weighted-Average Markup	Cluster Trade Price Deviation from BVAL	Control Trade Price Deviation from BVAL	Excess Cluster Price Deviation (Cluster-Control)
3/19/2020	5:08:42 PM	33	66	$165,479,150	$439,583	0.27%	-22.9%	-18.5%	-4.5%
3/25/2020	1:31:52 PM	243	1,408	$1,707,578,280	$52,934,596	3.10%	-16.4%	9.8%	**-26.2%**
3/27/2020	3:59:42 PM	73	146	$131,500,569	$412,040	0.31%	-2.3%	13.0%	**-15.4%**
4/1/2020	5:30:17 PM	130	260	$411,633,598	$345,445	0.08%	2.7%	3.1%	-0.4%
4/7/2020	5:13:23 PM	111	222	$385,155,106	$1,623,436	0.42%	-2.6%	-3.2%	0.6%
4/29/2020	7:20:41 PM	237	496	$493,555,499	$22,761,041	4.61%	2.2%	-1.3%	3.5%
5/15/2020	3:52:28 PM	62	124	$109,191,644	$2,794,392	2.56%	0.7%	-0.7%	1.4%

Table 11. Pre-period (fourth quarter of 2019) and Post-period (second quarter of 2020) breadth and volume comparisons for pair trades in the suspect 238 Non-Agency CMO that traded on March 25, 2020 to the 7,342 other Non-Agency CMO that traded during first quarter of 2020

The results show a dramatic increase in the trading activity of the suspect bonds relative to other Non-Agency CMO during the second quarter of 2020.

Group	Number of Issues	Quarter	Number of Traded Issues	Percent Traded	Pairs Volume (Current Face)	Pair Trade Percentage of Volume	Pair Volume per Issue	Number of Traded Pairs
Suspect 3/25/20 Bonds	238	Q4-2019	15	6.3%	$ 155,312,490	28.0%	$ 10,354,166	17
Other Non-Agency CMO	7,342	Q4-2019	596	8.1%	$ 2,857,093,533	18.4%	$ 4,793,781	731
Suspect 3/25/20 Bonds	238	Q2-2020	234	98.3%	$ 1,377,715,742	63.1%	$ 5,887,674	363
Other Non-Agency CMO	7,342	Q2-2020	1,010	13.8%	$ 6,174,048,197	40.7%	$ 6,112,919	1,380

Table 12. Markup distributions on the after-hours crossed pairs on April 29, 2020 vs. both the regular-hours pairs for April 29, 2020, and the regular-hours pairs for the Full Week beginning April 27, 2020

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price, expressed here in basis points) in a quantity-matched, riskless principal trade crossed by a single dealer.

Markup (in Basis Points)	After hours on Apr 29	Regular hours on Apr 29	Regular hours Entire Week
0-24 BP	3	16	82
25-49 BP	8	7	43
50-74 BP	3	2	25
75-99 BP	0	3	9
100-199 BP	0	10	32
200-299 BP	2	2	15
300-399 Bp	2	4	11
400-499 BP	220	2	4
500-999 BP	0	0	4
1000 BP+	0	0	1
Total	238	46	226
Pct trades >400 BP markup	92.4%	4.3%	4.0%

Table 13. Comparison of actual prices and proceeds of five dealer Non-Agency CMO purchases contained within the suspect March 25, 2020 cluster to benchmark prices and counterfactual proceeds

Benchmark prices on the five securities are sourced from other same-security trades on March 25, 2020. Counterfactual proceeds are derived by substituting the benchmark price for the actual price of each trade.

					Actual		Benchmark		Actual-Benchmark	
CUSIP	Execution Time	Original Face	Factor	Current Face	Price	Proceeds	Price	Proceeds	Difference ($)	Difference (%)
45254NLK1	2:07:29PM	$44,989,000	0.02236	$1,006,083	59.00000	$593,589	64.53125	$649,238	($55,649)	-8.6%
026932AC7	2:07:47PM	$100,130,000	0.36863	$36,910,608	33.00000	$12,180,501	63.25000	$23,345,960	($11,165,459)	-47.8%
54251UAD8	2:08:13PM	$35,289,000	0.55428	$19,560,092	22.00000	$4,303,220	28.50000	$5,574,626	($1,271,406)	-22.8%
55275BAC1	2:08:14PM	$22,237,000	0.43958	$9,775,037	29.00000	$2,834,761	35.68750	$3,488,466	($653,706)	-18.7%
00442KAC5	2:08:48PM	$45,406,325	0.40209	$18,257,462	32.00000	$5,842,388	40.00000	$7,302,985	($1,460,597)	-20.0%
Total						$25,754,459		$40,361,275	($14,606,816)	-36.2%

Table 14. Comparison of vulture investor's return to benchmarks from two large mutual funds with high concentrations of Non-Agency CMO holdings

The top panel's comparison is based on the funds' total returns and computes the unexplained excess of the vulture investor's return relative to the average fund return (+32.44%). The middle panel's comparison is based on the implied returns of fund Non-Agency CMO holdings assuming a 3.2% return on other fund holdings and computes the unexplained excess of the vulture investor's return relative to the average implied fund return on Non-Agency CMO holdings (+30.45%). The bottom panel's comparison is based on the implied returns of funds' Non-Agency CMO holdings assuming a 1.44% return on other fund holdings and computes the unexplained excess of the vulture investor's return relative to the average implied fund return on Non-Agency CMO holdings (+29.43%).

Fund Name	Holdings Report Date	Assets	Non-Agency CMO Holdings ($)	Non-Agency CMO Holdings (%)	Return %
Rational Special Situations Income Fund	2/29/2020	$179,484,840	$130,820,578	72.9%	6.43%
Angel Oak Multi-Strategy Income Fund	1/31/2019	$7,598,598,907	$4,243,983,634	55.9%	6.70%
Average of Funds					6.57%
Vulture Investor Capital Gain Return (39.0%) - Fund Average					**32.44%**
Assumed Residual Assets Return (US Aggregate Investment Grade Index):		3.20%			
Implied Non-Agency CMO Holdings Return					
Rational Special Situations Income Fund					7.63%
Angel Oak Multi-Strategy Income Fund					9.47%
Average of Funds					8.55%
Vulture Investor Capital Gain Return (39.0%) - Fund Average					**30.45%**
Assumed Residual Assets Return (iShares MBS Mortgage ETF):		1.44%			
Implied Non-Agency CMO Holdings Return					
Rational Special Situations Income Fund					8.29%
Angel Oak Multi-Strategy Income Fund					10.86%
Average of Funds					9.57%
Vulture Investor Capital Gain Return (39.0%) - Fund Average					**29.43%**

Figure 1. Markup Regression's Estimated Daily Intercept Shifts during Pandemic Crisis period beginning 03/02/20 and ending 04/30/20. (Regression reported in Table 5.)

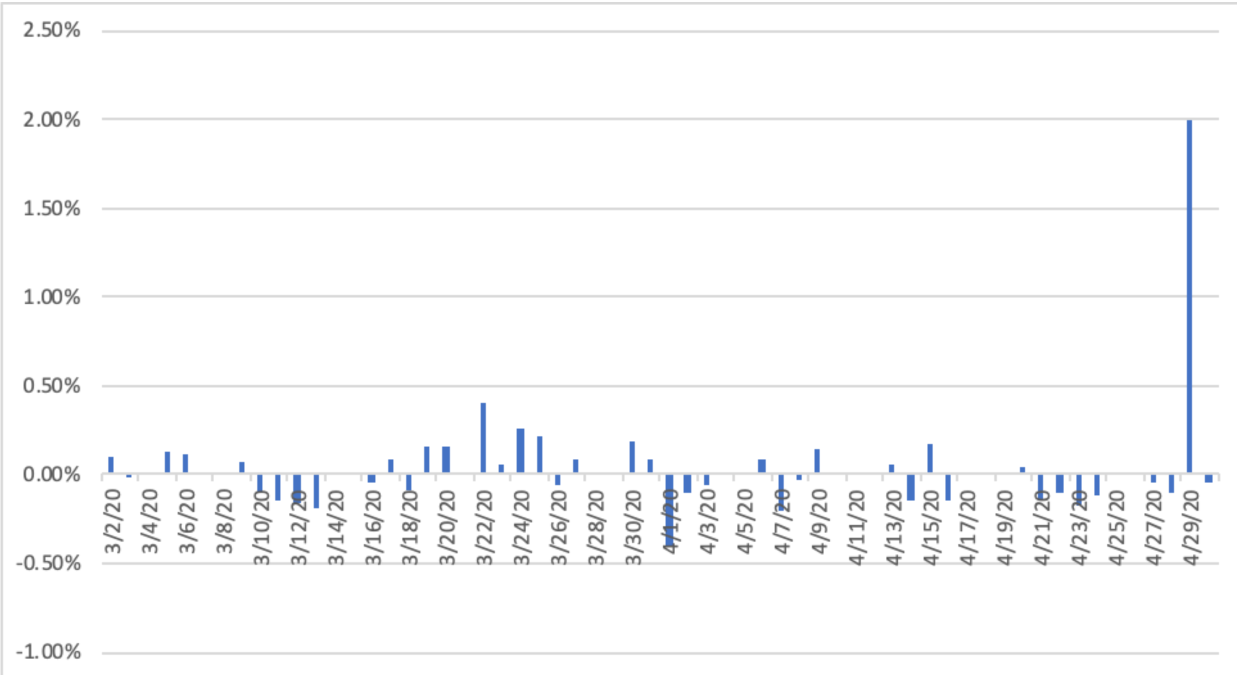


Figure 2. Comparison of Markup Distributions on Single-Dealer, Customer-Crossed Pairs of Corporates, ABS, MBS, Agency CMO, and Non-Agency CMO

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price) in a quantity-matched, riskless principal trade crossed by a single dealer. Full Sample: May 16, 2011–December 31, 2022.

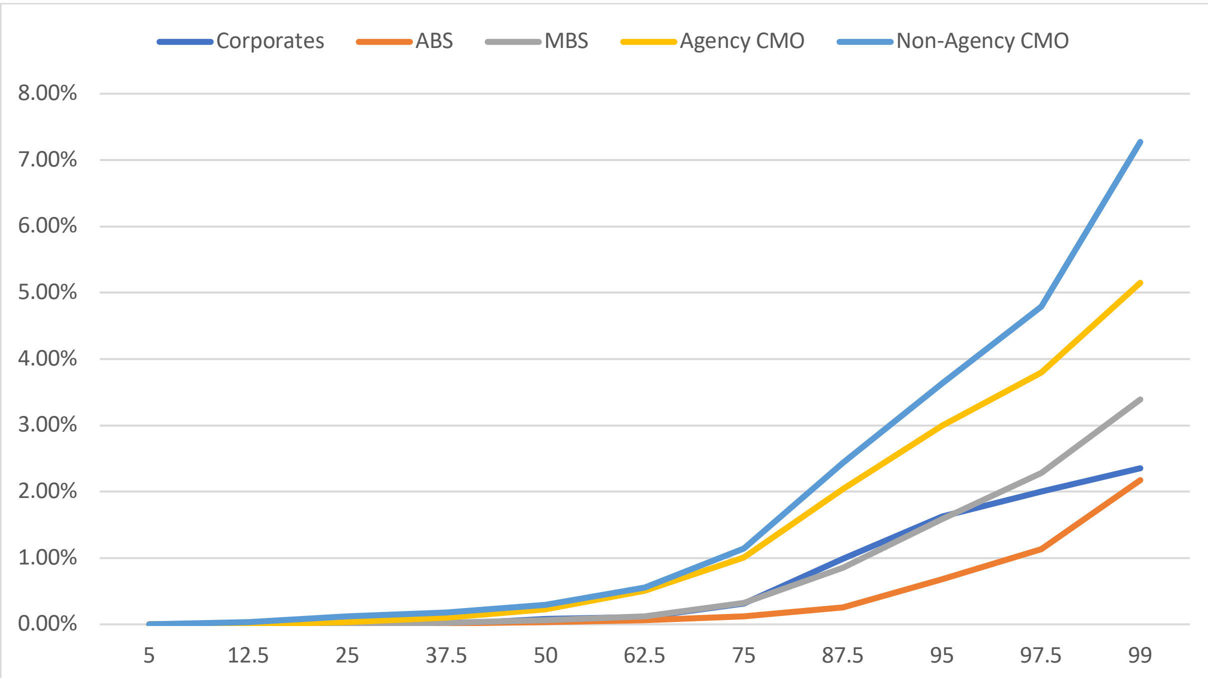


Figure 3. Distribution of Markups by Trade-Size Bucket on Single-Dealer, Customer-Crossed Pairs for Corporates, ABS, MBS, Agency CMO, and Non-Agency CMO

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price) in a quantity-matched, riskless principal trade crossed by a single dealer. Full Sample: May 16, 2011–December 31, 2022.

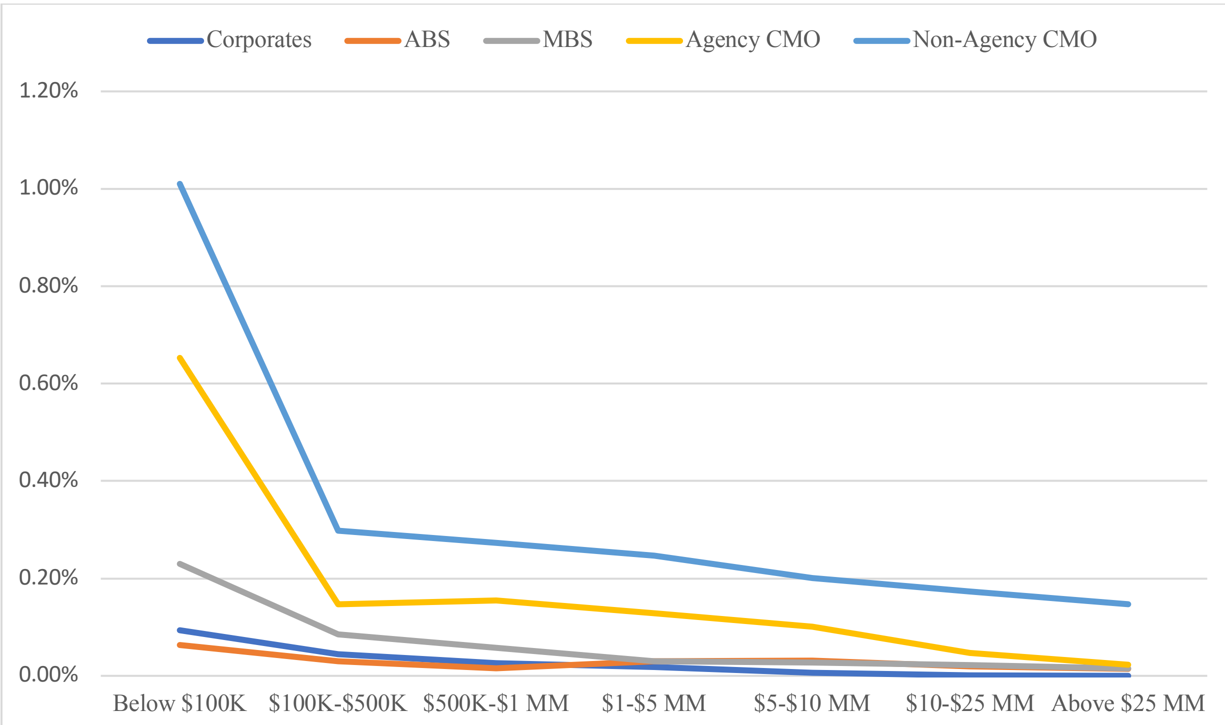


Figure 4. Standard Deviations of Markups for Single-Dealer Customer Crossed Pairs by Trade-Size Bucket for Corporates, ABS, MBS, Agency CMO, and Non-Agency CMO

Markup is defined as the difference between the sale price to one customer minus the purchase price from a second customer (as a percentage of the purchase price) in a quantity-matched, riskless principal trade crossed by a single dealer. Full Sample: May 16, 2011–December 31, 2022.

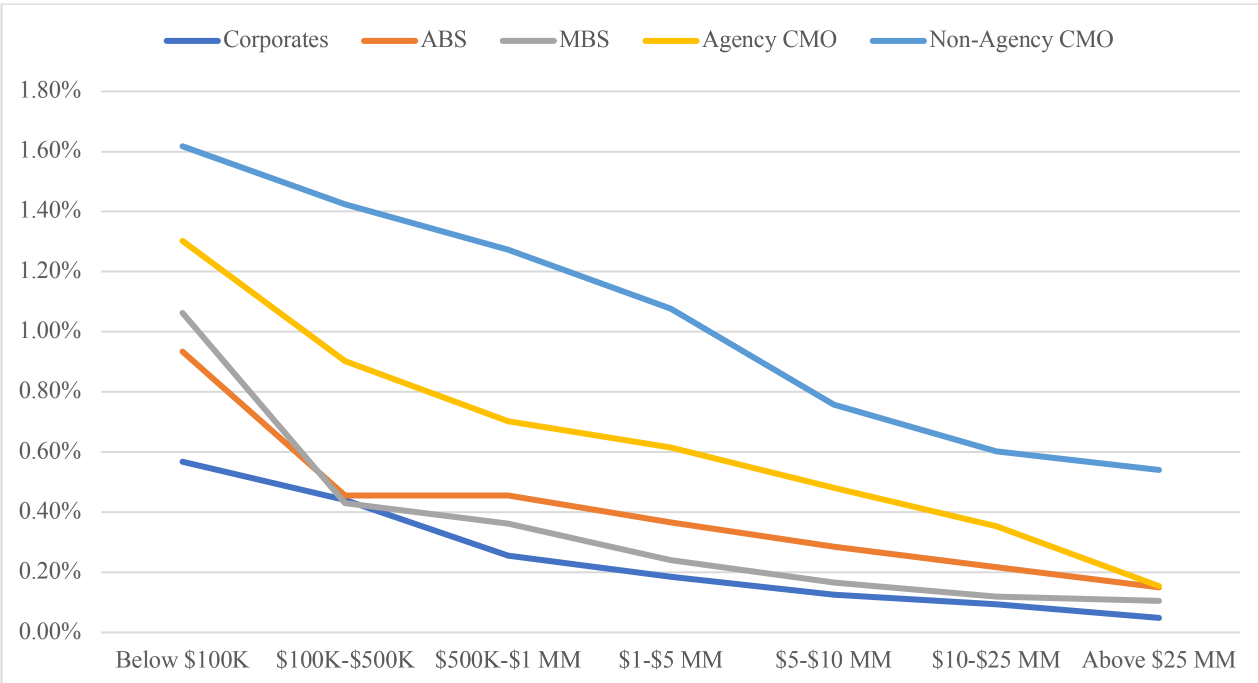


Figure 5. Dealer Markups (%) on the 238 Suspect March 25, 2020, Riskless Principal Trades Plotted versus the Dollar Invoice Market Values of Buy Trades ($ Million)

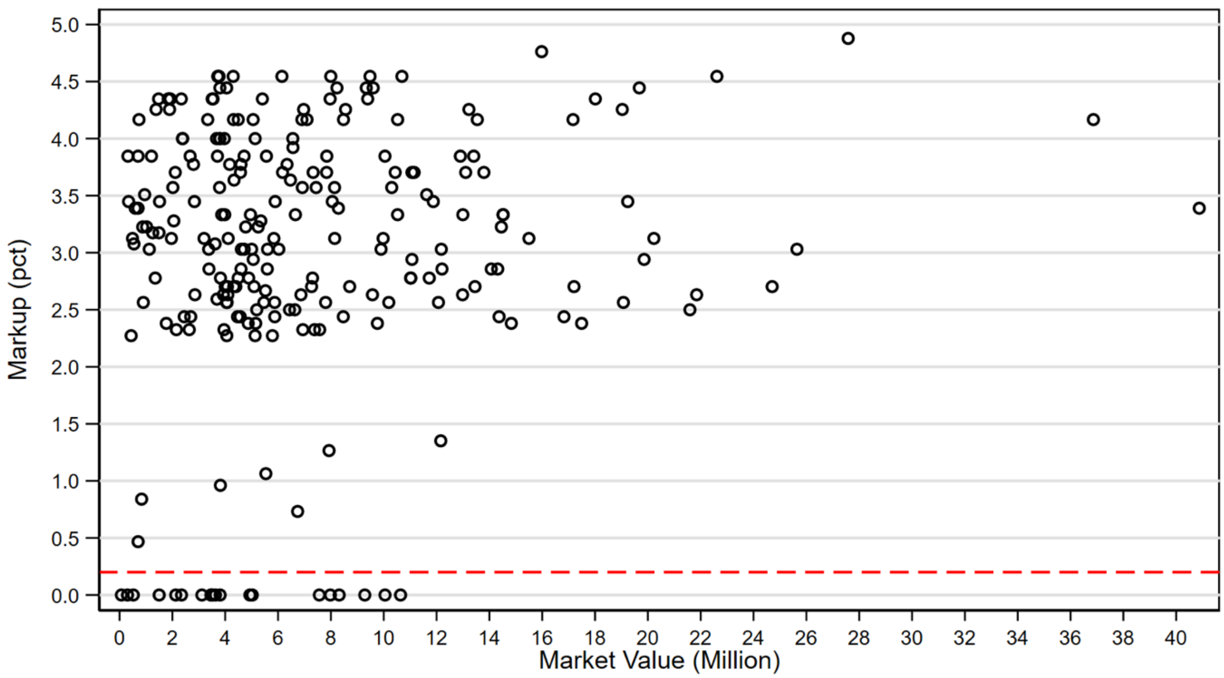


Figure 6. Dealer Price Point Markups on 238 Riskless Principal Trades versus Dealer Buy Price

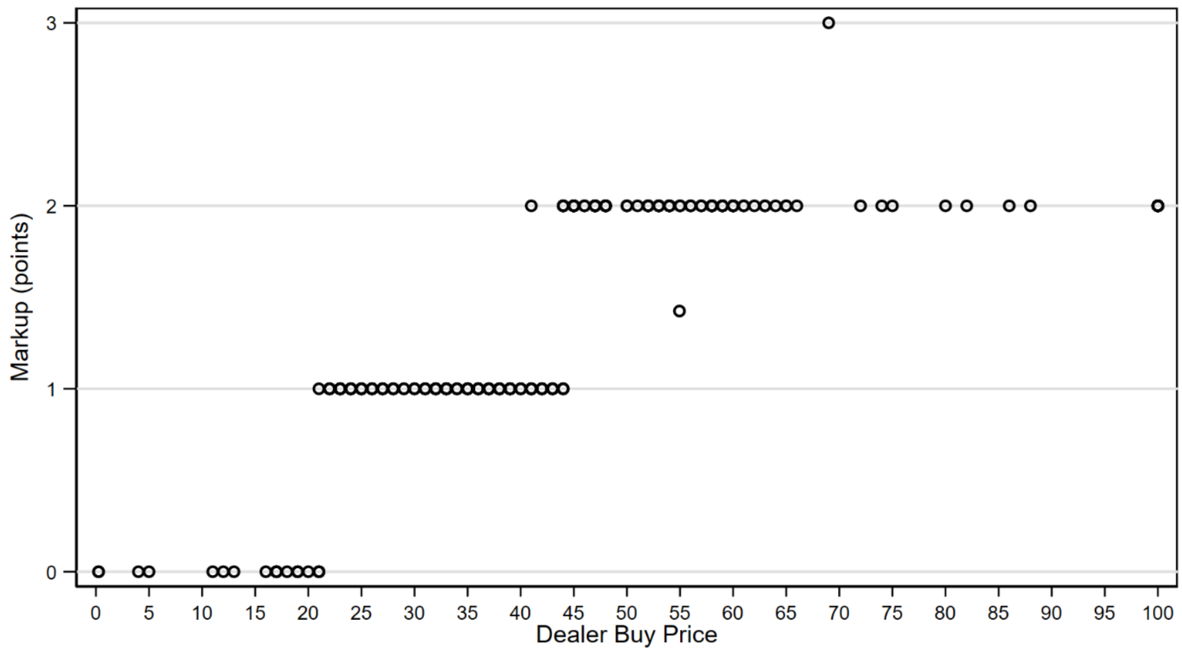
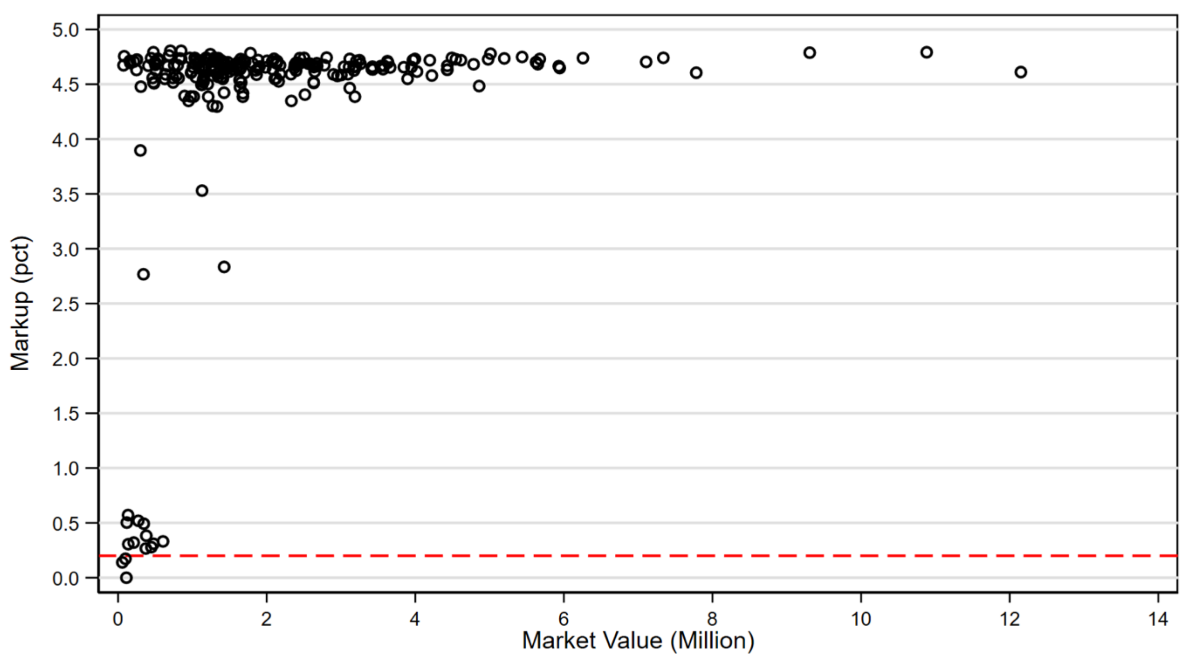


Figure 7. Dealer Buy Trade Markups (%) versus Dollar Market Value of Trade (millions).



Appendix A. Crossed-pair matching algorithms

In a first step, we identify chains of trades that start with a customer buy (sell), followed by an arbitrary number of interdealer trades and conclude with a customer sell (buy). All trades of the chain have to occur within 15 minutes in the same bond with the same par volume. If there are multiple customer buys or sells with the same volume, we follow a last-in-first-out schedule. For example, consider the sequence of trades (all within 15 minutes in the same bond with the same par volume) B-B-D-S-S, where B constitutes a customer buy, D an interdealer trade, and S a customer sell. In this example, the middle B-D-S sequence would be identified as one chain and the outer B and S trades would be combined to constitute another chain. We define chains without any intervening interdealer trades as single-dealer customer crossed pairs (Table 2). Chains that have an intervening dealer are broken-up in two interdealer customer crossed pairs (Table 3). For these interdealer-customer crossed pairs, we additionally include (partial) chains that start (end) with an interdealer trade and end (start) with a dealer buy or sell of the same volume within 15 minutes. Finally, for the "one-to-many” and “many-to-many” crossed pairs (Table 4), we sum up all trading volumes of customer buy and sell trades within 15-minute time intervals (starting with the first trade that occurs in a bond when there have been no other trades in this bond in the last 15 minutes). If the buy and sell volumes match and there are no intervening interdealer trades, we define all trades in this sequence as a "one-to-many” or “many-to-many” crossed pair.

Appendix B. A stylized three-party bargaining model of bond markups

We analyze the interactions of a bond seller S, a bond buyer B, and an intermediating bond dealer within a three-party bargaining model that extends Green, Hollifield, and Schürhoff (2007). The bond trades in an illiquid, decentralized dealer market. The dealer, acting as a pure broker via riskless principal trading, negotiates with two customer counterparties and executes its purchase and sale transactions simultaneously, incurring no intermediation costs. The dealer's customers do not communicate directly. The buyer's reservation value for the bond is v_B. The seller, possibly distressed, has a reservation value of v_S. The dealer has bargaining power $\theta_S \in [0,1]$ vis-à-vis the seller and $\theta_B \in [0,1]$ vis-à-vis the buyer.

The dealer pays p_S to buy the bond from the seller and receives price p_B from the sale to the buyer. Using generalized Nash solutions for the prices in both dealer transactions:

$$p_S = \theta_S \cdot v_S + (1 - \theta_S) \cdot p_B \tag{1}$$

$$p_B = \theta_B \cdot v_B + (1 - \theta_B) \cdot p_S \tag{2}$$

Solving (1) and (2) for p_S and p_B yields:

$$p_S = \frac{\theta_S \cdot v_S + (1 - \theta_S) \cdot \theta_B \cdot v_B}{\theta_S + \theta_B - \theta_S \cdot \theta_B} \tag{3}$$

$$p_B = \frac{\theta_B \cdot v_B + (1 - \theta_B) \cdot \theta_S \cdot v_S}{\theta_S + \theta_B - \theta_S \cdot \theta_B} \tag{4}$$

Example 1: Assume $v_B = 100$ and $v_S = 99$ with dealer negotiation powers $\theta_S = \theta_B = 0.5$. In such a symmetric setting, $p_S = 99.333$ and $p_B = 99.667$. Here, the seller and buyer each "gain" .333 versus their reservation values and the dealer carves out a similar profit from its markup, $p_B - p_S$. From an alternative perspective, the dealer and the buyer split the seller's "loss" (i.e., $v_B - p_S$) of .667 from selling below the seller's reservation value of 100. The dealer's markup in this example is 0.34% of the seller's transaction price, not too far from the median market of 0.20% found in our empirical study of markups for Non-Agency CMO.

Example 2: Giving the dealer full power versus both buyer and seller ($\text{i.e.}, \theta_S = \theta_B = 1.0$) would imply that the dealer could charge a 1.00 markup that captures all its customers' potential gains ($p_S = 99.00$ and $p_B = 100.00$). Note that the true protection against a dealer markup even larger than this 1.00 level comes from the customers' themselves, via the individual reservation prices limiting their willingness to transact.

Example 3: Even with symmetric bargaining powers ($\text{i.e.}, \theta_S = \theta_B = 0.5$), the dealer who finds a seller with a "low" reservation value, say, $v_S = 93.00$, could negotiate terms of $p_S = 95.333$ and $p_B = 97.667$, while extracting a markup of 2.45% (= 2.334/95.333). Again, given symmetric bargaining powers, the dealer and the buyer split the seller's 4.667 "loss" from selling below the buyer's reservation value of 100.

Now suppose there is a regulator-imposed cap κ on the markup in percent of the dealer's cost p_S^r, i.e., $p_B^r \leq (1 + \kappa)p_S^r$. When this κ percentage cap is binding, the dealer forgoes some profit to the benefit of one or both of the customers. Facing this cap, the dealer inflates p_S^r (relative to the no-cap solution) to increase its dollar profits $\kappa \cdot p_S^r$. The profit maximizing solution that fulfills the Nash solution of the buyer based on (2) together with a binding constraint $p_B^r = (1 + \kappa)p_S^r$ is:

$$p_B^r = \theta_B \cdot v_B + (1 - \theta_B) \cdot p_S^r = \theta_B \cdot v_B + (1 - \theta_B) \cdot \frac{p_B^r}{1 + \kappa} \qquad (5)$$

Solving (5) for p_B^r leads to

$$p_B^r = (1+\kappa)\frac{\theta_B \cdot v_B}{\kappa + \theta_B} \tag{6}$$

$$p_S^r = \frac{\theta_B \cdot v_B}{\kappa + \theta_B} \tag{7}$$

Example 4: In the $v_S = 93.00$ example above with symmetric negotiation powers, a 2% cap-constrained solution implies $p_S^r = 96.154$ and $p_B^r = 98.077$, with a dealer markup of 1.923. Note that in this case, the dealer and buyer again split the seller's "loss" from selling below the buyer's reservation value, but this is now limited to $v_B - p_S^r = 3.846$ (i.e., lower than the 4.667 in the no-cap solution). These outcomes imply that both the dealer and buyer are worse off than under the unconstrained solution.

Example 5: If the seller is truly distressed, perhaps due to significant margin calls from repo financing agreements or investor redemptions, the negative impacts of the regulatory cap on dealer markups may be high enough to induce (illegal) market collusion between the dealer and the seller. Suppose such a distressed seller appears with, say, $v_S = 80.00$. The 2.0% cap-constrained pricing solutions are unaffected as v_S does not appear in (6) and (7). Here, the distressed seller keeps all of the marginal "gains" from the unchanged selling price ($p_S^r = 96.154$) versus its new lower reservation price, while the outcomes for the dealer and the seller remain unchanged. Note that in a fully unconstrained world, $p_S = 86.667$ and $p_B = 93.333$, implying a dealer markup of 6.667 (7.69%).

In this example, as buyer and dealer both are now much worse off than without the regulatory cap, there is room for collusion should the dealer inform the buyer of the vulnerability of the distressed seller. The dealer and buyer could form a coalition where the collusive buyer agrees to make an unobservable concurrent or deferred side payment to the dealer as a compensation for driving down the collusive buyer's price, p_B^c. For example, a solution that still allows the seller to retain its original bargaining power would be

$$p_S^c = \theta_S \cdot v_S + (1-\theta_S) \cdot p_B^c = \theta_S \cdot v_S + (1-\theta_S) \cdot p_S^c(1+\kappa) \quad (8)$$

Solving (8) for p_S^c leads to

$$p_S^c = \frac{\theta_S \cdot v_S}{\theta_S - (1-\theta_S)\kappa} \quad (9)$$

$$p_B^c = (1+\kappa)\frac{\theta_S \cdot v_S}{\theta_S - (1-\theta_S)\kappa} \quad (10)$$

Example 6: Using our previous input example with symmetric bargaining powers and $v_S = 80.00$ generates equilibrium collusion outcomes of $p_S^c = 81.633$ and $p_B^c = 83.265$. In price terms, the collusive buyer is 14.81 better off than under the cap-constrained, no-collusion outcome, paying 83.265 instead of 98.077. At the same time, given its selling price of 81.633 (now 18.367 below fair value), the seller is even worse off compared to the completely unregulated case ($p_S^c = 81.633 < p_S = 86.667$). While the disclosed profit of the dealer now is just $p_B^c - p_S^c = 1.633$, compared to 1.923 in the case with the regulatory cap, any side payment larger than the 0.29 difference would make the dealer better off. For example, if the collusive buyer gave the dealer a side payment of 2.04, the dealer's total profit from the transactions would amount to 3.673 (= 2.04 + 1.633), a full 20% of the collusive enterprise's total capture of the 18.367 seller's loss.